iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 4 **Issue:** IV **Month of publication:** April 2016

**DOI:**

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

# Techniques to Improve the Strength of Ground

Arun singh[1], Dr. S.M. Ali Jawaid[2], Dr. Shree Ram Chaurasia[3]

[1]Research scholar, [2]Professor and Head, [3]Associate Professor, Department of Civil Engineering, Madan Mohan Malaviya University of Technology, Gorakhpur, India

***Abstract-*** ***In modern years quick development of infrastructures in metro cities compounded with inadequacy of useful and bound the engineers to progress the properties of soil to bear the load transferred by the substructure such as buildings, bridges, roadways, railways etc. The engineering techniques of ground development are removal and replacement, pre-compression, vertical drains, in-situ densification, grouting, vibroflotation, dynamic compaction, stone column, compaction piles, stabilization using admixtures and reinforcement. The purpose of these techniques to an improve the bearing capacity of ground and reduce the settlement of the soil. The methods among ground improvement techniques is supporting the soil with materials like steel, stainless steel, aluminium,fibre glass, nylon, polyester, polyamides in the form of other floorings or grids and geotextiles. The Main purpose of reinforcing a soil mass is to improve its stability, increasing its bearing capacity and reduce Settlements and Lateral deformations. Geosynthetics include permeable and impermeable materials that are either of knitted, woven or non-woven nature, The character of geosynthetic material varies in different application as it can serve as reinforcement, separation, filtration, protection, containment, fluid transmission and confinement of soil. Selection processes for ground improvement performs, improved analysis, and knowledge of long term performance and understanding of effects of variability are required to develop more efficient designs.***

***Keywords: Soil Strength Improvement, Geosynthetics, Vibrocompaction, Grouting, Compaction, Stone Column, Vertical Drains, Soil Reinforcement***

## I. INTRODUCTION

Ground improvement techniques such as stabilization, vibroflotation, dynamic compaction, stone column, compaction pile and compaction grouting are given the maximum importance in present days to adapt weak soil into the proper stable ground for different civil engineering projects. To increase the strength, bearing capacity and resistance to deteriorative forces of nature and manmade environment. It started with Henri Vidal and became familiar with the pioneer work of Binquet and Lee. Ground improvement techniques that improve the engineering properties of the treated soil mass usually the properties muddied are shear strength, stiffness and permeability. Ground improvement has developed into a sophisticated tool to support foundation for a wide variety of structures. When a project site come across any of the above difficult conditions, possible alternative solutions may be one of among as avoid the particular site; design the planned structure accordingly, remove and replace inappropriate soils, attempt to modify existing ground, enable cost effective foundation design, reduce the effects of contaminated soils, ensure sustainability in construction projects using ground improvement techniques. Ground improvement methods have made considerable developments since today’s commonly practiced techniques began to develop in the 20th century however most techniques have gone through changes.

## II. AIM/PURPOSE

The main goal of most soil improvement techniques used for reducing liquefaction hazards is to avoid large increase in pore water pressure during earthquake shacking. This can be achieved by densification of the soil and improvement of its drainage capacity.

### *A. Vibroflotation*

Vibroflotation is the method in which vibrating probe that can penetrate granular soil to depths of over 100 feet.

Figure: Vibroflotation compaction

Volume 4 Issue IV, April 2016
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

*B. Dynamic Compaction*

Dencification by dynamic compaction is performed by dropping a heavy weight of steel or concrete in a grid pattern from height of 30to 100 feet. It helps to increase the strength as well as improve to mitigation of liquefaction hazards.

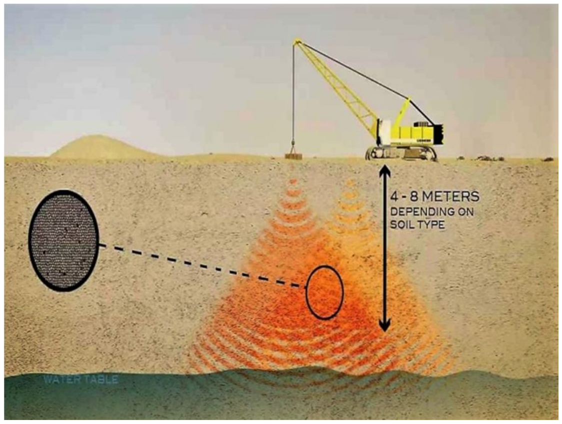



Figure: Dynamic compaction

*C. Stone Column*

Stone column are constructed by using gravel for column. Stone column can be constructed by the vibroflotation methods

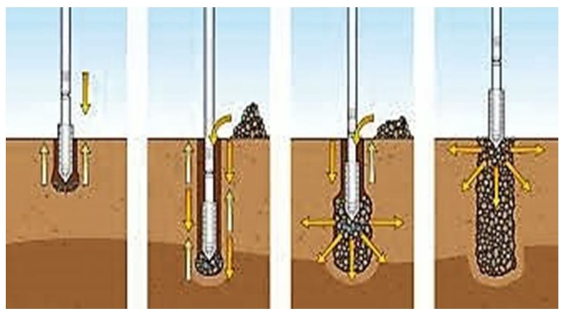


Figure: Stone Column

*D. Compaction Piles*

Installing compaction piles is a very effective process of improving the soil strength. Compaction piles are usually constructed prestressed concerete or timber. Installation piles both densifies and reinforced the soil. The piles are generally installed in a grid pattern and are generally driven to depth upto 60 feet.

*E. Compaction Grouting*

Compaction grout is the techniques in which we have to used water, sand, cement mixtures is injected under pressure into agranular soil. The grout forms a bulb that displaces and hence densifies the surrounding soilcompaction grout is the effective methods to improve the strength of soil.

Figure: Compaction grouting

Volume 4 Issue IV, April 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

## III. MECHANICAL IMPROVEMENT TECHNIQUES

Development of Dynamic Compaction this technique was invented and promoted by Louis Menard as early as 1969 but it was not until 29 May 1970 that he officially patented his discoveryin France. The idea of this method is enlightening the mechanical properties of the soil by transmitting high energy effects to the soil by dipping a heavy weight called pounder from a significant height. When feasible, dynamic compaction is probably the most favourite ground improvement technique in granular soils as it is usually the most economical soil improvement solution. Depth of influence or improvement is the depth where there are limited or practically minor amounts of improvement in the earth. Later and based on further site experiences others introduced a coefficient less than unity to the original equation and Varaksin has further advanced the relationship by introducing drop type and energy function coefficients. Menard performed his first dynamic compaction projects using 80 kN pounders that were dropped from 10 m. He was soon able to classify heavy duty cranes that were capable of efficiently lifting and dipping pounders weighing up to about 150 kN using a single cable line. Menard then developed and manufactured his own rigs that were able to lift 250 and more than 1,700 kN pounders. As much as these special rigs had their applications, they were specifically produced, their numbers were limited and they could not be manufactured commercially or in great numbers. However, the introduction of a new generation of cranes that are able to lift pounders using two single cable lines has now enlarged lift capacity commercially to 250 kN. The overview of these rigs was able to increase pounder lift capacity however it is still possible to improve the productivity of impact energy by dropping the pounder in free fall. Thus, the next major revolution in dynamic compaction was the development of the Menard Accelerated Release System which is able to release the pounder from the lifting device as the pseudo free fall commences. In this method Digital monitoring instruments are now able to record the coordinates of the impact point, drop height, number of drops per point and impact velocity. This enables the engineer to improve quality assurance and optimization of work parameters. This technique is most suitable for densification of loose granular soils.

## IV. ADVANCE OF VIBRO-COMPACTION

This method involves densification of granular soil using a vibratory probe inserted into ground. It is a deep compaction technique that was created in the mid-1930s in Germany for treating sandy soils. In this technique an electric and hydraulic vibrating unit called a vibro-probe penetrates the ground and the loose sands and causes in enhancement of density. Although the entrance of vibroflots have not changed much during the past seven decades and most equipment would seem very similar to the untrained eye, today specialist ground improvement companies manufacture vibro-probes with different abilities. Vibration frequencies are now closer to the soil’s ordinary frequency and the power range of the plant allows specific uses of each machine. Vibro-compaction is successful in loose sand soils typically with an original SPT value of 5 to 10 near the surface and not appropriate to clays. Relative density of up to 85% can be achieved

## V. ADVANCEMENT OF COMPACTION GROUTING

Compaction grouting is a ground behaviour practise that involves injection of a thick-consistency soil-cement grout under pressure into the soil mass, consolidating, and thereby increases density of surrounding soils in-situ. The inserted grout mass occupies void space created by pressure-densification. Pump pressure, as transmitted through low-mobility grout, produces compaction by displacing soil at depth until resisted by the weight of superimposing soils. Compaction Grouting when inserted into very dense soils, compaction grout remains somewhat confined, since the nearby material is quite dense. However when inserted into under-consolidated or poorly-compacted soils, grout is able to "thrust" these materials sidewise. When grouting treatment is applied on a grid pattern, the result is better compaction of displaced soils and greater homogeneousness of the treated soil mass. As a minor advantage, the resulting grout columns add strength in the vertical axis, as typical grout compressive strengths exceed those of the nearby soils. Compaction grouting applications include densification of foundation soils, raising and relieving of structures and foundation elements, mitigation of liquefaction potential, augmentation of pile capacity and pile repair, and densification of utility trench backfill soils. The method has also been used to support deep excavation into soft ground for a case in Shanghai. A few more cases are given by Welsh and Burke (2000). An another compaction grouting technique has also been projected by Naudts and Van Impe in which geo-textile bags are used. In accepting this method, regular sleeve pipes are connected to the required depth. Geo-textile bags are strapped spanning all or some of the sleeves. The geo-textile bags are inflated via a double packer with stable, low viscosity cement based suspension grout with high resistance against pressure filtration. Several bags are inflated at the same time. The inflation process is done in stages to allow the water to slowly (According pressure) filtrate through the geo-textile bags. During each grouting stage the pressure is methodically increased. The spacing between the grout pipes takes to be such that the soils are

Volume 4 Issue IV, April 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

subjected to vertical stresses in excess of those they will eventually be subjected to. The volume reduction of the nearby ground under the grouting pressure, as well as the influence radius of the compaction grouting can be statistically estimated with the method described by N audts and Van Impe. This in turn dictates the spacing between the grout pipes.

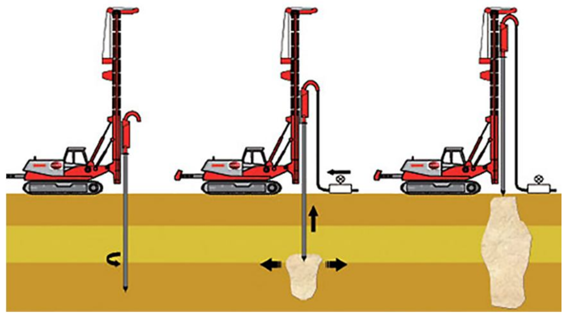


Figure Compaction Grout

## VI. SOIL MODIFICATION BY PRE-FABRICATED VERTICAL DRAINS

This technique increases the bearing capacity and reduces the compressibility of weak ground and it is completed by placing temporary extra on the ground. Extra generally more than the expected bearing capacity. It is most effective for soft cohesive ground. The process may be speed up by vertical sand drains/prefabricated vertical drains. these drains are installed in order to accelerate settlement and gain in strength of soft cohesive soil. Vertical drains accelerate primary consolidation only. As significant water movement is related with it. Secondary consolidation causes only very small quantity of water to drain from soil or in ground. Secondary settlement is not speeded up by vertical drains. Only relatively impermeable type of soil is benefited from vertical drains. Soils which are more permeable will consolidate under surcharge. Vertical drains are effective where a clay deposit contain many horizontal sand or silt lenses.

## VII. PHYSICAL AND CHEMICAL MODIFICATION

In this technique soil improvement is achieved by physical mixing of adhesives with surface layers or columns of soil. The adhesive includes natural soils industrial by products or surplus materials or cementations or other chemicals which react with each other and the ground. When adhesives are injected via boreholes under pressure into voids within the ground or between it and a structure the process is called grouting. Soil stabilization by heating and by freezing the ground is careful thermal methods of alterations. Some of the physical and chemical modification methods are

Grouting
Heating
Freezing
Vitrification

### *A. Grouting*

This technology has become a common ground improvement method used frequently for underground and foundation constructions. The process of grouting consists filling pores or cavities in soil or rock with a liquid form material to reduction of the permeability and improve the shear strength by increasing the cohesion when it is set. Cement base grout mixes are commonly used for gravely layers or fissure rock treatment. But the suspension grain size may be too big to penetrate sand or silty-sand layers. In this case, chemical or organic grout mixes are also used. In recent years, the availability of ultrafine grout mixes has extended the performance of hydraulic base grout for soil treatment. Sandy gravel soil treated using ultrafine cement mix. The grout mix can be classified into four types.

Mortar and pastes such as cement to fill in holes or open cracks.

Suspensions such as ultra-fine cement to seal and strengthen sand and joints.

Solutions such as water glass.

Emulsions such as chemical grout.

The operational limits of different grout mix are dependent on the type of soils and the particle size distribution of the soil. The grouting may be categorised as.

Penetration grouting.

Displacement grouting.

Compaction grouting.

Grouting of Voids e. Jet grouting.

*B. Heating*

Heating causes permanent changes in properties of soil and renders the material hard and durable. Workshop studiedneed shown that an increase in temperature increases settlements of clays under a given practical stress. Heat behaviour of a clay soil to about 400°C results in pronounced changes in engineering properties of soil. Heating is energy concentrated and to stabilize one m3 of soil 50 to 100 litters of fuel oil are required. It is not recommended now a day excepting in places where it is previously available as inherent energy in waste products and in landfills. However use of geothermal piles as heating structures is prevalent in places like UK. The idea of reconsolidation of clay using a combined vacuum and heating method in cold region has been attempted by Marques and Leroueil in Quebec. Another field trial was carried out recently by Pothiraksanon. In which hot water was circulated into the PVDs to elevate the ground temperature. However, these methods are still in the experimental stage and there are no large scale field applications yet. Another application of heating method is the so-called heat exchange pile which has been deliberated in detail by Brandl and Laloui. Some other methods of using heat for soil developmentdeterminations have been defined by Van Impe (1989).

## VIII. MODIFICATION BY INCLUSION AND CONFINEMENT

In this method adjustment of soil properties are achieved using reinforcement by means of fibres, strips bars meshes and fabrics imparts tensile strength to a constructed soil mass. In-situ reinforcement is achieved by nails and anchors. Stable earth retaining structure can also be formed by confining soil with concrete, steel, or fabric elements and Geo-cell. There has been a large increase in the use of admixtures for ground improvement for both cohesive and non-cohesive soil in recently years. Sand compaction piles, stone columns, dynamic replacement, semi-rigid and rigid inclusions and geotextile confined columns. A brief description of each technique under this method is presented in nextpassage.

## IX. VIBRO REPLACEMENT OR STONE COLUMNS

Vibro Replacement is a technique of constructing stone columns through fill material and weak soils to improve their load bearing and settlement characteristics

Different clean granular soils, fine grained soils do not density effectively under vibrations. Hence, it is essential to form stone columns to reinforce and improve fill materials for weak cohesive and mixed soils.In the method a hole jetted into soft, fine-grained soil and back filled with densely compacted gravel or sand to form columns. A variation of the stone column method is the vibro concrete column which is installed using dry bottom feed vibro equipment with stone aggregate replaced with a high slump concrete mix. One application of the vibro concrete column for a highway embankment over soft clay is described by Serridge and Synacy. Another technique similar to the stone columns is the rammed aggregate pier method. This method also installs columns using crushed stone. However, the construction process is different. Instead of being horizontally vibrated into place, the stone is densely compacted by vertical ramming in about 0.3 m layers in the rammed pier method. A patented bevelled tamper rams each layer of aggregate using static down force and vertical impact ramming energy, resulting in superior strength and stiffness. The tamper densifies aggregate vertically and forces aggregate laterally into the loose matrix soil. This results in matrix soil improvement and excellent coupling with the surrounding soils, thereby delivering reduction of liquefaction potential and highly reliable settlement control. The rammed aggregate piers can be used to reinforce a variety of soils, including loose sands, silts, and mixed soil layers

Volume 4 Issue IV, April 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

including clays, uncontrolled fill and soils below the ground water table.

## X. SAND COMPACTION PILES (SCP)

SCP is a special type of dynamic replacement which can be used for both clayey and sandy ground. The method was originated in Japan and has been widely used in Japan and other Asian countries. The method deserves special mentioning as the construction processes involved in sand compaction piles can be different from that for vibro compaction or stone columns. In forming sand compaction piles, sand is fed into the ground through a casing pipe and is compacted by vibration, dynamic impact or static excitation to form columns. Sand compaction piles can be used for the treatment of both sandy and clayey ground. This is different from vibro compaction. The main purposes of using SCPs for sandy ground are to prevent liquefaction and reduce settlement

## XI. GEOTEXTILE ENCASED COLUMNS (GEC)

The geotextile-encased columns (GECs) foundation system for banks on soft or difficult soils was introduced in 1994. The GECs consist of compacted granular fill similar to common stone columns, but with a main difference: GECs are confined in a high-strength woven geotextile cylinder. Consequently, they work properly even in extremely soft soils. Granular columns under compressive loads experience different failure modes, such as bulging, general shear failure, and sliding. However, the most common failure mode for stone columns in soft clays is bulging. With the help of geotextile-encased columns. Stone columns are progressively being used for ground improvement, particularly for stabilizing road embankments, foundation for oil storage tanks, etc. Stone column derives its axial capacity from the passive resistance developed against the bulging of the column and increased resistance to lateral deformation.

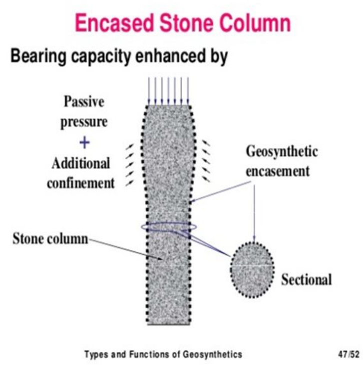



Figure :Encased Stone Column

## XII. CONCLUSIONS

This paper has endeavoured to offer of the new development in ground improvement techniques which are extensively used in the field of geotechnical engineering and will play a major role in the field and earthwork construction projects of many types in the years ahead. The further research area among the key problems is:-

How to best incorporate sustainability considerations in ground development method selection and implementation giving consideration to energy, carbon emissions, and life cycle costs.

How to improve and simplify constitutive showing.

Development of practical, economical and ecologically safe biogeochemical methods for soil stabilization and liquefaction risk mitigation.

Development of databases for variability of soil and material parameters required in the design of ground improvement.

Development of improved and more reliable methods for evaluating the long term durability of soils mixed with binder.

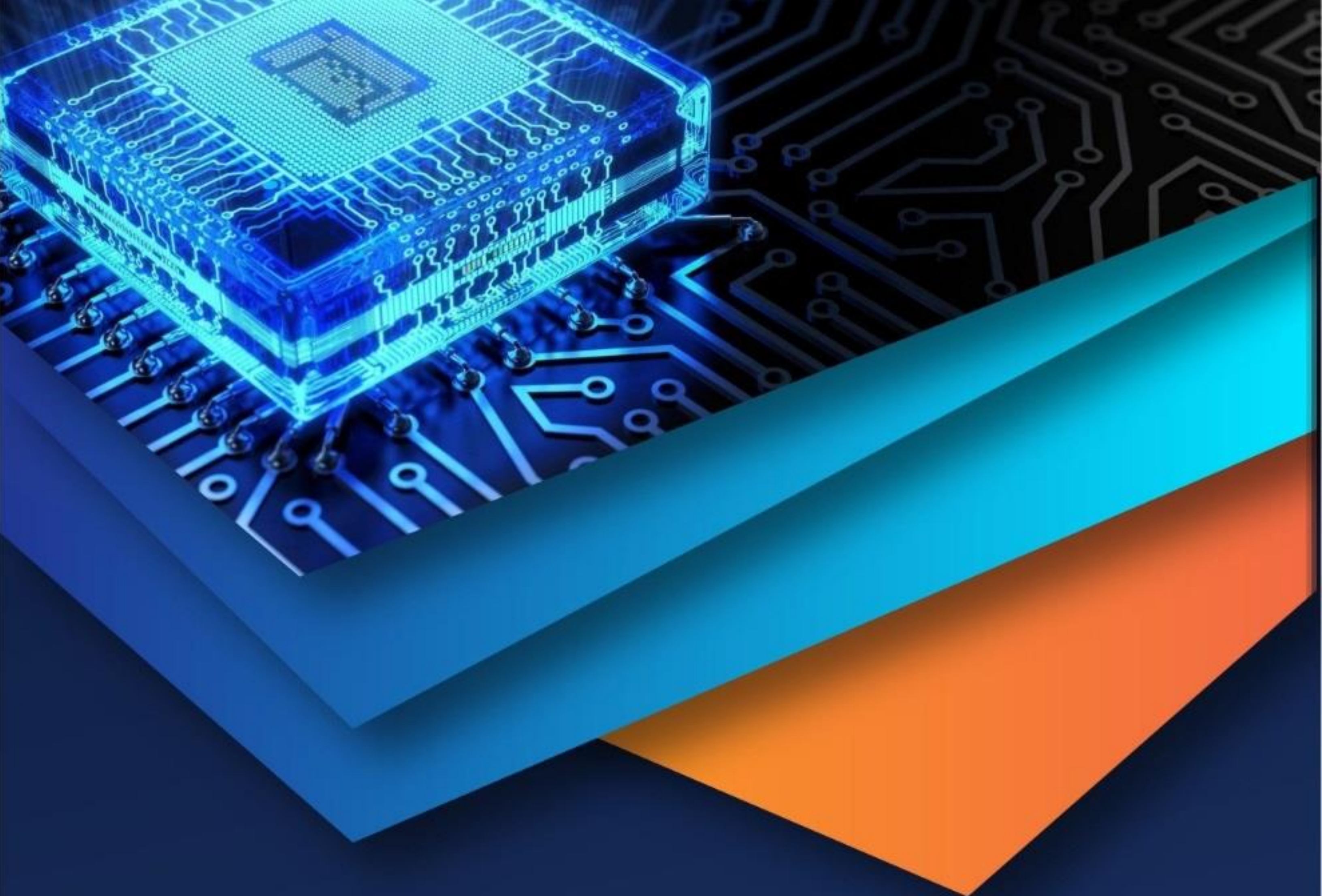
Understanding creep mechanisms in soils and interaction of creep with semi-rigid inclusions. It is expected that with constant

Volume 4 Issue IV, April 2016
ISSN: 2321-9653


research and ground experience in talking challenges such as above, the sub discipline of ground improvement will continue its development and importance as a critical component of successful geotechnical engineering and construction

## REFERENCES

[1] Hausmann,M(1990),―Engineering principles of Ground modification‖, Mc Graw-Hill Publications.
[2] Binquet,J.& Lee, K.L. (1975), ―Bearing capacity test on reinforced earth slabs‖, Journal of Geotechnical Engineering Division, ASCE, 101(12), 1241-1255.
[3] Guido, V.A., Chang, D.K. & Sweeney, M.A. (1986), ―Comparison of geogrid and geotextile reinforced earth slabs‖,Canadian Geotechnical Journal (23), 435-440.
[4] Varaksin, S.(1981), ―Recent development in soil improvement techniques and their practical applications‖, Solcompact Sols/Soils, Techniques Louis Menard, 15, rue des Sablons, Paris, 38/39-1981.
[5] Liu, J. (2003), ―Compensation grouting to reduce settlement of buildings during an adjacent deep excavation‖, Proc. 3rd Int. Conf. on Grouting and Ground Treatment, Geotechnical Special Publication120, ASCE, New Orleans, Louisiana, 2: 837-844.
[6] Welsh, J.P., & Burke, G.K. (2000), ―Advances in grouting technology‖, Proceedings of GeoEng 2000. Melbourne.
[7] Van Impe, W. F. (1989),‖ Soil improvement techniques and theirEvolution‖, Taylor & Francis.
[8] Charlie, W.A., Jacobs, P.J., & Doehring, D.O. (1992), ―Blastinginduced liquefaction of an alluvial sand deposit‖ Geotechnical Testing Journal, ASTM, 15(1): 14-23.
[9] Bo, M.W., Chu, J., Low, B.K. & Choa, V. (2003), ―Soil Improvement Prefabricated Vertical Drain Technique‖, Thomson Learning.
[10] Mitchell, J.K., & Katti R.K. (1981), ―Soil Improvement‖ - State of the Art Report. 10th ICSMFE, Stockholm, 4: 509-565.
[11] Karol, R.H. (2003), ―Chemical Grouting and Soil Stabilization‖, 3rd: CRC Press.




10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR: 7.429


# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY