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DFI of INDIA *News*

- 2 DFI of India Executive Committee
- 3 The Cover Story - Issues of Current Geotechnical Practices in India - Prof. V S Raju
- 6 DFI of India Chairman Message - Dr. K S Ramakrishna
- 9 DFII'19 Annual International Conference - Recap
- 11 Technical Report on Load Testing of CFA Piles at Gorakhpur - Dr. Sunil S. Basarkar
- 16 Geotechnical Site Characterization for Foundations - Dr. Sastry Putcha & Mr. Kumar Allady, Smart Structures
- 19 AFCONS Advertisement
- 20 What can DFI do for you?

Quarterly e-Newsletter from
Deep Foundations Institute of India
www.dfi-india.org

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Issues of Current Geotechnical Engineering Practices in India

Based on my experience of over 45 years as a foundation consultant (in addition to my academic responsibilities at IIT Madras and IIT Delhi), I would like to share my views about improvements needed in most of the current practices in the area of Geotechnical and Foundation Engineering in India. There is much scope for improvement with regard to Geotechnical Investigations which forms the basis for the design of foundations, earth retaining structures, underground metro stations, etc.

The following table gives a comparison between the best practices (mostly followed by the developed world) and the current situation in India.

Table: Geotechnical Engineering Practice

S. No	Best Practices (Mostly followed by the developed world)	Current Practices in India
	After Site Selection	
1	Contour Survey	Sometimes available
2	Geology of site by expert	By the Geotechnical Agency as part of the Geotechnical Investigation
3	Preliminary Geotechnical Investigation by an accredited Agency	Rarely Done
4	Project layout with the location of important structures made available to Geotechnical consultant	Generally not made available to Investigation Agency



Prof. V. S. Raju
*-Former Director IIT Delhi,
 Former Dean IIT Madras,
 Founder - VSR Consultants*

Table Contd.

As engineers, we are going to be in a position to change the world - not just study it - *Henry Petroski*

Scope of Detailed Geotechnical Investigation		
5	Geotechnical Consultant in Consultation with a structural consultant and on the basis of structural details.	Not the common practice. Most often a bill of quantities and a standard set of laboratory tests are given to the agency by Architect/Structural Designer. Inappropriate also because the laboratory tests are a function of the type of soil strata.
6	Detailed Soil Investigation by an accredited and qualified investigation agency. Investigations report under independent supervision by a qualified person.	Lack of accreditation process. Most investigation agencies are not accredited, they do not have trained manpower. Mostly not supervised.
7	An investigation report by the agency giving the results of field and laboratory tests only. No Foundation Recommendations.	Report containing results of Field and Laboratory Tests, recommendations for Foundations, Safe Bearing Capacity and Pile Capacities without having full details of the structures .
8	Interpretation of the results by a Specialist Foundation Consultant and recommendation for the type of foundation and foundation parameters.	Very rarely the case. The investigation agency hardly has qualified and experienced Foundation Engineers.
9	Interaction between Foundation and Structural Consultant and finalization of Foundation Design.	Mostly Absent
10	Involvement of Foundation Consultant during execution, review of results of further tests, ex. Pile Load Tests (Initial & Routine) .	Very Rare
11	Settlement Observations and information to Foundation Consultant	Very Rare
12	Foundation Performance assessment and report by Foundation Consultant	Absent

Extract from Euro code 7, BS EN 1997-1:2004

The provisions of this standard (Euro code 7) are based on the assumptions given below:

1. Data required for design are collected, recorded and interpreted by appropriately qualified personnel;
2. Structures are designed by appropriately qualified and experienced personnel;

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3. Adequate continuity and communication exist between the personnel involved in data collection, design and construction;
4. Adequate supervision and quality control are provided in factories, in plants, and on-site;
5. Execution is carried out according to the relevant standards and specifications by personnel having the appropriate skill and experience;
6. Construction materials and products are used as specified in this standard or in the relevant material or product specifications;
7. The structure will be adequately maintained to ensure its safety and serviceability for the designed service life;
8. The structure will be used for the purpose defined for the design.

These assumptions need to be considered both by the designer and the client. To prevent uncertainty, compliance with them should be documented, e.g. in the geotechnical design report.


*Euro code 7 is the latest and best code of practice. It helps in evolving Optimum Designs – Safety and Economy.
Ensuring this standard will benefit India significantly.*

Way Forward

It is heartening to note that Deep Foundations Institute of India with its last 6 years standing in India chose to roll on many initiatives with collaborative support from experts in different geo foundation domains from India and abroad to achieve the mission of elevating Indian deep foundation industry to the best of global standards.

As a part of this, thanks for forming the DFII Committee for Geotechnical Investigation for Foundation to develop and implement skill training programs covering lab technicians & field supervisors' and promoting good work practices in Indian deep foundation industry. I sincerely wish that these programs over a period of time will prove beneficial to India in achieving the global best standards.


DFI TESTING AND EVALUATION COMMITTEE WEBINAR SERIES



11:00 a.m. - 12:30 p.m. EST | October 2, 2019 | December 4, 2019 | February 5, 2020

Presentations for February 5 include:

- Cost Benefits of Bi-directional Load Testing
Van Komurka, P.E., D.GE, F.ASCE | GRL Engineers
- Foundation Engineering Revisited to Reduce Bridge Construction Risk
Paul Axtell, P.E., D.GE | Dan Brown and Associates



www.dfi.org/ITSMoney2019

DFI of India Chairman Message

Dr. K. S. Rama Krishna



The past one and half years have been very exciting for all of us at DFI of India (DFII). Most of our initiatives have taken off well and are showing good progress. Our networking is widening. The responses and support of industry to DFII initiatives are on the rise. My personal thanks and hearty congratulations go to Team DFII. I am also thankful to our US-based parent body DFI, for its continuous encouragement and support.

We are now moving on... from the nascent period of annual conferences, quarterly seminars and workshops to the next stage. We have set up a fully staffed, full time office. We are working in line with our vision and mission statements of helping the deep foundation and geotechnical industry in India to meet international standards. Our wide spectrum of activities include identification and implementation of potential technologies; skills development for diverse levels of the work force; outreach programs for students as also women geo-tech professionals, and establishment as well as promotion of good work practices to enhance safety, quality and productivity.

I am pleased to trace briefly our recent initiatives and activities which by successful execution are enabling DFII carve a niche for itself in the geo-technical and foundation engineering industry, in the country.

We had identified Continuous Flight Augur (CFA) Piling – an applied scientific knowhow in keeping with the prevailing global trends - as a potential speedy productivity-enhancing technology to be implemented for deep foundation operations in India. Seeing is believing, they say. Hence we have undertaken the onerous task of practical demonstration. We are implementing the country's maiden CFA piling technology in four phases.

The first phase commenced with our “selling the idea” to Nuclear Power Corporation of India Limited (NPCIL) and obtaining permission to install two CFA pre-trial piles and six test piles within a designated area in NPCIL's GHAVP, Gorakhpur Village near Hisar in Haryana. Following successful soil investigation, we formed a technical committee which prepared the CFA test pile design and test manual as also drew the plan for its installation. After finalisation by experts from DFI, USA and Europe, Phase-I operation, largely funded by Indian and foreign industrial organisations, was completed in July 2019.

The second phase comprised of integrity and load tests on the test piles in October-November 2019.

The third phase was a workshop on CFA piles held on November 14, a day prior to the inauguration of the 9th DFII Conference at the National Academy of Construction (NAC), Hyderabad.

In the fourth phase, the technical committee will draft a user manual for the design, installation and testing of CFA piles. Simultaneously, our successful demonstration of the CFA piling operation at the NPCIL

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A dedicated page is allotted for a nominal fee of Rs10,000/- per issue for the profile of a reputed company involved in the deep foundation Industry to showcase its capability in the field. Please contact DFI of India at dfiindiaoffice@gmail.com.

This is more than an advertisement since it carries your mission statement.

site will be highlighted and meticulously disseminated among the various end-users of this innovative technology, through a series of workshops to be conducted in different parts of the country.

We are confident that in due course CFA pile technology would secure its prime place in the Indian deep foundation construction practice, which we believe is a win-win proposition for all stake holders. We have also identified more such foundation technologies for potential application in the Indian milieu. We would be promoting their implementation through user manuals, workshops and seminars.

Aware of the crying need to create a large pool of trained and certified geotechnical laboratory and field technicians and as a first step towards substantial improvement of the quality and standard of geotechnical investigation in our country, DFII has recently of signed a Memorandum of Understanding (MoU) with NAC, Hyderabad to jointly develop and implement skills training programs related to the geotechnical and foundation industries. Immediately thereafter, a technical committee was formed to draft the syllabus and course content for Laboratory Technician courses. NAC has since submitted the necessary documents to Construction Skills Development Council of India (CSDCI) with a request to include Soil Investigation-Laboratory Technician among the list of job roles with CSDCI and the National Skill Development Corporation (NSDC). The Hyderabad branch of NAC has undertaken the onus of establishing the necessary infrastructure and trainers to conduct training in its premises. Once we succeed in our efforts to set in motion the DFII-NAC collaboration, we will replicate the model across India. Thus DFII would enable creation of large pools of professionally trained and certified laboratory technicians,

countrywide. We will work simultaneously on field technicians' programs, as well.

Yet another creation on DFII's anvil is a suitable model for training and certification of operators and technicians of foundation equipment. In this regard, we are holding discussions with Infrastructure Equipment Skill Council (IESC) -- a non-profit organisation promoted by the Indian Construction Equipment Manufacturers Association (ICEMA), supported by Confederation of Indian Industry (CII) and funded by NSDC -- on how to spearhead the "skilling" of the workforce in the Infrastructure Equipment Sector with primary focus on training and certification of operators and mechanics. We are also seeking the views of owners of infrastructure projects, foundation equipment manufacturers and specialist foundation contractors. We hope to achieve a breakthrough soon in this important and complex initiative.

Metro rail projects are coming up in several cities of our country. Geotechnical/foundation works pertaining to metro rail projects are unique, complex, and often not only add to project costs but also cause time overruns. For example, Chennai Metro Rail Corporation Limited (CMRL) faced several cost-time overruns while executing Phase-1 of its metro rail project. Determined to avoid similar problems in its Phase-2 implementation, CMRL has signed a five-year MoU with DFII to help CMRL in geotechnical areas like soil consolidation and deep foundation. In this connection, an international experts' working group has been formed with the help of DFII, USA.

We have embarked on Student Outreach Programs with a view to spread awareness and create career interest among students in the

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field of geo-technical and foundation engineering through lectures, webinars, student paper competitions and student internship programs, including the representation and participation of students in DFII conferences and seminars.

The Women in Deep Foundations (WiDF) initiative aimed at projecting women geotechnical professionals was launched at the DFII-2018 Conference at IIT, Gandhinagar. A follow-up to this was the panel discussion on WiDF, which was one of the highlights at the DFII-2019 Conference at NAC, Hyderabad in November. We invite the more active women Geotech professionals of India to be part of this initiative. We also invite articles from them for publication in DFII's quarterly newsletters.

On behalf of Team DFII I record our grateful thanks to all geotechnical and deep foundations industry professionals in India and abroad as well as Industry stakeholders and government/statutory institutions for their wholehearted support and financial as well as in-kind assistance to our CFA Pile technology and various other initiatives. I am sure such encouragement and support will provide us the fillip to forge ahead in making DFII an institution of great merit and service, and realising in the process our mission of helping the deep foundation and geotechnical industry in India attain parity with international standards.



DFI-PFSF Piling & Ground Improvement Conference

March 23, 2020 - March 25, 2020
International Convention Centre Sydney
Sydney, Australia

This second joint conference of the Piling and Foundation Specialists Federation (PFSF) and Deep Foundations Institute (DFI) will promote all aspects of deep foundations, retention and ground improvement works. Presentations at the historic International Convention Centre Sydney (ICC) will focus on design, construction and performance (or lack of) for building and infrastructure works.

Contact Information:

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DFII'19 Annual International Conference - Recap

DFI India 9th Annual International Conference was conducted successfully at NAC, Hyderabad on 15th and 16th November 2019, which was preceded by Pre-Conference workshop on 14th November 2019 titled *"Design, construction, and applications of CFA Piles in India"*

CFA workshop was coordinated by Dr. Sunil S Basarkar, who is also the coordinator of DFII's first technology initiative the prestigious 'DFII CFA Trial Pile Project'. The workshop witnessed in-depth deliberations by Indian and international experts about technical, commercial, and statutory aspects of CFA Piles in the Indian context; and ways in which this technology can help in the advancement of the Indian construction industry. At the end of the workshop, a panel discussion with audience interaction was organized and it saw some of the most enlightening discussions as representatives from owner, contractors and other stakeholders of the sector came together to discuss the way forward for CFA Technology in India and their responsibilities in making things happen for the greater good of industry.

Prof. V. S. Raju has been facilitated with the *"DFII Lifetime Achievement Award"* for the year 2019 for his remarkable contribution to the Indian Geotechnical construction industry.

Apart from regular and interesting programs, the conference also had an eye-opener Panel discussion on *'Women in Deep Foundation (WiDF) Program'* where practicing women professionals across the industry, came forward and shared their experiences and ways to encourage more women to join the industry and how the industry can support this cause.

One more panel discussion titled *'Way forward for Enhancing Standard of Indian Geo Foundation Industry matching with the Global Best'* highlighted the phenomenal scope available for implementing new technologies, good work practices, student programs, and skill training programs in the Indian context. DFII initiated several programs in this direction and progress achieved on various fronts has been showcased as a part of this program. Panelists represented divergent interests of industry, i.e., Owners (Mr. Srinivas, CGM, CMRL), Contractors (Mr. Hari Krishna, MD, Keller India), Consultants (Dr. K S Rama Krishna), Equipment Manufacturers (Mr. Manfred Schoepf From Bauer Germany, Mr. Mohan Ramanathan, MD, ACT),



Inauguration of the Conference



Panel Discussion - CFA Technology Workshop



Contd. Lifetime Achievement Award to Prof. V S Raju

Technical photo feature of relevance are invited from the readers. The feature shall preferably illustrate a modern technology or testing procedure. Please prepare the feature with six to eight good quality pictures with brief and crisp description.

Skill Training Institutes (Mr. K Bikshapati, DG, NAC) and Academic Institutions (Prof. Amit Prashant from IIT Gandhinagar) who are members of respective DFII committees shared their thoughts relevant to the subject and this has been well received by all delegates.

DFII set up 5 committees to drive important initiatives that will benefit the Indian Geo-Foundations industry in the long run, comprising experts from 50 plus Global/

Indian organizations who have been volunteering their services. Utilizing the presence of a good number of these professionals during the conference, side-line meetings were conducted for respective committees to review the progress of activities and to agree on the way forward. DFII Executive Committee Meeting was also conducted on 14th Nov'19.

Covering 7 parameters, feedback has been sought from 200 plus delegates to understand whether the conference served its intended purpose. 70 plus delegates for shared their views and 80% to 90% rating was given by them confirming their satisfaction regarding key speakers and other presenters, quality of presentation, topics chosen relevant to the Indian context, DFII efforts to implement new technologies and skill programs, conference food and other arrangements.

DFII is thankful to 10 sponsors and 23 other exhibitors for showcasing their products/services. We are grateful to 8 key speakers representing organizations Magnum Piering (US), Keller ASEAN (Singapore), AECOM (India), Langan Engineering and Environmental Services (US), V S Raju Consultants (India), Duke Energy (US), Betterground (Hong Kong), Smart Structures (US), and to other speakers for their interesting presentation on divergent topics. We are happy that the presence of Ms. Theresa Engler, Executive Director, DFI US, Ms. Lucky Nagarajan from DFI US galvanized this event. We are also thankful to Dr. K S Ramakrishna, Chair, DFII, Mr. I V Anirudhan, Vice-Chair, DFII, Ms. Mary Ellen, Technical Director, DFII and conference technical and organizing committee members for their continuing basis support and guidance at every stage of the conference.

Lastly, we are thankful to Chief Guest Shri Shailendra Kumar Joshi (Chief Secretary, Govt. of Telangana) for his participation in the inaugural session, Shri. K. Bikshapati (DG NAC), staff and volunteers from NAC, Hyderabad for their enthusiasm and active involvement which added so much value and contributed to the success of this event.



Panel Discussion - Way forward for Enhancing Indian Geo Foundations Industry standard matching with the Global Best

Many publications of DFI are available from OneMine.org , a web-based document library containing over 1,30,000 articles, technical papers and books from organizations all over the world. DFI Members can access OneMine at no additional cost, while non-members can purchase and download documents for \$25 per download.

Technical Report on Load Testing of CFA Piles at Gorakhpur – A DFI of India Technology Initiative

- Dr. Sunil S. Basarkar



Dr. Sunil S. Basarkar
GM (Geotechnical and Design) - AFCONS
Coordinator - DFI CFA Pile Technology Initiative

Introduction and Background of CFA Trial Piles Installation

Installation of CFA trial piles at Gorakhpur had been an ambitious technology initiative by DFI of India, aimed to introduce and popularize the use of such piles, and to address the growing fast track piling needs of India. These piles were installed from 27th to 30th May 2019 and comprised two pre-trial piles and six trial piles of 600mm diameter with 11m depth. Two pre-trial piles were planned for verifying the piling rig kit assemblage condition prior to the execution and the remaining six trial piles used for the load test validation and demonstration purpose. The site for trials was located at Gorakhpur village, Hisar District, Haryana, about 210kms Northwest of Delhi.

Soilmec SR40® rig fitted with continuous flight auger (Fig. 1) with an attached drill bit, sleeve, rotary head, cathead, auger guide and sensors for recording all desired technical data. This rig was fitted with Jean Lutz S software, and it was possible to record the piling profile throughout the depth, the volume of concrete consumed, auger lifting rate, drill rate, concrete pressure, and auger rotation speed. Other deployed equipment were Schwing Stetter® Concrete pump, Hydraulic crane, and Excavator.

M35 grade concrete produced at site batching plant giving a slump spread of excess of 800mm was used. A rigid reinforcement cage with 9-20mm dia tor bars and 10mm dia helical @ 150mm c/c ensured adequate rigidity for pushing in wet concrete.

General Sub-surface Features of Site

Geotechnical investigation comprising three exploratory boreholes was conducted within the trial site during November 2017. Generalized subsoil profile in the trial location, with water table about 3.0m below ground, is described in Table 1 on next page. Average ground elevation of the site was 214.80m, with water table observed at 3.0m below ground in the boreholes.

Pile Load Test Proposals

Static load tests were performed on CFA piles during the month of November 2019, and the Table 2 on next page summarizes the load test activities.

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Fig. 1: CFA piling at site



Table 1: Generalized Sub-soil Profile

Depth	Soil description	SPT N_{field}	Avg. field N
GL to 3.5 m	Fine sandy silt with traces of clay SM-ML	5 to 6	6
3.5 m to 6.0 m	Fine sandy silt with traces of clay SM-ML	15 to 23	20
6.0 m to 7.5 m	Fine sandy silt SM-ML	9 to 16	12
7.5 m to 13.5 m	Fine sandy silt with silty sand patches SM-ML	13 to 32	23
13.5 m to 15.0 m	Silty sand / Fine sandy silt SM-ML	37 to 50	42
15.0 m to 19.0 m	Fine sandy silt with silty fine sand SM-ML	44 to 85	64
19.0 m to 24.0 m	Fine sandy silt with fine sand patches SM-ML	62 to 91	80
24.0 m to 30.0 m	Fine sandy silt / silty fine sand with clay SM-ML	>100	120

Table 2: Summary of Piles and Load Tests

Sl. No.	Pile No.	Date of Installation	Load Test Type	Max. Test Load (MT)	Date of Load Test	Remarks
1	PTP-1	27 May 2019	-	-	-	Pre-trial piles. No load test performed
2	PTP-2	28 May 2019	-	-	-	Pre-trial piles. No load test performed
3	P1	29 May 2019	Pull-out	70.0	12-14 Nov 2019	Kentledge method
4	P2	29 May 2019	Vertical Compression	170.0	21-22 Nov 2019	
5	P3	29 May 2019	Vertical Compression	170.0	06-08 Nov 2019	Kentledge method
6	P4	30 May 2019	Lateral	12.0	14-15 Nov 2019	Reaction through concrete blocks
7	P5	30 May 2019	Pull-out	70.0	16-18 Nov 2019	Reaction through concrete blocks
8	P6	30 May 2019	Lateral	12.0	13-14 Nov 2019	

All static load tests were performed as per IS: 2911 (Part 4)-2013, with maintained load application on an incremental basis. These load tests were intended to assess their ultimate loads and confirm safe working loads. Each of these load tests were performed up to the computed ultimate pile load.

Piles P2 and P3 were instrumented with Embedded Data Collectors (EDC) and Thermal Integrity Profiling (TIP) sensors, to understand load transfer characteristics and the temperature-time variations of the CFA pile. EDC comprised sturdy strain gages and temperature sensors (Fig. 2) installed at three levels (1.22, 5.79 and 10.36m below ground), which were arrived based on the sub-surface profile. Gages were connected to cables and extended to ground to the outlet transmitted box. Thermal Integrity Profiling (TIP) was meant to evaluate temperature variation along entire cross-section & along pile length and to measure heat generated during concrete curing in addition to assess the quality of CFA piles. TIP sensors (Fig. 3) installed at 300mm intervals in piles P2 and P3.

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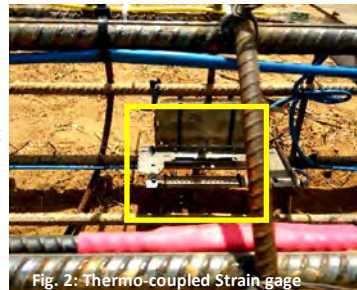


Fig. 2: Thermo-coupled Strain gage

General arrangements for Vertical compression, Pull-out, and Lateral load test are captured in Figs. 4 to 6. These arrangements catered to the code requirements and ensured at least 25% excess reaction capacity for all categories of loading. In all these tests, pile head was prepared about a week prior to the conduct of the load test.

The reaction during **Vertical compression load test** was obtained from kentledge load comprising 1m^3 concrete blocks placed on a platform supported by a set of primary and secondary girders (Fig. 4). Load was applied through a 300MT hydraulic jack placed co-axially above the bearing plate. Displacement was recorded through four LVDTs placed near each corner of the bearing plate.

During **Lateral load test**, the load was applied through a 150MT hydraulic jack butting against test pile through a bearing plate. Looking at a high capacity jack, a pressure gauge of least count was deployed to measure minimum load increment. Reaction system comprised frictional resistance from concrete blocks resting on the ground (Fig. 5). Lateral pile displacement was measured by two LVDTs attached to the pile along the load axis, opposite to the jack and mounted on an independent datum bar.

During the **Pull-out load test**, load was applied by hydraulic jack centrally placed on the main girder supported on a concrete pedestal. 8 nos. of 36 dia bolts of Fe500 grade steel were used to pull the pile, through a square plate welded to 450mm dia. casing, which in turn was welded to main pile rebars. Reaction load due to uplift was transferred to subgrade (with minimum 15T/m^2 SBC ensured) through a system of girders and concrete blocks (Fig. 6). Pile head displacement was recorded with four LVDTs placed equidistant at pile top.



Fig. 4: Kentledge arrangement for Vertical Load Test



Fig. 5: Arrangement for Lateral Load Test



Fig. 3: TIP cable & Sensors attached to pile rebar



Fig. 6: Pull-out Load Test Set-up

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Load Displacement Characteristics CFA Piles

Figs. 7 to 9 presents comparative load-displacement curves on two piles under Vertical compression, Lateral and Pull-out loads. These curves indicate remarkable nearness and consistency in load-displacement behaviour.

Both the piles for **vertical load tests**, P2 and P3 were subjected to a maximum test load of 179.87MT. Planned test load for these piles was 170MT giving an approximate Safe load of 68MT. Pile P2 indicated maximum displacement of 12.722mm, with a net displacement of 8.88mm (rebound of 3.842mm); the corresponding displacements for pile P3 were 12.533mm and 9.953mm (elastic rebound of 2.60mm) (Fig. 7). Since the ultimate load was not reached during testing, Chin (1970) method was used for its determination.

Load assessment for piles P2 and P3 are summarized in Table 3 below.

Piles for **lateral load tests**, P4 and P6 were subjected to a maximum test load of 12.873MT, giving an approximate Safe load of 4.80MT. Pile P4 indicated maximum displacement of 2.065mm; the corresponding displacement for pile P6 was 2.42mm. As apparent from Fig. 8, displacement of 5mm was not reached, indicating that these piles possessed higher ultimate lateral capacity than the computed value of 12.0MT.

Pile P1 indicated maximum displacement of 1.623mm, with a net displacement of 0.70mm (rebound of 0.923mm); the corresponding displacements for pile P5 were 1.45mm and 0.798mm (elastic rebound of 0.652mm) (Fig. 9).

Assessment parameters	Pile No.	
	P2	P3
Load at 12mm displacement (MT)	179.87	178.00
Safe load s 2/3 of Load at 12mm (MT)	119.91	118.67
Load from Chin's method for 60mm displacement (MT)	234.65	212.54
Safe load 50% of load @ 60mm displacement (MT)	117.325	106.27
Ultimate load from Chin's method (MT)	250.00	222.22
Safe pile load with F-2.5 (MT)	100.00	88.89
Adopted safe Load (MT)	100.00	88.89

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Table 3: Assessment of Key Loads during Vertical Compression Test

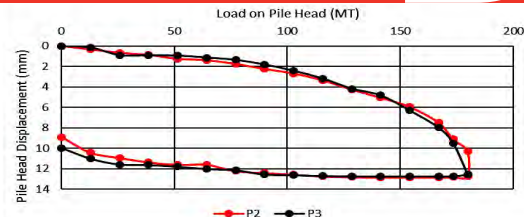


Fig. 7: Curves for Vertical Compression Load Tests

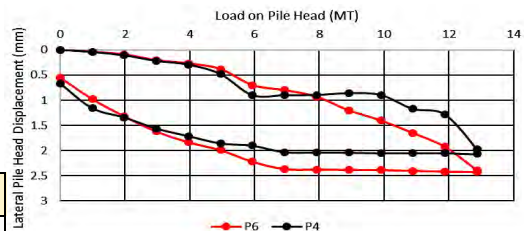


Fig. 8: Curves for Lateral Load Tests

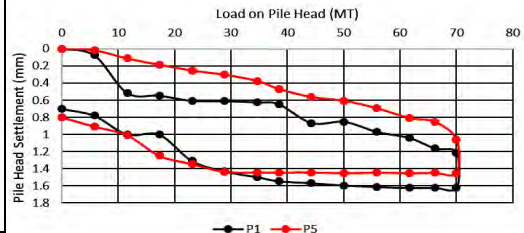


Fig. 9: Curves for Pull-out Load Tests

The executive committee members of DFI of India represent all the stakeholders in the foundation research, design and construction. The members will express their views about the role of DFI and other similar organizations in the development and transfer of modern technology for infrastructure development of India

Load displacement for Pull-out load test on piles P1 and P5 indicated that even at a maximum test load of 70MT, 12mm displacement was not reached. Attempt to determine the ultimate load by Chin (1970) method did not yield a clear trend line. Hence, it was concluded that the piles had more inherent capacity than the computed ultimate load of 70MT.

Closure & Way Ahead

From the foregoing load test results, similar load-displacement behavior under vertical compression, pull-out and lateral loads are evident. This fact is significant and is an indication of consistent quality and workmanship under CFA piling, which is in stark contrast to bored cast-in-situ piles. This apart, CFA piling also demonstrated their advantage of speed over its counterpart, namely bored cast-in-situ piles.

All three versions of tests indicated ultimate loads much higher than the computed loads indicating that higher values of design parameters may be permitted with confidence – although this fact needs further augmentation through a database of more load test results.

With successful CFA piling demonstrations and consistent pile capacities evidenced through limited number of load tests, it is apparent that these piles are well suited to Indian conditions and can be practiced confidently.

With the success of this CFA technology initiative, DFI of India intends to actively pursue to disseminate these findings, bring these piles under purview of the Indian code of practice and popularize their use with all the stakeholders, so that such piles find gainful acceptance in Indian contracts.

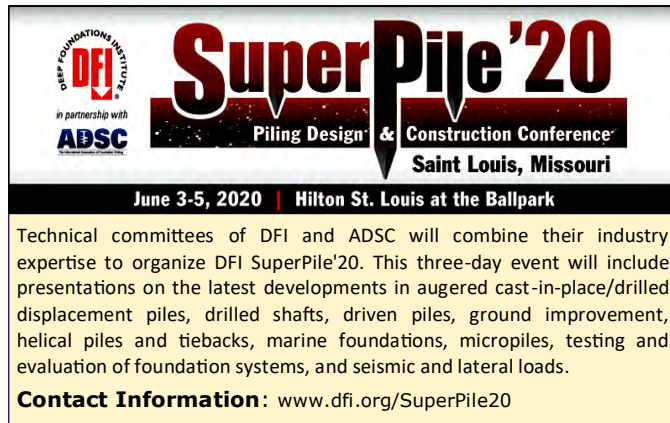
Acknowledgments

Above successful CFA technology demonstration is an outcome of collective efforts of all stakeholders since 2017, and the author on behalf of DFI of India expresses his immense appreciation to partners and sponsors to this initiative.

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SuperPile'20
Piling Design & Construction Conference
Saint Louis, Missouri

June 3-5, 2020 | Hilton St. Louis at the Ballpark

Technical committees of DFI and ADSC will combine their industry expertise to organize DFI SuperPile'20. This three-day event will include presentations on the latest developments in augered cast-in-place/drilled displacement piles, drilled shafts, driven piles, ground improvement, helical piles and tiebacks, marine foundations, micropiles, testing and evaluation of foundation systems, and seismic and lateral loads.

Contact Information: www.dfi.org/SuperPile20

Geotechnical Site Characterization for Foundations

- Mr. Sastry Putcha, VP, Smart Structures
- Mr. Kumar Allady, CEO, Smart Infrastructures Group

Introduction

As one of the DFI-India Support Committee members, I participated in the monthly agenda-filled conference calls. I have noticed that the small management group of DFI-India, were full of ideas and planned and implemented them at a rapid pace. They listened to the support committee's suggestions and recommendations. In this action-filled, friendly and cooperative atmosphere, DFI management readily reciprocated and offered and provided guidance and encouragement to DFI-India. It didn't take long for DFI-India to evolve into DFII. With positive actions falling in-place rapidly, this process became the new normal. DFII formulated several technical committees and established a Newsletter to help keep all stakeholders informed about their different committee activities.

Geotechnical Site Characterization

One of the early committees that became quickly active, is the DFII Committee for Geotechnical Characterization for Foundations. DFII enunciated that the formation of the committee is rooted in meeting needs of:

- 1) Providing increasing awareness of the importance of complete and competent site investigation for the design and construction of foundations and underground structures.
- 2) Developing and implementing skill programs covering manpower involved in geotechnical investigation.

DFII Newsletter

I was impressed that the DFII team has dedicated Jan-Mar'20 quarterly newsletter by covering these committee activities and interesting articles on Geotechnical Site Characterization. Thankful to DFII for their invitation, I felt happy to contribute an article for this newsletter. The Goal of DFII is to develop criteria and recommendations for Geotechnical Site Characterization for Foundations. To reach this goal, a series of building-block courses are in the works starting with a Soil Investigation Laboratory Technician training course. Actionable items have been assigned to various committee members and understand that the course development is progressing well. There is no better choice than the development of Geotechnical Site Characterization of Foundations as the DFII first comprehensive training program.

Soil Exploration—From Present to Future—Role of Advanced Technologies

As is well known, current geotechnical engineering practice is to conduct pre-design subsurface exploration programs sometimes even before the exact pile/pier locations are determined. This process leads to some uncertainties in estimating project pile capacities and pile depths. The uncertainties occur due to several factors such as designers' dependence on the data from soil borings, field and lab testing data at locations away from those of

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the design pile locations, the experience of drillers, technicians and engineers and assumptions involved in the data analysis.

FHWA Recommendation to reduce uncertainties through Advanced Geotechnical Methods in Exploration

In the above context, the FHWA—Center for Accelerating Innovation website, discusses Advanced Geotechnical Methods in Exploration (A-GaME) to “mitigate risks and improve reliability by optimizing geo-technical site characterization with proven, effective exploration methods and practices”. After enumerating the drawbacks of the present processes, FHWA discusses the benefits of optimizing geotechnical site characterization to include mitigation of risks, development of a reliable geotechnical basis for design as well as construction and accelerated project delivery approaches. But FHWA’s recommendations for advanced technologies are still limited to present-day methods of exploration such as cone penetration testing, seismic and electrical geophysical testing and borehole televiewer logging methods, etc. These methods have evolved from earlier technologies that still have not yet reached the advanced level of minimizing uncertainties. The authors suggest a more current and rapidly evolving approach — the use of rapidly advancing sensor technology — to arrive at the mitigation of uncertainties articulated by FHWA. Sensors, embedded in deep foundations prior to installation, can provide data to accept the foundation installation in real-time in the field. The deep foundation installation which can be supplemented

with the geotechnical exploration data for safe, more economical and accelerated project construction.

This method consists of installing and driving monitoring of driven concrete piles embedded with internal sensors located at appropriate locations within the pile. This process minimizes uncertainties associated with the presence of nonhomogeneous materials in ground horizontal and vertical directions adjacent to the pile. These spatial variabilities previously contributed to some uncertainties in pile capacity determinations during the driving installation monitoring using older techniques. Embedded Sensor technology enables 100% pile testing which provides immediate and accurate determinations of pile capacities in the field at the time of installation. LRFD Resistance Factor of 0.75 is currently assigned for 100% testing by AASHTO.

Efforts are underway to increase these resistance factors given the accuracy of the evolving embedded Sensor Technology. Since the Sensors are embedded in the piles in the casting yard, by the time the piles are brought to the construction site, they are ready to be stood-up at their design location and driven to or above accurately measured design capacities. Embedded sensor technology therein decreases construction delay times associated with older technology instrumentation installations and subsequent office pile capacity assessments thereby increasing field installation productivity and cost-effectiveness. In one recent FL-USA project, 24-inch size, 26 piles were driven in one day. Early case histories analyses indicate significant cost savings are achieved due to the real-time sensor measured data of driving stresses, determination of independent

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pile skin, tip and total combined capacities as well as monitoring of the maintenance of internal pile integrity for every pile in real-time. Other recent case histories of 100% Concrete pile testing indicate there are several other benefits of embedded sensor installations, such as the shortening of Critical Path construction schedules which also contribute to overall significant project cost savings.

Statistical data analysis that shows 100% testing of piles yield cost-effective testing:

In their June 29, 2011 paper “Testing and Remediation Observational Method for the Design and Construction of Non-Redundant Pile Foundations, John H. Sherman and Carl P. Schmertmann” demonstrated that reducing uncertainties in pile design and construction has the potential to greatly reduce foundation installation and time costs for driven piles and drilled pile foundation based on the statistics-guided Testing and Remediation process”. The examples cited in their paper “predict large percentage savings when the percent of piles tested equals 100%”.

More work needs to be done in this area but the preliminary results of 100% Embedded Sensor pile testing supplemented with limited geotechnical exploration data, is promising as it provides comprehensive documentation of the design Geotechnical Characterization for Foundations .

DEEP FOUNDATIONS INSTITUTE

 **S3: Slopes, Slides and Stabilization**
Hotel Kabuki | San Francisco

August 4-6, 2020 www.dfi.org/S3-2020

S3: Slopes, Slides and Stabilization

August 4, 2020 - August 6, 2020
Hotel Kabuki
San Francisco, California

Technical Committees of Deep Foundations Institute (DFI) are combining their industry expertise to organize this 2.5-day conference on effective application of deep foundations, ground improvement, and soil mixing for stabilization of slopes and excavation support. The goal of the event is to provide presentations and panel discussions on current technologies, design concepts, research, and case histories for challenging slope and landslide repairs, excavation support and slope stabilization projects using deep foundation and ground improvement methods.

Contact Information:

www.dfi.org/S3-2020
E-mail: events@dfi.org

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WHAT CAN DFI DO FOR YOU?

Overview

DFI is an international association of contractors, engineers, suppliers, academics and owners in the deep foundations industry. For more than 30 years, we have brought together professionals for networking, education, communication and collaboration. As a member, you help create a consensus voice and a common vision for continual advancement in the planning, design and construction of deep foundations and excavations.

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For more information please visit www.dfi.org/annual2020

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