Reverse Circulation Drilling

also referred to as Airlift Drilling, is an efficient technology for large diameter drilling. It is a very robust and straightforward means of operation and sets the standards for cost effectiveness and versatility in challenging ground conditions. Read more about it on Page no. 3.

Picture Courtesy: mhwirth

Volume 7 Book 2, July 2021

DFI of INDIA News

DEEP FOUNDATIONS INSTITUTE DFI FINDING COMMON GROUND®

Quarterly Newsletter from Deep Foundations Institute of India

www.dfi-india.org

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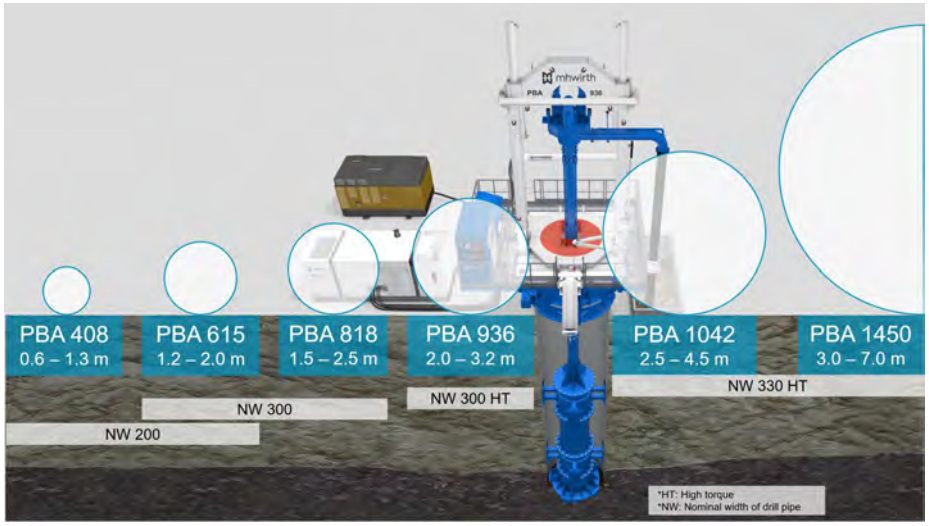
Reverse Circulation Drilling

Nikolas Schmitz - Head of RCD & Minerals, MHWirth

Cover Story

Reverse Circulation Drilling Rigs

For today's construction industry, large-diameter piles are common practice, as they are more competitive than drilling a larger number of smaller piles. More and more piles are installed by drilling rigs, replacing less efficient methods. Pile top drill rigs (PBA), based on reverse circulation drilling (RCD) technology are an efficient solution for large diameter drilling (0.6 m to 8.0 m/1.97 ft to 26.3 ft) and drilling depths of up to 500 m (1,640 ft.) in various geological conditions onshore and offshore.



Reverse Circulation Drilling (RCD) Technology

RCD, also referred to as airlift drilling, is a very robust and straightforward means of operation and sets the standards for cost effectiveness and versatility in challenging ground conditions.

Video about RCD technology used in MHWirth pile top drill rigs: https://youtu.be/8D2MFwhl5KA

Areas of Application

RCD rigs are a beneficial drilling solution for numerous drilling applications in the onshore and offshore construction industry (see table). To cover these areas of applications, six different machine models meet the diameter range from 0.6 to 8.0 m (1.97 ft to 26.3 ft).

Onshore	Offshore
Metros	Bridges
Superstructures and buildings	Causeways
Industrial plants	Harbors
Secant walls	Jetties, piers, dry docks, dolphins
Water dam rehabilitation	Platforms for oil and gas
Sewage outfalls	Wind turbines

Major Project References for Pile Top Drill Rigs in India

More than 350 pile top drill rigs have proven their exceptional quality and outstanding reliability in numerous projects around the world, following are some of them for flagship projects in India.

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Mumbai Trans Harbour Link – Offshore

Five Wirth™ PBA 818 are drilling approx. 1,100 piles for the 21.8 km long road bridge, connecting the city of Mumbai with Navi Mumbai, its satellite city. Drilling diameter is 2.2 m and depths are of up to 50 m.

Chennai Metro Rail Project – Onshore

For foundation of a high-rise building within this outstanding infrastructure project, a Wirth™ PBA 818 currently drills numerous piles with 2.15 m in diameter and depths of up to 35 m.

Mumbai Port Extension – Offshore

For construction of the 2,500 m long approach trestle more than 600 piles with 1.2 m diameter were drilled for a drilling depth of up to 45 m. The Wirth™ PBA 615 combines a small footprint with light weight and increased performance

Mr. Amol Shingarey to Chair DCGCF

DFII Committee for Geotechnical Characterisation for Foundations (DCGCF) is working tirelessly from last three years under the chairmanship of **Prof. V S Raju** (Former Director, IIT Delhi & Former Dean IIT Madras). It's goals are a) to increase awareness of the importance of complete and competent site investigation for the design & construction of foundations & underground structures; b) develop & implement skill programs covering manpower involved in geotechnical investigation, and to implement good work practices .

The committee has come a long way and is ready with skill training programs which will be launched later this year. They have also developed a roadmap to engage owners and contractors highlighting the importance of proper site investigation and the benefits.

After leading the committee for nearly three years and bringing it to a comfortable stage, Prof. V S Raju wished to hand over the Chair's responsibility, and **Mr. Amol Shingarey** (MD, Geotech Services Pvt Ltd, Nagpur) was the unanimous choice. Mr. Amol has been instrumental in developing the skill training programs and is the backbone of committee since it's inception. Prof. Raju will continue to guide the committee as an advisor.

Mr. Shingarey has more than 40 years of experience in different fields of geotechnical engineering. DFII welcomes Mr. Shingarey in the new role, and wishes him all the best.

Growing Together

Mr. G V Prasad, Director - Operations, DFII

Director of Operations Message

Coming together is a beginning, keeping together is progress, working together is success - Henry Ford

DFII team felt elated when the executive committee members of IGS, Dr. Ravi Sundaram and Dr. Parthasarathy offered us getting support from IGS leadership in implementing skill training programs initiated by the DFII Committee for Geotechnical Characterization for Foundation (DCGCF). They are part of DCGCF comprising of 12 members representing major geotechnical investigation companies and other organizations in managerial positions. Over the last two and half years, this team has been working on the ambitious goal of developing a suitable program of training and certifying around 4000 soil lab technicians across India. We are hopeful of launching this program in few cities during 2021. Other programs of this committee will facilitate raising the standards of geotechnical investigation practices of the Indian construction industry.

It is highly motivating to see an overwhelming response to a recently held workshop program on the topic "*CFA pile – Theory, Prospects and Application in India*" through joint efforts DFII and IGS Delhi chapter teams. This program was conceptualized and organized under the leadership of Dr. Sunil Basarkar, chair, DFII CFA pile committee, and Mrs. Arati Bhargava, Chair, IGS Delhi chapter and esteemed speakers Prof J.T. Sahu from IIT Madras, Mr. Andrews M Baquerizo made interesting presentations.

Construction Equipment Rental Association (CERA India) leadership approached us with a request to organize one webinar for their members covering the scope for new foundation technologies in India. They also sought our support in developing and implementing a training program catering to piling rig operators in enhancing their skills. CERA India controls around 60 % of construction/foundation equipment, and the partnership between DFII and CERA will immensely serve mutual interests and the Indian construction industry.

In the recent past, few of the major organizations like L&T approached the DFII team with a request to train their field personnel for imparting knowledge and skills specific to a few specialized deep foundation technologies. We are mobilizing expertise within India and globally to kick start a few programs this year.

The response to various DFII programs is growing, and we are hopeful that more companies/professionals will embrace technological advancements, skill programs, and good work practices promoted by DFII in their day-to-day work. In turn, this will help in enhancing the performance standards of the geotechnical and foundation industry in the long run.

Thankful to various stakeholders, it is acknowledged that there is a phenomenal scope in India for more programs/initiatives in the future, and we seek continuing support from and all in expanding the DFII community to execute this big mission collectively. In the past, we signed MOUs with the leadership of Chennai Metro Rail Limited

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and the National Academy of Construction to work jointly in related areas and we look forward to reaching a similar understanding with IGS and others in the future to achieve the common good. DFII office is also to be expanded in sustaining current programs and to take up new initiatives. It requires more funds for sustaining its office cost and to execute various programs and it is exploring various funding options and revenue models to achieve this goal. We request all the beneficiaries to recognize this compelling need and come forward benevolently to financially contribute to DFII, participate in the various program, to become members to serves mutual interests.

DFI USA office is staffed today with a dynamic 15-member team and doing a commendable job in handling close to 30 technical committee activities, multiple conference/webinar programs throughout the year, activities of 3 regional chapters at the global level. India placed globally at 3rd position economy size-wise has got bright chance to replicate this success.

It is worth mentioning that the vision and selfless services of founding members Dr. K S Ramakrishna, Mr. Anirudhan, Prof Shailesh Gandhi, Dr. Balakumar, Dr. Sunil Basarkar, Mr. Mohan Ramanathan, Mr. Hari Krishna are fructifying in terms of DFII organization receiving many accolades as a part of its journey. The continuing guidance and support provided by the DFI President and Board of Trustees, Executive Director Mrs. Theresa, Technical Director Mrs. Mary Ellen is enabling us to achieve this feat. I feel excited to work with this great organization in the current position and am thankful to DFII leadership and office staff Mr. Pranav and Mr. Mahendran for supporting me in fulfilling my responsibilities.

Students Outreach program 'GroundWork' - Report

DFI of India and DFI USA wish to reach the student community and propagate the challenges and fulfilment of being a geotechnical professional. Therefore, DFI and DFI of India developed GroundWork with the sole agenda of reaching out to the students. The major goal is to lay the foundation for the next generation foundation engineers, by

a) Supplementing academic coursework with practical design, construction, QC/QA topics.
b) To provide professional development teaching on personal growth and business topics.
c) Highlight various project roles in the deep foundation industry (engineer, contractor, manufacturer, owner, in addition to academic).
d) Describing various types of careers and introduce companies in deep foundations.
e) To create awareness of DFI and resources available.

Eventually, DFI India plans to reach out to the foundation industry to help aspiring geotechnical students and researchers gather quality internship opportunities and employment opportunities.

The technical committee for GroundWork comprises Prof. A Boominathan, IIT Madras, Prof. Amit Prashant, IIT Gandhinagar, and Dr B Umashankar, IIT Hyderabad, was formed to flag start this initiative. The committee will be expanded, adding members from the industry.

The GroundWork was formally launched during DFI India 2020 virtual conference. DFI of India conducted four technical and

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professional development sessions during January 2021, February 2021, March 2021 and April 2021. The details of these sessions are given below.

Webinar 1 on 19 Jan 2021

Prof. Harry G Poulos, Senior Consultant, Coffey Services Australia, spoke on 'Foundation Design Challenges for Tall Buildings'. Ms. Mary Ellen Large, Director of Technical Activities, DFI, USA, made a presentation on 'Body Language.'

Webinar 2 on 16 Feb 2021

Prof. Rolf Katzenbach, Professor, Technical University, Germany, presented 'Sustainable Foundations of High Rise Building in Soft Soil Recommendations for Technical Solutions'. Prof. Anne Lemnitzer, Associate Professor at the University of California, Irvine (UCI), gave a presentation on 'Abstract writing.'

Webinar 3 on 16 Mar 2021

Dr. Devon Mothersille, Director, Geoserve Global Ltd, London, provided an 'Introduction to the Anchoring Technologies' in his enriched presentation, followed by a presentation by Ms. Jewels Stover, Project Manager - Major Projects Dvn. at Nicholson Construction, Denver, Colorado, US, on 'Negotiations.'

Webinar 4 on 20 Apr 2021

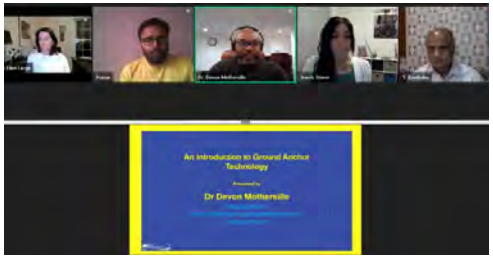
Dr William Cheang, Principal Consultant (Geotechnics) Engineering Simulations, Design Integration Analysis, Bentley Systems, presented on 'Underground Infrastructures and Metros'

Webinar 5 on 18 May 2021

Mr. N. Ramakrishna Raju, Vice-President & Head (Engineering). Tata Projects Limited, presented on 'Ground improvement for Railway embankments on soft marine clay and expansive soils - Case Studies. It was followed by Ms. Srilakshmi Nagarajan, General Manager, Engineering and Business Development, Giken America making a presentation on 'Mentorship with Intention and Purpose'.

Watch DFII GroundWork Webinar Recordings here:

https://youtube.com/playlist?list=PLplslBNgY6TmFRyleTkh44CrO39OF4Ab0



Drilled Shaft Foundations for the Hurricane Dock Bridge (A RCD Story)

Introduction

The Missouri Department of Transportation (MoDOT) recently replaced the Hurricane Deck Bridge that carries Highway 5 traffic across the Osage Arm of the Lake of the Ozarks in Camden County, Missouri. The replacement structure is on a new alignment adjacent to the existing bridge and is founded on large diameter drilled shafts socketed into the bedrock using full-face, casing top mounted, Reverse Circulation Drilling (RCD). This article describes the foundation design and construction for this interesting $32 million bridge replacement project.

The owner is MoDOT, the general contractor was American Bridge, and the design consultant was Parsons. Both Case Foundation and Hayes Drilling acted as sub-contractor to American Bridge to install drilled shaft foundations; Case in the water using RCD equipment and Hayes on the land using traditional rotary drilling equipment. Dan Brown and Associates (DBA) provided foundation engineering and design services as sub-consultant to Parsons.

Foundation Design

Over a dozen boreholes including rock coring were drilled form a barge during the design phase. The location of each drilled shaft included at least one boring per shaft. Some of the borings were also logged with an Acoustic Tele-Viewer (ATV) in an effort to further evaluate the *in-situ* quality of the bedrock. This region is known to contain karstic features in the bedrock and the ATV logs provided a reliable means to inspect borehole walls for such features. An example of the ATV results in the bedrock is provided in Figure 1a, along with the corresponding photograph of recovered rock core in Figure 1b.

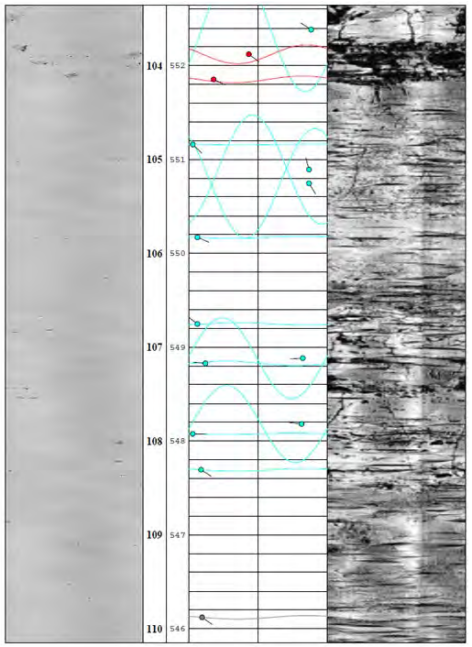


Fig 1a: Representative ATV Results in Dolostone Bedrock

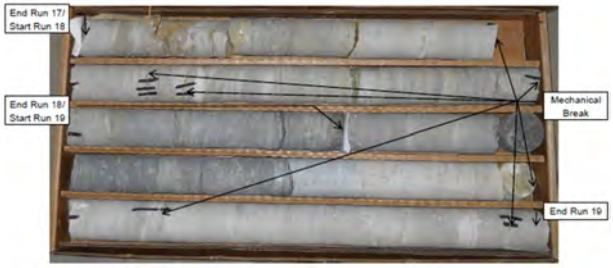


Fig 1b: Corresponding Photograph of recovered Dolostone Bedrock core

The dolostone bedrock beneath the caissons was determined to be adequate on the basis of the core results. The average unconfined compressive strength (q_u) of the bedrock cores as measured in the laboratory was 5,680 psi (39162 KN/m^2). As is typical with sedimentary bedrock in the Midwestern United States the q_u of the bedrock cores contained a fair amount of variability and therefore many tests were performed in an effort to quantify the variability. The measured q_u values on the 225 samples tested ranged from 650 psi to 18,420 psi with a standard deviation of 3,090 psi (21305 KN/m^2). The average unit weight of the bedrock core samples prior to testing in the laboratory was 159 pcf (2547 Kg/M^3). Core recovery and Rock Quality Designation (RQD) were both good with the exception of some zones of karst near the surface of the bedrock.

Contd.

The bridge design includes eleven two-column bents supported on drilled shafts with rock sockets. The two shafts at each bent were tied together with a waterline strut oriented in the transverse direction of the bridge. Each column was supported by an 8.5 ft diameter drilled shaft permanently cased to rock and with an 8 ft diameter socket extending about 20 ft into dolostone bedrock. The contributions of both side resistance and base resistance generated in the rock socket were included in the calculations of geotechnical axial compressive resistance.

The diameter was controlled by lateral considerations and the relative large unsupported length between the mudline and the waterline strut. The submerged overburden soil was soft and provided little lateral resistance. A schematic of the subsurface profile longitudinal with the bridge is provided in Figure 2 with the bent locations superimposed. At some locations, the water is 80 ft deep with only about 10 ft of soil above bedrock. Due to the relatively large unsupported shaft length, the structural engineer concluded and specified that the maximum allowable plumbness tolerance was one percent.

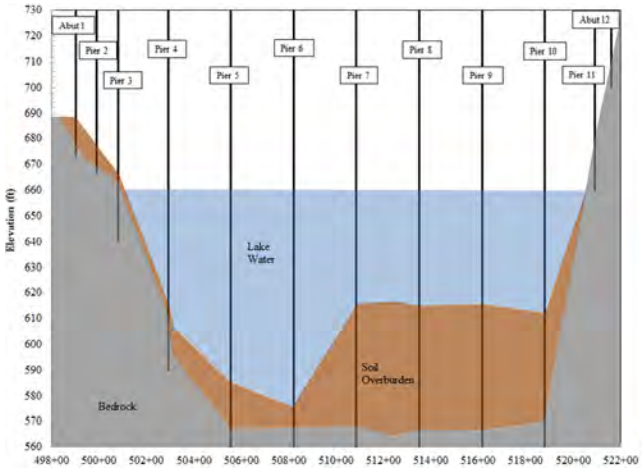


Fig 2: Subsurface Profile.

The socket length was controlled by axial considerations and less favorable bedrock conditions were encountered at some shaft locations. The core recovery and RQD at some locations indicated soil-filled solution cavities and poor-quality bedrock at a few of the shafts near the surface of the bedrock.

Fig 3a: Reverse Circulation Drill Rig

Fig 3b: Reverse Circulation Drill Rig

Foundation Construction

The drilled shafts at Bents 4 through 10 were constructed by Case Foundation under subcontract to American Bridge. These locations represent the over-water bents and included a total of 14 shafts. The drilled shafts necessary to support the bents on land were constructed by Hayes Drilling under subcontract to American Bridge.

After installing the permanent casing into bedrock and removing the soil overburden inside the casing, Case Foundation drilled the rock sockets with an RCD rig. The rig was mounted to the top of the permanent casing as shown in Figures 3a and 3b and the excavation was advance using a full-face cutter assembly as shown in Figure 4.

Fig 4: Full-Face Cutter Assembly

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The configuration of drill rig and cutting tool combined to make what was essentially a large plumb bob. This proved beneficial in achieving the maximum one percent vertical tolerance specified in the construction documents.

Another benefit of the reverse circulation drilling method is that an airlift is constantly working to remove cuttings. This process results in a very clean excavation which greatly reduces the risks of post-construction integrity test anomalies as well as provides more reliable base resistance.

Following the excavation of the drilled shaft, standard MoDOT drilled shaft construction specifications required each rock socket be visually inspected with a television camera. The socket walls and base were viewed with the camera and indicated a very clean excavation and rock socket conditions commensurate with the design.

At one shaft location, a clay-filled solution cavity was encountered that required mitigation. The cavity was approximately two to three feet in vertical dimension and the top of the cavity was approximately 5 ft beneath the top of bedrock. Upon encountering this feature, the drill stem advanced rapidly as would be expected when transitioning from bedrock to clay. The drill assembly was immediately retrieved to prevent potential loss of the tool.

A previously agreed upon contingency plan was instituted immediately to mitigate the issue. This contingency plan was included in the drilled shaft installation plan and proved very valuable. Because the risk of encountering such features were made known early in the project, the Owner, Engineer, and Contractor were able to rapidly respond to the issue and successfully and efficiently mitigate the problem under fair financial terms. A well thought installation plan provided by the Contractor in combination with a thorough identification and description of construction risks by the Engineer helped the Owner feel comfortable agreeing to the financial terms of the possible mitigation effort prior to the commencement of construction. A photograph of the completed Hurricane Deck replacement bridge is provided below in Figures 5.

Fig 5: Photograph of New Hurricane Deck Bridge

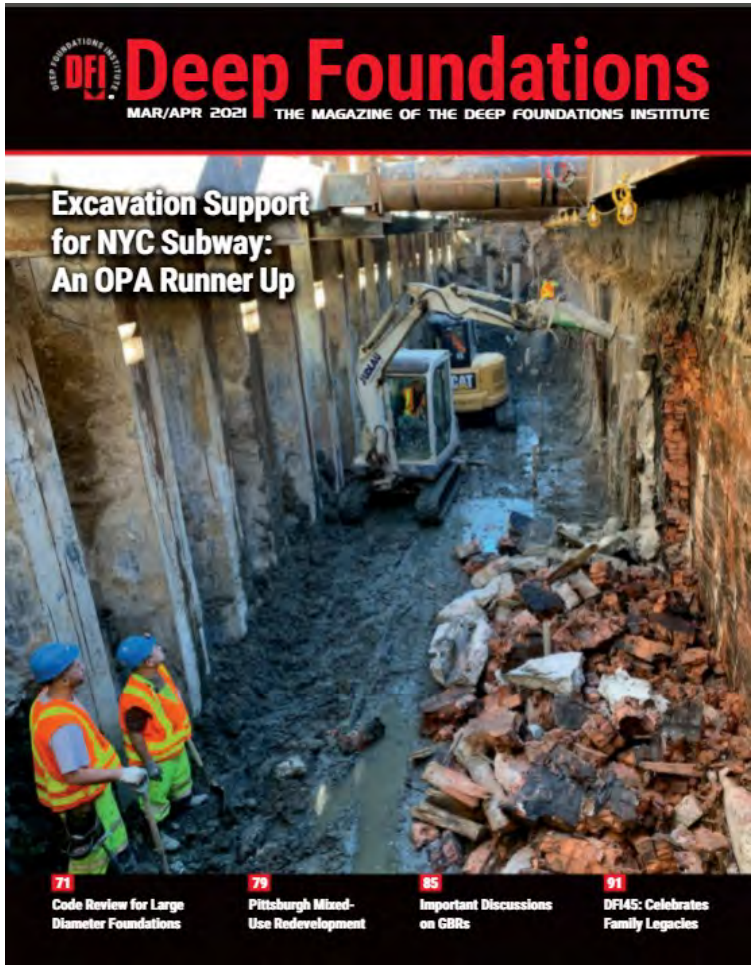
Summary

Several aspects of foundation engineering were necessary during the design phase of this interesting bridge replacement project. The final selected foundation elements included drilled shafts with rock sockets and one instance of a spread footing bearing on shallow bedrock.

During the investigation of the existing caissons, ATV testing proved very beneficial, particularly in zones with low core recovery or RQD.

A comprehensive drilled shaft installation plan agreed upon by all parties in advance of the construction can and did yield benefit. A good plan should include a consideration of the anticipated risks and an agreement on how to proceed if difficulties associated with those risks are encountered. A good faith effort is necessary by the Contractor and a willingness to share risk is necessary by the Owner, along with a competent and experienced design engineer retained throughout the entire design and construction process.

– ***Paul J. Axtell,*** P.E., D.GE – Dan Brown & Associates, Overland Park, KS



DFII & DFI Upcoming Events

DFI India is getting ready for it's much awaited 10th anniversary conference scheduled in Nov 2021. Keeping in mind the ongoing pandemic situation and future projections, DFII2021 is planned in online format. It is spread over two consecutive weekends, i.e., on 12-13 Nov & 19-20 Nov'21, giving sufficient networking & exhibition opportunity during the in-between week days.

The four day conference will pack highly insightful keynote lectures from industry leaders worldwide, a very interest Panel Discussion, along with WiDF & Student Outreach programs. All the technical papers submitted last year for DFII2020 will be considered and published/presented during DFII2021.

More details on technical program , schedule, sponsorship/exhibition opportunities will be announced soon.

For more information & updates follow https://www.linkedin.com/company/dfi-india
Or visit: http://www.dfi.org/dfieventlp.asp?13430

Event	SuperPile 2021	S3: Slope, Slides and Stabilization	46th Annual Conference on Deep Foundations	DFI-India 2021	SuperPile 2022	47th Annual Conference on Deep Foundations
Date	June 23-25, 2021	Aug 03-05, 2021	Oct 12-15, 2021	Nov 12-20, 2021	June 15-17, 2022	October 4-7, 2022
Venue	Philadelphia, Pennsylvania	San Francisco, California	Las Vegas, Nevada	Online Conference	St. Louis, Missouri	National Harbor, MD

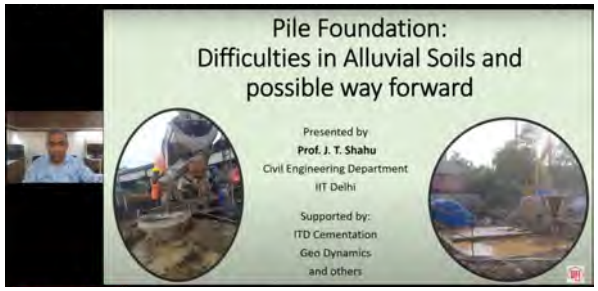
The executive committee members of DFI of India represent all the stakeholders in the foundation research, design and construction . The members will express their views about the role of DFI and other similar organizations in the development and transfer of modern technology for infrastructure development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

DFII Technical Committee News & Reports

CFA Piles – Theory, Prospects & Applications in India - Workshop Report

DFII in association with IGS (Delhi Chapter) organized Online Workshop on CFA Piles – Theory, Prospects & Applications in India on 17th March 2021 – an event which is part of ambitious dissemination efforts to understand how CFA piling technology can be a game changer in Indian piling industry and share plans of its implementation in India.

The Workshop commenced with words of Introduction on IGS (DC) by Chairperson **Ms. Aarti Bhargava**, followed by Overview of DFI of India activities by **Mr. G V Prasad**, Director (Operations). This was followed by planned presentation on Workshop theme by the experts as follows:



1) Pile Foundation: Difficulties in Alluvial Soils and Possible Way Forward – by **Prof. J T Shahu** (IIT Delhi & Hon. Secy., IGS)
2) World Case Studies on CFA Piles from a typical project to an Extreme Application – by **Mr. Andres M. Baquerizo** (Vice President, Keller- North America)
3) CFA Piles – Design Approaches, Suitability and Applications in India – by **Dr. Sunil S. Basarkar** (M/s Afcons Infra, & Chair, DFI of India's CFA pile Technology Implementation committee)

This workshop evoked an overwhelming response with 212 participants turning out and actively participating in discussions which followed after each of the presentation. Participants hailed from Contractors, consultants, academia, equipment manufacturers and suppliers, and post graduate engineering students. It was worthy noting that international participants from Australia, Palestine, Iraq, Philippines, Qatar, Panama & Ghana were also part of this workshop indicating its global reach.

This seminar had very inspiring standards and was curtain raiser for the promising applications that CFA piles hold for speedier completion of infrastructural & real estate projects in India.

Benefits of Seminar:

This workshop was intended to present applications of CFA piles particularly in North India, due to suitable Sub-soil conditions.

The online workshop had a wide reach of the global participants from various organization and fulfilled the objectives of awareness and dissemination of CFA pile technology.

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Awareness is low, in India, on the potential use of CFA Piles, and hence this seminar has been effective in initiating this objective.

Lacunae in bored piling, Global application of CFA pile, work done on CFA piles in India, efforts for their regular use had was convincingly presented.

Concerned engineers from Consultants, government departments, academia, and private firms discussed on possibilities of this technology applications for implementation.

Acknowledgements:

Appreciations for The Indian Geotechnical Society (Delhi Chapter) with special mention of excellent support from Ms. Aarti Bhargava, **Prof. Bappaditya Manna**, and Prof. J T Shahu which lead to successful fulfillment of its workshop objectives.

Thanks to Mr. Andres M Baquerizo for sharing his immense knowledge and time with us.

Special thanks to the participants, and those who worked behind the screen for smooth working and conduct of this workshop.

Support from DFI (USA) and DFI India Office had always been there; seamless conduct of the webinar owes specially to Mr. Pranav Jha (Asst. Manager - Operations, DFII) for managing the behind the screen activities.

- Dr. Sunil S. Basarkar

Coordinator, Online IGS (DC) & DFII On-line Webinar on CFA piles

Watch the Workshop session recording here: https://youtu.be/PnqLmLplXZA

Women in Deep Foundations (WiDF India) Webinar Series 'Civil Engineering Careers - Connect & Grow' - Report

After the huge success of it's first webinar titled "*Bridging Academia and Practice*" which was conducted in Dec'20, the WiDF India group went ahead and delivered two more highly engaging webinars in Feb'21 & Apr'21.

Second webinar was conducted on 24th Feb'21 titled *"Education Beyond Classroom"*. It was moderated by **Dr. Yogini Deshpande** & **Akhila Manne**, and the panelists were **Dr. R Chitra**,CSMRS, Delhi; and **Dr. Akanksha Tyagi**, IIT Roorkee.

Third webinar titled "*Foundations for Future*" was conducted on 08th Apr'21. It was moderated by **Dola RoyChowdhury** & **Sayantani Ghosh**, and the panel consisted of **Dr. Sunil S. Basarkar**, Afcons Infra; and **Sridhar Valluri**, Keller India.

DFII is thankful to all the speakers, moderators, & WiDF India team.

Watch all the 'Civil Engineering Careers - Connect & Grow' webinars here: https://youtube.com/playlist?list=PLp1slBNgY6Tl_jJaJCPl3vAvCbAQTVqM4

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