

## Helical Piles/Screw Piles

Screw piles, also known as helical piles or screw anchors, are structural, deep foundation elements that are used to provide stability against forces exerted by lateral loading, axial compression, and tension. They consist of one or more circular, helical plates welded to a central square shaft or a circular hollow tube. Shaft diameters range from 50mm up to 600mm and helix diameters range from 150mm up to 1200mm depending on capacity requirements. Helical piles offer unique advantages over other foundation types. The main advantages associated with the use of screw piles are that they can be loaded to their full capacity immediately after installation, they may be installed rapidly with very little noise or vibration and may be installed using various sizes of lightweight equipment which makes them especially suited for use on soft or marshy terrain or on sites with restricted access, including inside of existing buildings.



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**DFI of INDIA**

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## The Cover Story

### Applications of Helical Piles

New foundations Support to new structures including

- Residential, commercial and industrial buildings
- Small Lightweight Bridges, wharves, and jetties
- Transmission towers and wind turbines, Solar Power Foundations
- Transportable buildings
- Signal gantries, Railways Signals
- Oil and Gas Pipe Lines.

Strengthening Existing Foundations

- Permanent or temporary support for re-leveling of existing structures
- Seismic/gravity capacity improvements

Anchoring

- permanent support for new or existing retaining structures,
- slope stabilization

### Advantages of Screw Pile Foundations

Helical piles offer unique advantages over other foundation types.

The main advantages associated with the use of screw piles are,

Easy Installation

Minimized Vibration

Eliminates the Use of Concrete

Corrosion Protection

Environment-Friendly

Can be used in a Range of Soil Conditions

### Bearing Capacity of Screw Pile/ Helical Piles

Screw piles generate their load capacity solely from the flat contact area of the projecting helical plates with the surrounding soil mass.

As a result, screw piles have a higher bearing capacity than conventional piles of the same length. The necessary load-bearing capacity is achieved by bolting more sections of pile together and screwing them in.

### Geotechnical Factors in determining Screw Pile Capacity

Screw piles can be used in compression to support structures transferring loads through weak or liquefiable soils to harder soils or rock, and in tension to resist uplift loads from structures and provide support to retaining structures. In most situations, the installed screw pile will have both compression and tension loads.



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• A screw pile carrying both compression and tension loads needs to be found deeper below weaker/ softer/ liquefiable soils

- A screw pile under only compression loading needs to have an adequate thickness of hard soil beneath the helix to prevent punching failure and pile deflection
- A screw pile under only tension loading requires an adequate thickness of hard soil above the helix to reduce the risk of pull-out.

There are a number of key geotechnical factors that need to be taken into consideration when designing for screw pile capacity:

- Seismic Actions
- Compression capacity in coarse-grained (cohesionless) and fine-grained (cohesive) soils
- Tension capacity
- Lateral capacity
- Capacity derived from installation torque
- Pile deflection
- Pile spacing
- Strength reduction factors

## Helical Pile Installation

Helical piles are installed using excavators fitted with a rotary driver head attachment. Below is an example. The "true flight helix" of a helical pile allows it to be screwed into the ground with little ground disturbance and minimizes augering of the soil. Most often, pile designers would conduct pile load testing in compression, tension, and lateral loading in order to evaluate the pile's ability to be installed for the ground condition and to evaluate the capacity to torque ratio (K) for each pile type/geometry for a given soil condition. This is generally used to optimize pile design before mass production.



## The Cover Story

Generally, the geotechnical capacity of an individual helical pile is evaluated in the field using correlations of torque to capacity derived through extensive field pile load testing and experience.

### Various Types of Screw Piles/ Helical Piles

Various types of Screw piles/ Helical anchors are designed to meet the need of the project. It can vary from project to project as to which tube dimensions would match the number of helix or helices. Some of the variety of Screw Piles are pictured below. Single Helix, Double Helix, and Tripple helices.



### Conclusion:

The main benefits of screw pile foundations include shorter project times, ease of installation, ease of access, reduction of the carbon footprint, ease of removal when the foundations are no longer required, reduced risk to the workforce, and reduced costs.

Presnetly the only designers and manufacturers of Screw Piles/ Helical Anchors in India are Tethys Business and Projects Pvt Ltd. They are exporting to USA, UK, Canada, Australia and New Zealand since 2011. Visit [www.tethysprojects.com](http://www.tethysprojects.com) for more details.



## From the Chairman

Dr. K S Ramakrishna, DFI of India Chair

We are pleased to inform that DFII successfully completed 5 years since its inception and we are thankful to the DFI US team and the DFII member fraternity who through their support have made our activities and progress possible. After formation of the full-time office of DFI of India, we are pleased to inform that necessary steps are being taken in building up a framework that provides opportunities to more stakeholders to get involved in DFII Activities that benefit Indian Deep Foundation Industry and in the realization of vision and mission of DFII.

One of the main objectives of DFII is to build the required infrastructure to provide training programs in different specialized areas to cater to professionals/workmen in the deep foundation industry. To spread awareness of such need, 8th DFII annual conference (DFI-India2018) to be held at IIT Gandhinagar during Nov'18 is chosen as a platform to present and deliberate case studies and the challenges facing India's infrastructure projects as related to geotechnical works. Presentations will showcase proactive solutions that optimize the performance of the deep foundation scope of various infrastructure projects by achieving enhanced time and cost efficiency, higher quality and safety. Different sessions/topics are chosen in such a manner that it will be of interest to owners, contractors, government representatives, designers, consultants and educators involved in geotechnical design and construction.

A working committee is being formed to assess the availability and current skill levels of geotechnical professionals/engineers/supervisors/rig operators and to identify the gaps in skill levels that are impacting the performance of Indian deep foundation industry. This team will endeavor to assess the infrastructure needs to bridge the current gap and to build skill base catering to future needs with reference to best practices at the global level. There will be panel discussions organized during the Nov'18 conference to generate awareness about this genuine issue and to build consensus among deep foundation industry stakeholders about the necessity of putting required infrastructure in place to impart skill training to human resources in this industry. DFII got an opportunity to work with Chennai Metro Rail Limited (CMRL), a governmental organization for developing guidelines, training programs and workshops that will help in mitigating various risks associated with the geotechnical and foundation engineering design and construction.

Owners/contractors/other stakeholders of metro rail projects are expected to participate in this workshop and DFII is hopeful that learnings from such workshop

once implemented will create a win-win situation for all stakeholders in the smooth implementation of projects. We are happy to inform that DFII's first technology initiative, i.e., continuous flight auger (CFA) test pile project implementation is going smooth. With team efforts of CFA pile committee members, design construction document is completed successfully and being reviewed by DFI team in the USA.

DFII is getting a good response for its request for In-kind contribution for implementation of this project and it is hopeful to complete the piles (six piles) installation and testing by Nov/Dec'18. With the level of activities expected to increase further in India, DFII is seeing the scope for more members joining this important forum as a part of different working committees for taking up more number of initiatives that will bring more professionalism to Indian deep foundation industry in the long run. It is ever indebted to DFI team for finding time to participate in regular conference calls for a review of all on-going initiatives and review of design and construction documents developed for innovative technology initiatives, including providing grants. Without respite, DFI US team made it a point to attend weekly conference calls held on every Friday over last 5 years. It is heartening to note that such collaborative efforts have enabled us to build DFII image in India in deep foundation industry. With the increased level of activities, we wish that this will evolve as one of the finest professional institutes in the years to come.

*Excerpts from the DFII regional report published in DFI July-Aug'18 issue.*



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### INTRODUCTION

Grouting techniques have a long history of usage in dam construction and can be applicable to address challenges in seepage remediation. Jet grouting is widely recognized as the most suitable ground improvement technique for its applicability to the majority of soil types. The technique enables the arrangement of grout columns in various geometrical configurations, employability for new facilities as well as for existing ones and for wide ranges of soils. Jet grouting application is a proven technique for seepage control in dam foundations, foundation retrofitting, subsidence control, contaminant barriers, tunneling and mining operations, offshore construction, etc.

The process of jet grouting consists of disaggregation of soil and mixing it with a cementing agent or binder. This is achieved by high-pressure jets of grout comprising of a water/binder suspension injected through a nozzle, by which the soil around the borehole is eroded. The eroded soil is brought into suspension and these particles are rearranged and mixed with the cement suspension, which subsequently sets and hardens to form a stabilized jet grout column. This paper focuses on the engineering aspects of jet grouting for the creation of a cut-off wall for seepage control. Fig. 1 shows the application of jet grouting works especially in dam foundations for seepage control.

### JET GROUTING TYPES

The design of the grout column is based on the soil conditions (Fig. 2) and its application for a specific project. Accordingly, different jetting techniques namely single, double and triple fluid type systems. These are classified based on the number of fluids injected into the subsoil i.e. water & grout or air & grout, water, air & grout. The grouting process is influenced by the soil conditions i.e., grain size distribution, organic content of the soil, groundwater, geometrical form and quality of the jet grout columns required.

The most recognized systems of jet grouting are the S, D and T jet systems that correspond to single, double, and triple jetting methods respectively (see Fig. 3). The S-process is used for small to medium sized columns. D jet system employs simultaneous cutting and mixing of the soil using grout suspension combined with an air jet. The T jet system performs simultaneous cutting and mixing of soil along with water and air jets. The typical range of diameters of the jet grout columns using various jetting systems is presented in Table 1.

### PROCESS OF JET GROUTING

Drilling is the first step in the jet grouting process which consist of eroding the soil and jetting of binder suspension (usually cement and or bentonite plus water) into the soil. The jetting process helps to achieve the required mechanical properties of the jet grouting columns. Schematic of the jet grouting process is presented in Fig. 4. Field pictures of the mixing and jetting process are shown in Fig. 5 & Fig. 6

## Jet Grouting Applications for Seepage Control

### OPERATION PARAMETERS AND SUITABILITY

The jetting is carried out as a 'bottom-up' operation in which the drill string (Fig. 4), with the jetting monitor attached at the base, is slowly raised and rotated while injecting the grout to form a column of soil/cement.

During jetting, the spoil returns (excess material from the soil/grout mix) rises to the top of the drill hole. The jet grout column characteristics (diameter, composition, permeability, strength, effective thickness of the cut-off wall etc.) are majorly dependent on the jetting parameters employed and

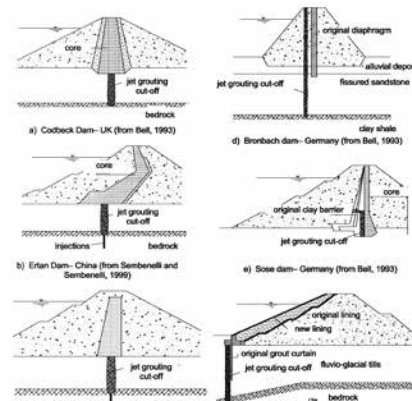


Fig. 1. Cross-sections of jet grouting cut-offs in dams (Croce and Modoni, 2007)

Soil Type	Diameter (m)	
	Single Jet	Double/Triple Jet
Gravel	0.6-1.2	1.0-1.6
Sandy Gravel	0.5-1.0	0.9-1.8
Silty Clay	0.5-1.0	0.8-1.5
Clayey Silt	0.4-0.6	0.7-1.0

Table 1 Typical diameters for different systems

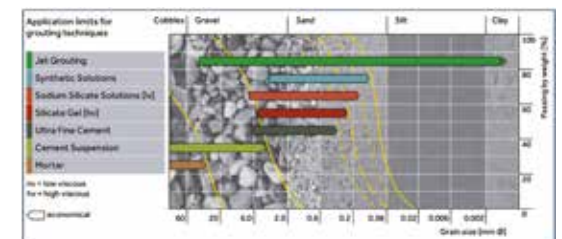


Fig. 2. Jet grouting applications in various soil types

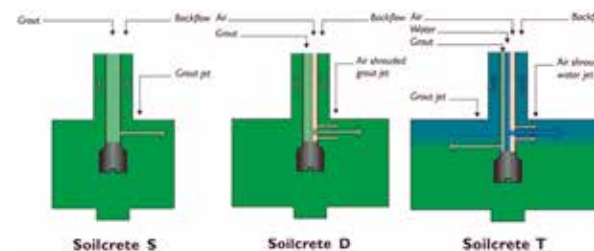


Fig. 3. Jet grouting systems

## Jet Grouting Applications for Seepage Control

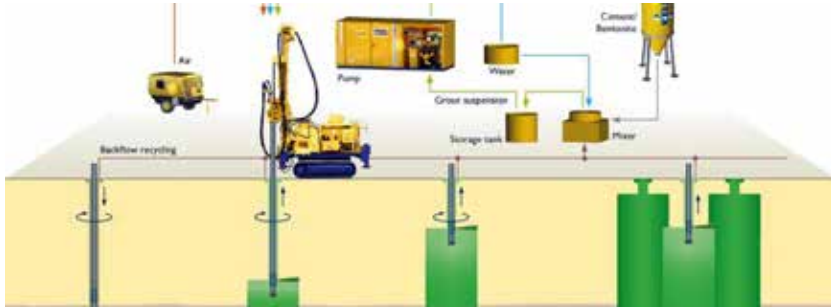


Fig. 4. Jet grouting process



Fig. 5. Batching and mixing setup



Fig. 6. High-pressure pumping and jetting setup

the type of soil encountered. These include rotation and extraction speeds, jetting pressure and grout flow rate, the grout mix, as well as soil type, grain size distribution and consistency of the in-situ soils.

### QUALITY CONTROL ASPECTS

The ideal jetting parameters for a particular project site are to be established based on initial trials and experience as well. The grout properties such as viscosity, density and bleed are initially tested in a laboratory study (Fig. 7) before adopting the grout mix at the site. These properties are further tested at site frequently to ensure consistency of the mix in the whole project. Jetting pressure and withdrawal rates can be monitored at the site with real-time data acquisition systems. Apart from these parameters, to ensure the formation of the diameter of the jetted column including verticality, ACI (Acoustic column inspector) testing (Fig. 7), Inclinator test, tell-tale tests and visual column inspection (Fig. 7) may appropriately be selected, based on availability.

### SEEPAGE CONTROL BY JET GROUTING

Seepage control practices in geotechnical and geoenvironmental engineering can be generally classified into four categories (Chen et al., 2010), as per the following:

1. Creating an impervious barrier with low permeability and high critical hydraulic gradient
  2. Provide filters and lower the hydraulic gradient
  3. Control the effective water level fluctuation
  4. Creating hydraulic containment to arrest the flow of water
- Jet grouting belongs to the first type of seepage control method where the seepage is controlled through the low permeable barrier. Jet grout cut-off walls act as a sealing structure. The sealing effect of grout against water ingress is generally achieved by selecting a suitable grout suspension and if necessary by the addition of bentonite. The type and quantity of the injected grout material as well as the kind and volume of the remaining soil particles in the grouted mass guide the sealing properties.

### Pattern and length of jetted columns for seepage control

Cut-off walls represent an extension of a dam's waterproofing system into the subsoil which is made by connecting several vertical overlapped elements. Waterproofing of coarse alluvial deposits below cofferdams is performed by building diaphragm consisting of rows of overlapping jet grout columns extending down to impervious layer or to required design depth. Different patterns of jet grout columns are presented in Fig. 8. The depth of cut-off walls is usually established based on the reservoir storage and target hydraulic gradient.

### Strength and permeability for seepage control applications

Strength is a general index used for identifying the quality of engineering material. Strength is often used as a quality control check for cement-bentonite materials typically the unconfined compressive strength. However, the strength requirement for cut-off walls varies substantially from 10kPa-500kPa. A realistic minimum strength for many applications using bentonite-cement mixes is 50kPa. Jefferies (2012) based on his study suggests a minimum strength for slurry trench cut-off walls at 28 days as 100kPa. However, the strength of samples collected from jetted columns show wide variation and this scatter is much more in cement-bentonite mixes (Jefferies, 2012; BRE, 1999). The variation is attributed to the presence of soil from the ground dispersed into the slurry.

Permeability is the most important parameter in seepage control applications. In cut-off walls, the material of the elements (panels, piles, jet-columns etc) have a very low permeability ( $<10^{-7}$  m/s) and are to be practically impervious. The trend of variation of permeability with time is quite interesting based on the binder used for jetting. The permeability of cement-bentonite materials tends to decline under continued permeation with water.

### Conclusions

Jet grouting technique is a proven application to address challenges in seepage remediation. This technique is one of the widely recognized ground improvement methods, for its applica-



## Jet Grouting Applications for Seepage Control



Fig. 7. Jet Grouting QA-QC testing

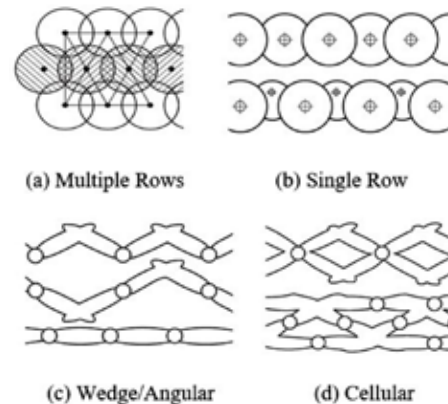


Fig. 8. Different patterns of jet grout columns

bility to most soil types and solution to various challenges in the field of geotechnical engineering. The technique is flexible and capable of conforming to different types of waterproofing systems. It is widely used for seepage control as the treatment can be executed without disturbing the nearby existing structures and even without lowering the reservoir water level. In this paper, the crucial parameters (operational and mechanical) in design point of view are discussed and different systems for executing jet grouting are also elaborated. Apart from the engineering parameters effective quality control measures to be followed at the project site and seepage control applications also discussed.

Special Note: This is a modified version of the paper titled "Engineering Aspects of Jet Grouting in Seepage Applications" submitted to DFI-India 2018 conference in Gandhinagar.

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### Next Event

### DFI-India 2018 at IIT Gandhinagar

DFI-India 2018: 8th Conference on Deep Foundation Technologies for Infrastructure Development in India

November 15 - 17, 2018

IIT Gandhinagar, Gujarat, India

Following a one-day workshop, on *Ground Improvement Techniques - Column Support Embankments and Soil Mixing*, this two-day conference follows seven successful DFI of India Annual Conferences. A technical program with keynote lectures and presentations that will showcase proactive solutions that optimize performance of deep foundation for various infrastructure projects by achieving enhanced time and cost efficiency, higher quality and safety.

The workshop and conference will be of particular interest to contractors, developers, local and government representatives, designers, consultants and educators involved in geotechnical design and construction. Equipment, material and instrumentation suppliers, contractors and other vendors will present their products and services in the Exhibit Hall.

Visit <http://www.dfi.org/India2018> for more details. Registration details on Page 14.

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## Way ahead for Indian Deep Foundation Industry

Dr. K.S. Ramakrishna, Chairman, DFII

This year DFII began treading the path of introducing modern technology initiatives, and developing skill training programs that will directly benefit the industry in the long run. To make the readers aware of what is that in store for immediate future, we chose to reproduce the forwarding-looking solutions presented by Dr. K S Rama Krishna in his paper presented for IGS 2009 seminar held at Guntur. Though not currently widely used in India, these solutions can find wider usage to reap these benefits fully.

These initiatives have been implemented in L&T which resulted in the time-efficient, quality construction of foundations with significant cost savings. Training the front line and supervisory staff, exposing the field engineers to all aspects covering design to installation, and integrating all concerned from design to installation are the key factors contributing to the success of these initiatives.

### Integrated Driven Piling Rigs with Hydraulic hammers

Among the type of piles adopted in Indi, bored piles are the most common ones. Driven cast-in-situ piles fall into the second category in terms of popularity. Unfortunately, precast driven piles are not very common even though they offer several advantages. Both types of these driven piles are installed using drop hammers mounted on A-Frames or steel lattice towers held in position by guy wires. These are moved on skids or pipe rollers which is laborious and time-consuming. Driving energy is imparted by drop hammers lifted and dropped with the aid of diesel engines. This equipment suffers from various limitations such as slow mobility, difficult maneuverability, a large number of the labor force, limited hammer capacity, inefficient energy transfer to pile head, instability, etc. As a result of these limitations, the pile installation speed and capacity to drive deep are quite low. In developed countries and several countries in the Far-East crawler mounted integrated driven piling rigs with highly efficient hydraulic hammers have been in use for a few decades (Fig. 1). These rigs have been introduced in KGD6 Onshore Gas Terminal Project in Kakinada, India to drive around 1.0 Million meters of precast concrete piles to depths of 48 to 50 m into dense sand founding layer overcoming medium dense to dense sand layers at intermediate depths. Productivities increased by 2 to 3 times that of conventional rigs described above and a number of workers required per rig had dropped to half (from 12 or 13 in the case of conventional rigs to 5 or 6 for integrated rigs). As a result, the unit driving cost had also decreased significantly (10%).

### Mechanical Pile Splices for Precast Piles to Replace Field welding of Pile Joints (Fig.2)

Precast piles are normally driven in segments of suitable lengths to take care of the handling stresses and very soft or very hard intermediate soil layers. These sections are joined by either field welding of embedded steel end plates or mechanical splices to either end of the two pile segments to be joined at the pile location.

It has been observed that the field welding and cooling of joints take time. In addition, there is always a possibility of quality issues arising from field welding. When using conventional rigs, the entire piling gang and piling equipment are on standby while the field weld joint work is in progress. All these make the field weld joints unattractive both from time and cost points of view. "Sure-Lock" mechanical splices from the USA were introduced at HMCPCPL piling site in Haldia and continued at RIL KGD6 project at Kakinada and currently at Dharma port site. The productivity improvements were closely monitored, and it is found that while the welded joint takes about 120 to 180 minutes the mechanical splicing would take hardly 5 minutes. The mechanical splice has the advantages of high quality and high strength. The need for a separate welding gang is also eliminated.



Fig. 1: Integrated Driven Piling Rig with Hydraulic Hammer



Fig.2: Sure, Lock Mechanical Pile Splice for Precast Pile Segment



## Way ahead for Indian Deep Foundation Industry

### Integrated Multi-Purpose Piling Rigs to Install Driven Cast-in-situ Piles (Fig.3)

High capacity integrated multipurpose hydraulic piling rigs with hydraulic hammers have been introduced first time at the Indian Oil Corporation Ltd project site in Panipat, India. An extensive training was carried out to the entire team at the site to ensure that the speed of fast driving equipment is matched by the timely supply of pile reinforcement cage and concrete. It is found that once clear work front is available it is possible to drive 30 to 35 piles per day per rig.

### Hydraulic Pile Head Breakers to Eliminate the Slow Laborious Manual Breaking of Pile Heads (Fig.4)

Once concrete piles are installed to the required depths and the top portion has to be cut-off up to the required level below ground level to enable pile embedment into the pile cap. The method employed in our country is manual labour with hammer and chisel or jackhammers. With projects size and corresponding pile numbers increased significantly in recent years the above methods were found to be time-consuming. Hydraulic pile breakers hung from and powered by excavators to crush concrete of square and round piles were introduced at RIL Kakinada and IOCL Panipat project sites. Where the reinforcement is not very congested these hydraulic breakers are found to be very effective in cutting down on labour as well as time.

### Hydraulic Rotary Piling to Install Bored Piles through Tough Fill Materials such as Slag

Several of our steel industries have been dumping the blast furnace slag and other industrial by-products in open areas around the existing plants for several decades resulting in large areas of fill with thicknesses ranging from a few meters to as high as 20 meters. With the current large-scale expansion of the steel industry, fresh units are being set up in these filled up areas. Because of heavy loads and sensitivity to differential settlements the plant structures and equipment are generally supported on boredcast-in-situ piles. Conventional tripod-winch-chisel/bailer type of boring has been in use for several years. Hydraulic rotary piling rigs have been introduced after careful trials and are found to increase productivity significantly. Currently, in a project at SAIL, Burnpur, India more than 35000 bored piles of 550 mm diameters and around 20 m lengths are being installed with both rotary piling rigs and conventional tripod rigs. While the boring progress with tripods is around 10 m/day of 2 shifts through the slag rotary piling rigs are able to drill around 60m/per day of 2 shifts which is equivalent to 3 piles/day/rig. Temporary casings are being used to stabilize the walls of the pile bore.

### Embedded Load Cells in Land Piling Jobs for pile Load Tests

For piles with large load carrying capacity, it is very risky and cumbersome to carry out static load test using the conventional Kentledge or pile/anchor reaction systems. Osterberg Cells ("O-Cells") are becoming very popular throughout the world for their simplicity and reliability. One such test is being introduced at one of the prestigious projects in the national capital. In this system, a load cell is placed at a predetermined location within the pile and strain gauges are fixed at several locations along the length of the pile. Using a hydraulic pressure system, the load cell is energized by taking reaction from both segments of piles. Load settlement data of both segments of the pile are monitored besides load distribution along the length of the pile. Such tests should be made popular as they would give reliable information and at the same time are faster, easier and safer to conduct compared to conventional pile load tests.



Fig. 3: Integrated Multipurpose Piling Rig with Hydraulic Hammer for Driven cast in situ Piles



Fig. 4: Hydraulic Pile Head Breaker

## Way ahead for Indian Deep Foundation Industry

### Special Polymer to Stabilize Walls of Pile Bore in Slag

Temporary or permanent steel liners are being used to stabilize the walls of the slag fill in the steel industry. This method slows down the boring rate. Through several trials by a team from L&T and the manufacturer of the special polymers from USA a polymer mix was developed and is being used successfully at TISCO Jamshedpur site resulting in improved piling productivity from 10 m/day (2 shifts) with conventional tripod rigs to 75 m/day for 550 mm diameter piles and from 3 m/day to 75 m/day for 1000 mm diameter piles.

### Vibro-Compaction for Structures on Slag Fill

Various man-made obstructions, slag skulls, etc. were being encountered in a slag fill making pile boring very difficult and time-consuming, at one of the steel plant sites. Vibro compaction trials were carried out in the heterogeneous slag fill. From various field density tests, laboratory shear box tests and field footing load tests (1.3 m x 1.3 m size) it is observed that slag fill can be well compacted by Vibro compaction technique resulting in high allowable bearing pressures. These trials if accepted by client and consultant would pave the way to minimize or altogether eliminate the necessity to support structures on piles.

### Slide Grip Vibro-cum-Impact Hammer System to Accelerate Sheet Pile Installation and Excavation (Fig. 5)

Sheet piling is not very common in India and this is posing major problems in both availabilities of the right type of sheet piles as well as sheet pile driving equipment. Drop hammer, impact hammers, and modern hydraulic or electrical type vibro hammers are being employed. Because of the above-mentioned reasons, the sequence of sheet piling and excavation also suffers some setback leading to difficulties in driving to required depths and at times leads to the collapse of the walls of the excavation. Wider application of sheet piling by making available the sheet pile materials and installation equipment would benefit the construction industry immensely. Side grip vibro hammer together with reversible type impact hammer was imported from Finland. The equipment mounted on an excavator is found to improve handling ease and installation speed. At L&T's Dhamra Port project Arselor AU20 sheet piles of 12 m lengths were installed for the wagon tippler location at a rate of 100 sq. m/day of one 12-hour shift.

### Trench Cutter to Install Dam Cut-off Walls (Fig. 6)

Dam cut-off walls are being installed in India with the help of Reverse Circulation Rigs of old designs. National Hydroelectric Power Corporation (NHPC) changed this trend by making it mandatory to employ the state-of-the-art Hydromill/Trench Cutter equipment. This equipment brings speed and quality to the cut-off wall construction. At NHPC Parbati Hydro-Electric project site a 45-meter-deep dam cut-off wall in plastic concrete was constructed 5 months ahead of schedule using Trench Cutter technology.

### Automation for Data Logging and Pile Installation Monitoring Systems

Data logging and pile installation monitoring system was introduced on Multipurpose Integrated drove piling rigs to eliminate manual recording and reporting and to improve the installation process of driven cast-in-situ piles. Manual data recording errors are eliminated, and it is also possible to send the data from the piling rig to any desired place through the internet.



Fig. 5: Side Grip Vibro-cum-Impact Hammer System for Sheet Piling



Fig. 6: Trench Cutter at a Dam Cut-off Wall Site

## CFA Trials in India



**Mr. G V Prasad**

Director Operations - DFI of India

### Interesting journey in CFA test pile trial project implementation

Reviewing construction practices in the execution of geotechnical scope of major infrastructure projects in the US, Europe, and other countries, it will be understood that there is substantial scope in India for deploying such technologies to see a gain in terms of cost/time/quality/safety. What is to be done to achieve this objective, what steps are involved in this regard? To answer these questions, we have chosen to narrate our experience while taking lead in introducing CFA pile technology to India.

We are thankful to Mr. Arvind Shrivastava, Chief Engineer, (Civil), Nuclear Power Corporation of India Limited and their team who have given us two-hour time during March'18 to give a presentation about DFI future plans and also about the progress of CFA test pile project being implemented by DFI. We are overwhelmed to see their positive response to DFI initiatives and for their commitment to support DFI on such initiatives. During our interaction with other representatives from EIL, Bauer, L&T, Soilmec, Keller and other organizations as a part of DFI fraternity, we hear from them recalling their experience with CFA piles in their foreign projects by leaving behind a question that, why this could not be implemented in India yet. CFA technology is in vogue in Europe and US for more than 2 to 3 decades and it is yet to find space in India. July'17 issue of DFI quarterly newsletter gave coverage about this technology and readers can refer to this to understand more clearly. <http://dfi.org/update/DFI%20India%20News%20July%202017.pdf>

A CFA pile is a non-displacement pile drilled using a full length stemmed auger and backfilled with concrete or grout. Methodology for installing this involves 3 simple steps:

1. The pile is constructed by advancing the auger through the soil to the pile termination depth.
2. Concrete or grout is then pumped through the auger shaft as the auger is being withdrawn.
3. Steel reinforcement is typically installed immediately after concreting/grouting to complete the pile.

### CFA Piling Equipment and Accessories

A CFA pile is installed using a conventional hydraulic rotary piling rig modified with CFA kit or with flying mast suspended from a crane. Available conventional rigs in India can be converted for immediate implementation of CFA technology. CFA kits and other accessories can be readily obtained from foundation equipment suppliers.

### CFA Pile Installation Productivity

We are producing below information shared by HJ Foundation and based in Miami, Florida, USA. It highlights the best productivity achieved by them in CFA pile installation in one of their projects. HJ Foundation recently installed 36-inches (914 mm) diameter CFA/Auger piles covering a depth of 170 ft (51.8 m) with a Value Engineer solution up to a World Record CFA Pile to 182.3ft (55.5 m). Full-length cage reinforcement is used for CFA pile execution. This is done for 3rd phase building developed by Estates at Acqualina along the Sunny Isles Beach.

The overall project scope includes 2 number 50 story buildings, 2 level basement garages (below the ocean level), podium, villas, and amenities. The test piles use 2 Osterberg cells (O-cells) located at different depths for test piles. Strain gauges were used throughout the pile length to analyze friction capacities at different depths. Production piles will sustain design loads up to 1290 tons in compression and 600 tons in tension. The basement will have a soil mix plug (seal) on the walls and perimeter minimizing water intrusion during the construction phase. Secant soil mixes walls and overlapping soil mix plug and excavation is provided by a JV between HJ Foundation and Hayward Baker.

### Proactive Action – Need of the hour

When CFA pile is found to be simpler, less cumbersome. What are the reasons prevailed in using this technology over last many years? What is to be done now to make this a reality so that all stakeholders of Indian deep foundation industry will get benefitted?

Understanding that no codes/manuals are available in India, understanding that extra care to be taken while concreting the pile and in the placement of reinforcement cage before concrete get set,





## CFA Trials

DFII chose to demonstrate this by executing 6 nos. test piles and subjecting them to load tests. In accordance with such decision, DFII sent the proposal to DFI US with a request to provide possible grants for execution of test piles during Dec 2016. DFI responded positively to such request and sanctioned a grant of 30000 USD from their DFI 2017 committee project fund during April 2017 with the understanding that the balance portion of 50000 USD would be met by DFII by taking help from local industry through in-kind or cash contribution.

Upon receiving such approval,

1. DFII formed CFA pile committee comprising eminent engineers working in senior management of well-established organizations in the Indian deep foundation industry.
2. The committee was requested to prepare draft pile design and construction document, including method statements covering pile installation, testing procedures and concrete mix design document.
3. This team approached Nuclear Power Corporation of India (NPCIL) with a request to provide land in their greenfield project for execution of the test pile project and this was committed by them during Aug 2017
4. The pilot program comprises installation and testing of 6 test piles in suitable soil conditions of NPCIL greenfield project at Gorakpur in Haryana, 230 Kms from Delhi. The 600 mm diameter piles will be installed to depths of around 18 m each and tested.
5. The site has been made accessible during Nov 2017 and DFII team visited the site to organize soil investigation in the given location.
6. Soil investigation report was completed by the first week of Dec 2017.

DFI US team provided guidelines, manuals, design documents of CFA pile as practiced in the US.

Taking the reference of the same, draft documents covering test pile design, pile testing methodology has been developed by DFII team.

7. As the busy executives of DFII and DFI have to find the time of their tight schedules, it took around 8-month time to develop the documents, to have three rounds of review and to firm up the document.

### The benefits are

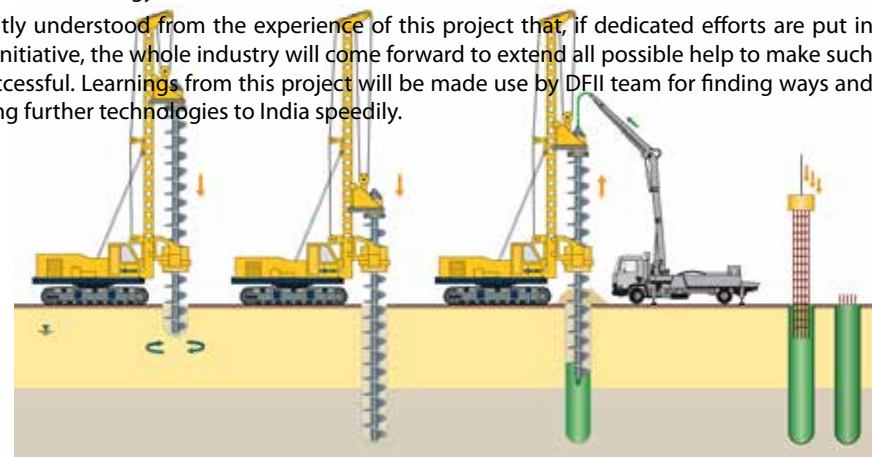
- Simple CFA pile installation process
- Less equipment and resources required
- No support fluid required to stabilize excavated hole
- Possible cost savings
- Easier maintenance and cleaner work site
- Possible reduction in time schedules

### Way Ahead

It is to be further noted that:

1. Based on current developments, it is expected that test pile installation would happen during Dec'17/Jan'18.
2. DFI team provided unstinted support to the project in coordinating to get help from Bauer/Soilmec Europe teams for organizing deployment of piling rig, CFA kit, accessories, and their expert team for supervision of the job during installation. This is to ensure that the execution of the whole project happens smoothly.
3. It is heartening to note that ITDCem who is presently executing the job for NPCIL at Haryana has come forward to provide required resources, other equipment, local support for pile installation and testing. Responsibility will remain with DFII for providing concrete, reinforcement and also for overall coordination with DFI, Bauer/Soilmec, NPCIL, and others.
4. DFII team plans to develop the detailed design, installation, and testing document by the time execution gets completed so that the test pile results can be appended to this immediately after completion of the works.
5. This will be showcased in various forums so that these documents will serve as a reference for execution of CFA piles for various clients.
6. Efforts will be made for the inclusion of this document in Indian Bureau of Standards and to have IS code for this technology.

It is abundantly understood from the experience of this project that, if dedicated efforts are put in CFA pile like initiative, the whole industry will come forward to extend all possible help to make such initiatives successful. Learnings from this project will be made use by DFII team for finding ways and means to bring further technologies to India speedily.



CFA Piling procedure sequence

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