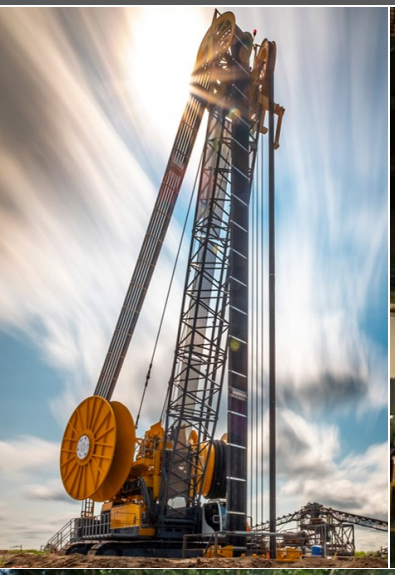
# Trench Cutter Technology

## – The Multipurpose Solution

The Trench Cutter Technology, also known as hydro mill, is well-known for constructing diaphragm walls for complex retaining structures, is however not the only purpose for which the technology can be used. The world demands much more than just retaining structures. Read more about the Trench Cutter Technology on **Page no. 3.**



Picture Courtesy: BAUER

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# DFI of INDIA News



Quarterly Newsletter from
Deep Foundations Institute of India

www.dfi-india.org

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# Trench Cutter Technology - The Multipurpose Solution

Cover Story

*- Extract from Mr. Franz-Werner Gerressen's Keynote Presentation during DFI-India 2022 Conference*

## Introduction

The trench cutter technology (also known as hydro mill) is well-known for constructing diaphragm walls for complex retaining structures.

This however is not the only purpose for which the technology can be used. The world demands much more than just retaining structures. **Retaining walls** are just one possibility to use the advantages of this technique.

The other applications include:

* Cut-off Walls
* Foundation (Barrettes)
* Mining

Recently, the technology could also satisfy the idea of using the trench cutter technique as bulk sampling equipment.

## Retaining walls

Retaining walls is one of the most common ways to use the diaphragm wall technique. These walls in general accommodate high loads and thus often provide permanent solutions for many applications, such as metro stations, underground parking areas, and shafts for e.g., sewage treatment and more.

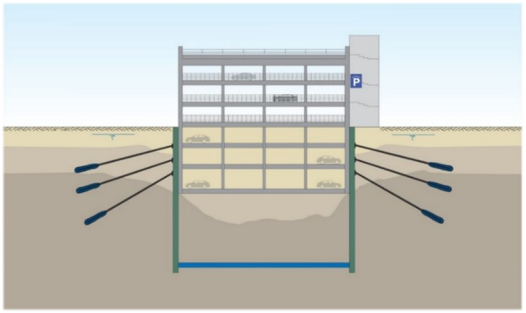

*Fig. 1. Retaining wall*

Over the years the success of the method has been seen on many big projects around the world. Besides the mentioned advantages, the ability to work without restrictions in nearly every soil and/or rock environment can lead to an efficient and economical solution compared to other methods.

## Cut- off Walls

The aim of cut-off walls is to seal large areas in the ground. This, for example, can be used to rehabilitate dams or to encapsulate areas of contamination. Compared to retaining walls, cut-off walls commonly do not accommodate any reinforcement. Furthermore, the filling material has different properties than concrete. Thus, static loads cannot be transferred into the ground, but the walls are more flexible and can withstand movements to a certain degree. This is advantageous if for example dams settle or move under water pressure..

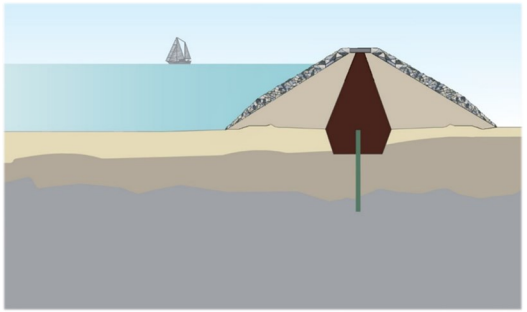

*Fig. 2. Cut-off wall*

## Foundation (Barrettes)

An alternative to foundation piles in some cases can be a foundation with barrettes. These bearing elements can

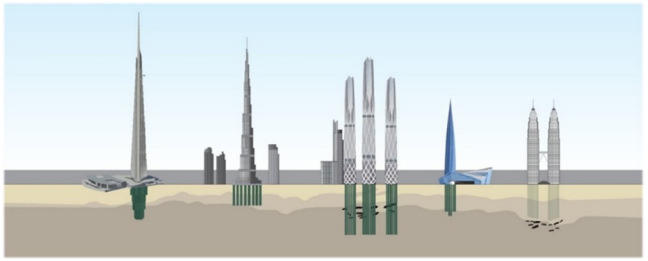

*Fig. 3. Foundation*

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accommodate high loads and in general have the same working process as retaining walls. The layout of these elements can be single bite panels, but also can have other geometric shapes. An advantage of barrettes compared to bored piles can be a reduction in the number of elements and therefore reduction in construction time, especially for huge foundation projects .

## Mining

A totally different idea to use the diaphragm wall equipment is in mining applications. Here, in general, cutters with big footprints try to perforate ground and mine gold-containing, diamond-containing or other materials of value. This method applies if open-pit mining gets uneconomical or as part of a big exploration campaign.

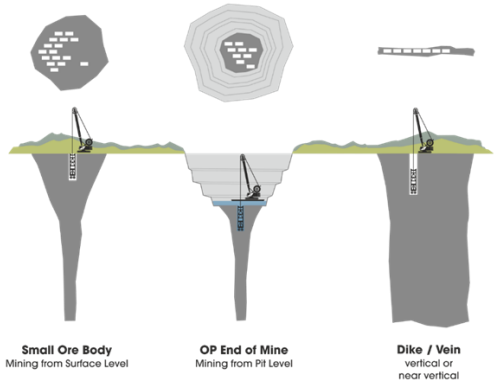


*Fig. 4. Mining application*

## Reference Case Studies

### Execution of a cut-off wall at the dead sea – unique conditions require unique solution

The Dead Sea Works Ltd., Beer Sheva, Israel operates several large-scale salt pans at the "lowest place on earth". . The northernmost salt pan (PAN 5) covers an area of approximately 75 km$^2$ with a capacity of about 150-200 million m$^3$. The dike, which runs parallel to the Jordanian border, has an approximate length of 18 km. Soil conditions show an alternating sequence of salt and clay layers. . The salt layers are very porous, which cause sinkholes due to revers erosion. Therefore, besides heightening, a rehabilitation of the dike was also required. A new two-phase cut-off with an internal sheet pile wall was developed and introduced.

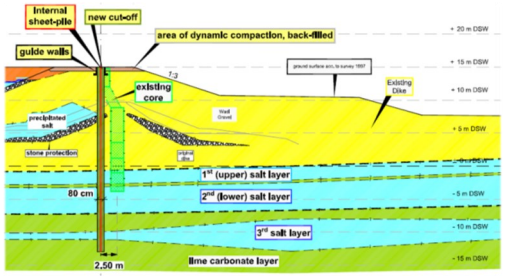


*Fig. 5. Cross section of dike*

Upon completion, 550,000 m$^2$ of cut-off wall has been installed.

### Foundation / Barrettes: Residential tower Bullfinch crossing, Boston USA

In Boston, USA the foundation works for a residential tower were carried out using barrettes. The building is advertised as the tallest for-rent residential building in Boston. Further the elevator shaft was also constructed using the diaphragm wall technique.


*Fig. 6. Residential tower*

The depth of the elements varied between 19 and 25 m and the elements were embedded into a bedrock.

### Mining application: FalCon project, Sasketchewan Canada

For mine development, a reliable and detailed bulk sampling program is inevitable. The use of a trench cutter system was considered. High demands for equipment were obvious to execute ten exploration trenches. Not only demands on depth capability, but also safety standards and the integrity and quality of the samples required a new technology, which was able to fulfil all specifications.

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## Director of Operations' Message

*Action is the foundational key to all successes*
*– Pablo Picasso*

DFII leadership wish to update its well-wishers that its actions on multiple fronts in a continuing manner is leading to desirable outcomes incrementally. These are expected to provide profound value addition to the Indian deep foundation industry in the long term in the related areas.

I take the pleasure of presenting a few important developments in the recent past related to various DFII programs and its impact.

DFII Committee for Geotechnical Investigation for Foundation (DCGCF) under stewardship of Mr Amol Shingarey, Chair and Dr. Parthasarathy, Vice Chair implemented two 5-day training programs at Nagpur & Bangalore meant for soil lab technicians during April and June'22. 20 technicians attended this program from the local regions and the participants found this program very beneficial. Two years efforts of DCGCF members in developing this program yielded desirable results, and its our goal to launch this program next at National Academy of Construction (NAC), Hyderabad during Dec'22. Robust infrastructure of NAC with whom DFII signed five-year MOU can be made use to train more number of soil lab technicians from Hyderabad and other regions. Its DCGCF mission to engage owner organizations, professional bodies and other stakeholders to promote advancements in geotechnical investigation practices, cover soil lab technicians, field supervisors and geotechnical engineers in different geographics in imparting of relevant training for implementing good work practices.

Another heartening news is Dr. Sunil Basarkar, Chair of the CFA pile committee succeeded in making a presentation to the Soil and Foundation Engineering (CED 43) committee about CFA pile prospects in India and DFII efforts in promotion of this technology in India. After a lot of discussions and opinions, it was agreed that a document containing standard guidelines for CFA design and construction should be initiated by forming a separate committee which will later culminate in developing IS code for this technology. Dr. Basarkar was chosen as co-convener for this committee, and DFII congratulate him on this accomplishment. DFII efforts in execution of CFA trial piles and in documentation of the records caught the attention of major owner, foundation equipment, EPC consultant, contracting organizations and we are hopeful to see a few CFA pile projects implemented during this year a reality.

We launched a platform on the DFI website for the benefit of students in availing internship programs by empanelling the three companies that volunteered for this purpose. Our goal is to expand this list with more companies for providing internship programs catering to students in all regions.

Seeing the good response to training programs catering to field personnel in foundation construction held over the last two-year period, we set up a committee under the leadership of Mr. Ravikiran Vaidya, Principal of Geodynamics, and comprising other professionals from reputed

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organizations. We planned two programs during this year and we are hopeful that the foundation industry will get benefited from the same in enhancing the foundation construction work practices.

Under the leadership of Mr Anirudhan, Chair of DFII and Prof Murali Krishna, IIT Tirupati, this year DFII 2022 conference event held during Sept'22 jointly with IIT Tirupati was a grand success and we got overwhelming response by getting participation from hundred plus organizations. There was representation from owner companies like NPCIL, CMRL and also leadership team members from major organizations like L&T, Keller, ITDCEM, Afcons, Baur Engineering, EIL, AECOM, Bauer Equipment, Sany India, Liebherr and others attended the conference. During the EC meeting conducted at the DFII conference, 2022, DFII leadership team proposal to launch two more initiatives covering helical pile technology, foundation equipment operator training programs received wide applause from the industry leaders. An action will be soon initiated to form separate committees for handling these programs and to achieve steadfast progress. Mr Mohan Ramanathan, Vice Chair of DFII will play a pivotal role in driving these two programs.

We thank all DFII members and other well-wishers for their contribution to the success of the DFII mission.

*- G Venkata Prasad,*

*Director of Operations, DFI of India*

# DFI India Life Time Contribution Award 2022

DFI of India acknowledges several veterans' immense contributions to geotechnical engineering in the field and academia. We are proud to honour one of them during every annual conference with our Life Time Contribution Award and are pleased to present the 2022 award to **Er. P.L. Bongirwar**.

**Mr Pramod Laxman Bongirwar** is a Distinguished Alumnus of IIT Bombay who joined the Public Works Department (PWD), Maharashtra, in 1968 in Class 1 cadre and retired as Principal Secretary in 2003. He did his B.Tech in Civil Engineering and MTech in Structures from IIT Bombay.

Mr Bongirwar served as a member of the IRC Committees for over 20 years and several other prestigious committees that have shaped multiple key transformational policies and encouraged bold initiatives.

Mr Bongirwar is currently developing technologies for improving the performance of roads and pavements.




DFI members can post their professional achievements, corporate achievements, awards, other news related to geotechnical profession here. Please send the details 15 days before every quarter, April, July, October and December to activities@dfi-india.org

# Geotechnical Monitoring of Deep Shoring Adjacent to Train Infrastructure

- Jakub Szary, B.Sc., AScT, Municon West Coast Monitoring Ltd., Vancouver, BC, Canada

## Project Background

The Gilmore Place development site is located in Burnaby, British Columbia, Canada and consists of a rectangular lot, 28,328 m$^2$ (7 acre) in area, with an above-grade train station and caisson supported guideway system bisecting the site diagonally from the southwest to the northeast. The project consists of two phases and will incorporate the existing train infrastructure into the final design of the structure. Once complete, the project will be home to the tallest tower in Western Canada standing at 64-storeys or 216 m (709 ft).

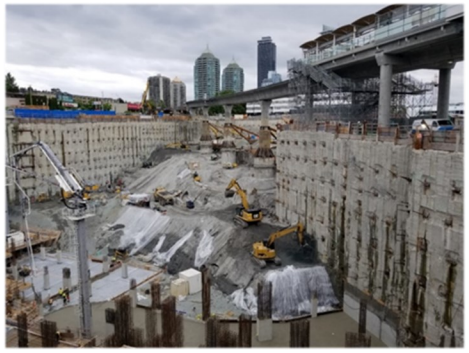

*Fig. 1. Construction site, May 2021*

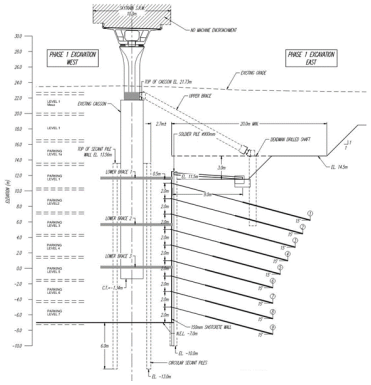

*Fig. 2. Typical monitoring plan elevation view indicating the locations of load cells, tiltmeters, AMTS targets, and extensometers.*

A perimeter secant pile cut-off wall was designed and constructed to a depth of up to 37 m (121 ft) below ground surface and consisted of 1.0 m (3.3 ft) diameter drilled piles spaced 750 mm (2.5 ft) on-center, tied back with soil anchors. Each pile was filled with concrete with a specified

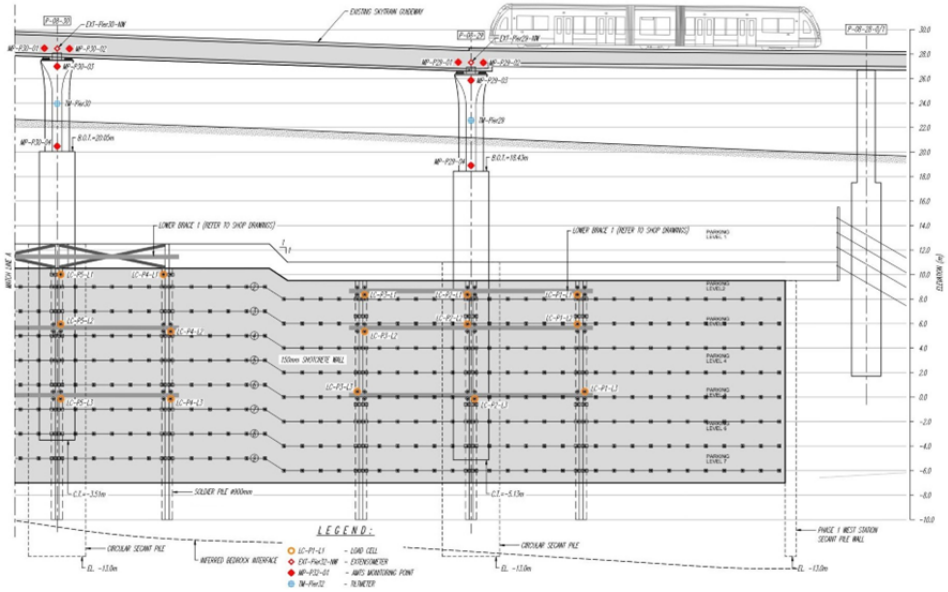

*Fig. 3. Typical monitoring plan elevation view indicating the locations of load cells, tiltmeters, AMTS targets, and extensometers.*

strength of 10 MPa (1450 psi) at 28 days, with every 4$^{th}$ pile reinforced with a W610 steel section. Due to the excavation extending below the bottom of the existing guideway supporting caissons, additional secant

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piles and a bracing/jacking system was also designed to support 3 free-standing guideway piers and to enable jacking of the piers if excessive movements occur during construction.

## Instrumentation & Monitoring Plan

A robust, automated instrumentation program was designed and implemented in coordination with the design team to monitor various shoring elements and train infrastructure in real time, and to provide immediate alerts (via text message and email) to the design team and stakeholders if values exceed predetermined thresholds. All instruments were connected to an Automatic Data Acquisition System (ADAS) to collect data remotely. Data was recorded in approximately 1-hour intervals and presented on a privately accessible website made available to the project team .

- An automated motorized total station (AMTS) was included in the monitoring program to provide 3D displacements at locations of monitoring prisms throughout the site.
- Tiltmeters were installed on each station and guideway supporting pier within the project limits.
- In-place inclinometers (IPI's) were installed in 17 pile locations adjacent to the train station and guideway piers. to measure lateral soil movements.
- Vibrating wire strain gauges and load cells were utilized to monitor the bracing elements supporting the 3 free-standing piers.

## Baseline Monitoring

The AMTS, tiltmeters, and extensometers were installed in the spring of 2019 and allowed for a baseline monitoring period of approximately 1 year prior to the start of major excavation work. The data indicated consistent diurnal and seasonal fluctuations in all three data sets. Extensometer data indicated increases of the structural expansion joint distance during colder periods of the year, suggesting contraction of the guideway section pair.

During the warmer months of the year, the expansion joint distance was noted to decrease, suggesting expansion of the guideway sections. Displacements of ± 11 mm (0.43 inch) were observed over the course of the baseline monitoring period and were strongly correlated with temperature changes.

The baseline monitoring data was critical in understanding the behavior of the train infrastructure prior to commencement of excavation work. The observed movements were observed in multiple (independent) sensors and were strongly correlated with temperature. After review of the baseline data, thresholds were increased to allow for diurnal and seasonal temperature variations in the data and an additional set of thresholds were established where temperature-corrected data was used. Data viewed as a 24-hour rolling average provided a means to reduce diurnal effects when interpreting data.

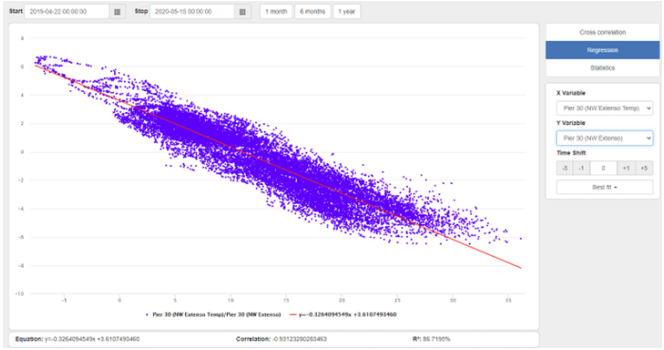

*Fig. 4. Temperature correlation for Pier 30 northwest extensometer*

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## Construction Monitoring

Remote monitoring continuously recorded data during excavation and construction work. Coordination was required with the construction team to install inclinometers, load cells, strain gauges, and additional AMTS monitoring prisms as excavation and shoring work advanced. Inclinometer installations required piles to be completed with casings installed in W-beam webbings by the piling contractor. Load cell installation required coordination with the geotechnical representative and was completed during anchor testing. Load cells were also used to confirm anchor testing results in the field. Strain gauge installation required welding and was coordinated during construction of steel members throughout the site.

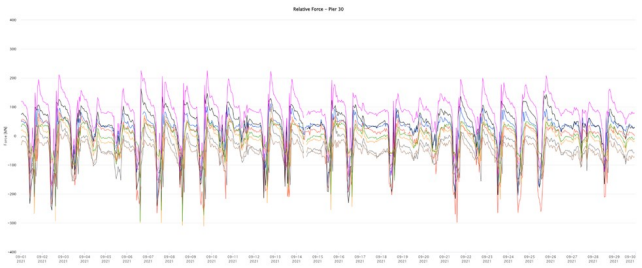

*Fig.5. Pier 30 strain gauge data (September, 2021)*

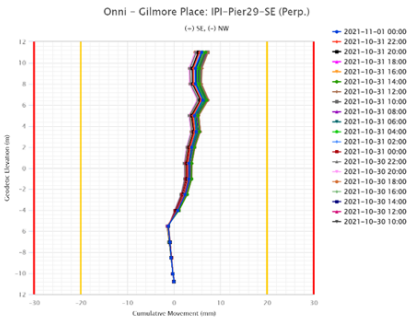


*Fig. 6. Perpendicular inclinometer movements over 24 hours for location IPI-Pier29-SE*

Diurnal and seasonal effects continued to be observed as additional instrumentation was installed. These effects were particularly apparent in the larger, steel bracing members of the 3 free-standing piers. Loading varied by up to 400 kN (90 kip) daily due to thermal contraction and expansion of the pipe braces. Thermal fluctuations were observable in load cell data. Anchor loads varied by approximately 10 kN (2 kip) daily. Inclinometer sensors experienced more stable temperature conditions due to being located below grade and better insulated from diurnal and seasonal temperature fluctuations. However, inclinometers located within the free-standing piers exhibited daily movements of 3 mm (0.12 inch) due to greater temperature exposure.

The primary challenge relating to the remote monitoring system is line of site considerations with the AMTS system (To function correctly, the AMTS requires un-obstructed view of monitoring targets and reference prisms). Other challenges included contractor damage to equipment.

Phase 1 shoring and excavation work was completed in December 2021. Guideway movements were limited to 15 mm (0.6 inch) and within the Level 1 threshold of ± 25 mm (1 inch). No noticeable trends were observed in the load cell data, indicating good anchor performance. Inclinometer data also indicated minimal movements within the shoring wall adjacent to the bracing structure and was within the Level 1 threshold.

## Brace Removal

Building construction adjacent to the 3 free-standing piers continued into January 2022.

It followed a bracing removal sequence developed by the design team. A reinforced concrete wall was constructed around the secant piles of each free-standing pier and was locked-in with parkade slabs as construction advanced, transferring loading from the bracing elements to the building structure as bracing elements were removed. The consultant team hypothesized that slab pours coincidentally occurred at inopportune times such that the pier's position was locked-in during contraction of the bracing elements caused by diurnal thermal movements.

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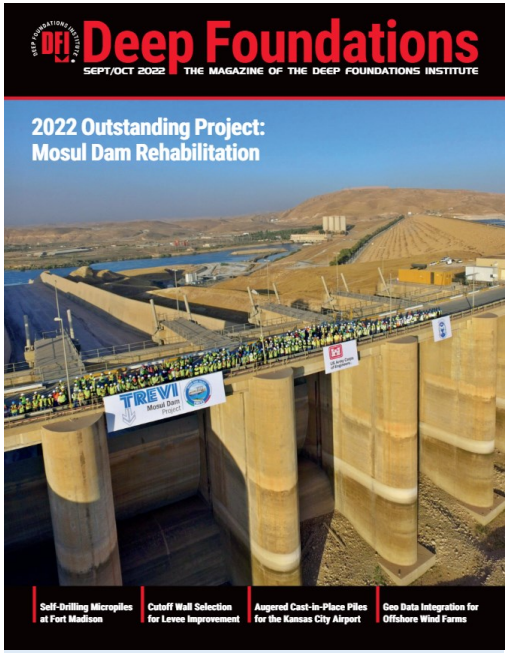
The monitoring system was remotely reconfigured to allow for more frequent AMTS and strain gauge data collection during jacking. The remote monitoring system successfully monitored movements of the pier and stress levels in the bracing elements during jacking.

## Conclusions

The remote instrumentation program employed during this project proved to be a reliable system for monitoring shoring and train infrastructure elements. The system was able to accurately monitor movements, loads, and strain, providing the project team with critical data regarding the performance of the shoring system and train infrastructure in real time. Diurnal and seasonal movements were able to be quantified during the baseline monitoring period and were strongly correlated with temperature changes. Thermal effects continued to be observed during construction. Daily load changes of 400 kN (90 kip) were observed in the steel bracing elements supporting 3 free-standing piers within the excavation. Anchor loads varied by approximately 10 kN (2 kip) daily. The system was able to be reconfigured during pier jacking operations to provide critical data at more frequent intervals.

The system continues to monitor shoring and train infrastructure elements, and is expected to remain in place for several years during excavation and shoring works for Phase 2 of the development.




Read latest DFI Magazine Sept-Oct'22 issue here: https://www.nxtbook.com/dfi/DEEP-FOUNDATIONS/september-october-2022/index.php

## DFII & DFI Upcoming Events


### November 16-18, 2022 – Sydney, Australia

***The International Convention Centre Sydney (ICC)***

This second joint conference of the Piling and Foundation Specialists Federation (PFSF) and Deep Foundations Institute (DFI), at the historic International Convention Centre (ICC) Sydney, will promote all aspects of deep foundations, and retention and ground improvement works. Sessions will cover design, testing, construction, ground improvement, risk and project delivery practices, challenging project case studies, and developments and innovations.

For more details & to register, visit: https://www.india.dfi.org/pfsf2022

| Event | DFI-PFSF Piling & Ground Improvement Conference | SuperPile 2023 | S3 2023 | DFI48 |
|---|---|---|---|---|
| Date | Nov 16-18, 2022 | June 7-9, 2023 | Aug 8-10, 2023 | Oct 31 - Nov 3, 2023 |
| Venue | Sydney, Australia | Atlanta, Georgia | Boston, Massachusetts | Seattle, Washington |

## Recap - DFI India 2022: 11th Annual conference

After two years of virtual conferences during 2020 and 2021, DFI India's most awaited 11th Annual Conference on Deep Foundation Technologies for Infrastructure Development in India was held between 15th Sept'22 to 17th Sept'22 in an in-person format, at Fortune Select Grand Ridge, Tirupati.

The event consisted of a two-and-a-half-day conference programme including a half-day special session on the quality assurance and control of bored cast-in-situ piles and diaphragm walls.

The Conference Chairs were Prof. A Murali Krishna, IIT Tirupati and Er. Anirudhan IV, Chairman, DFI, India . The co-organizers of the conference were IIT Tirupati and IGS Tirupati.

**Prof. A. Murali Krishna**

Professor,
Civil & Environmental Engineering Department,
IIT Tirupati

**Anirudhan IV**

Geotechnical Consultant,
Geotechnical Solutions, Chennai.

Chairman, DFI of India

The conference was a huge success with big support from Sponsors and good attendance from CEOs/MDs from Keller, L&T GeoStructure, Bauer Engineering, ITD Cementation, and senior management personnel from Sany India, Liebherr, and PRD rigs attended the conference.

Attendees from major government organizations like NPCIL, CMRL, & EIL. were present in the conference.

The conference started on 15th September with Inauguration Session. The chief guest was Prof. V. S. Raju, (Formerly: Director IIT Delhi, Professor & Dean, IIT Madras), Foundation and Geotechnical Consultant and the Guest of Honour was Prof. K N Satyanarayana, Director and Professor of Civil Engineering, Indian Institute of Technology, Tirupati.


Life Time Contribution Award 2022, was awarded to Er. P.L. Bongirwar, PWD, Maharashtra, the citation was read by Er. Mohan Ramanathan and awarded by Prof. V. S. Raju. Exhibition area was inaugurated by the Guest of Honour.

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## Keynotes Presentations

Seven keynote presentations were delivered by experts from the industry and academia.

Franz-Werner Gerressen
Director of Method Development Department,
BAUER Maschinen GmbH
*Trench Cutter Technology – The Multi-Purpose Solution*

Dr Sujatha Manoj
Technical Director,
Mott MacDonald, Sydney, Australia.
*Sustainable Design and Value Engineering of Deep Foundations of supertall towers, in weak carbonate rocks in Middle East Region*

Dr. Rajiv Ranjan
Additional Chief Engineer
Nuclear Power Corporation India Ltd, Mumbai
*SSSI analysis of a safety related NPP structure in frequency domain considering kinematic and inertial interactions ...*

Michel Fontes
CEO,
FONNTES GEOTÉCNICA, Brazil
*Use of Technology and Innovation applied to Mining Engineering, a Brazilian case study*

Jonathan Daramalinggam
Divisional Engineering Director,
Keller's AMEA Division
*Practical Ground Improvement solutions in seismic areas: A specialist contractor's perspective*

Dr S Nallayarasu
Professor and Head,
Dept. of Ocean Engineering, IIT Madras
*Foundations for Offshore and Coastal structures - Challenges and Technologies*

Dr. Florian Krenn
Managing Director,
GEOCONSULT India Pvt. Ltd, India
*Metro TBM tunnelling*

## Special Session on QA/QC of Bored Cast-in-situ Piles and Diaphragm Walls

A Special Session on QA&QC aspects of Bored Piles and Diaphragm Walls during the conference to address several quality control issues the Indian Deep Foundation industry face during the execution of bored cast-in-situ piles (drilled shafts) and Diaphragm Walls. Four topics were covered in the session chaired by **Dr. Sunil Basarkar,** General Manager, Afcons Infrastructure Limited

1. Concrete Properties for Bored Piling works - **Mr. Manish Mokal**
2. Stability fluids, quality tests, and their applications for Pile bore stability -**Mr. Thomas Domanski**
3. Tremie Concreting – importance and guidelines -**Dr. Karsten Beckhaus.**
4. Quality tests on the executed pile with particular reference to PIT, CHSL, Thermal Integrity Profiling and other approaches -**Dr. Seth Robertson**




## Contributory Papers

For the conference, total 117 abstracts were received and 50 papers were published in the conference out of which 27 contributory papers were presented in the conference.

## Panel Discussion

Women in Deep Foundations (India) Group organized an engaging panel discussion program on 'Aspects of Growth of Women in the Industry', The program had a lot of interaction with the delegates & panelists and received all round compliments.

## DFII Student Awards 2022 – Research and Masters

The winners were **Sujata Jitendra Fulambarkar,** Research Student, IIT, Delhi **Gayathri Venu Latha**, Research Student, IIT, Delhi, **Godson M D,** Masters Student, Vellore Institute of Technology, Vellore

Overall the conference was a huge success with record turnaround of delegates and sponsors/exhibitors. DFI of India thank all the guests, sponsors, exhibitors, and delegates for their attendance; and the co-organisors IIT Tirupati & IGS Tirupati Chapter for their continuous support in organizing the event successfully.

# DFII Technical Committee News & Reports

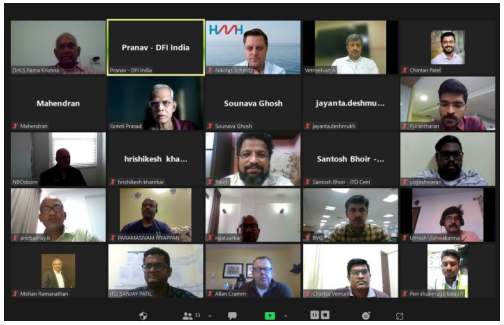
## DFII Committee for Geotechnical Characterisation for Foundations


DCGCF committee developed a 5-days short term training program for existing geotechnical investigation laboratory technicians to access their competencies, impart them with additional training and certify their knowledge. Two 5-days training programs were successfully conducted at Nagpur and Bengaluru in April'22 & June'22. 20 lab technicians were trained and certified during these programs.

More training programs are planned in NAC Hyderabad by end of 2022.

## DFII Training Committee

DFII formed a new committee to cater to the need of industry training on various technology/topics of current importance. As a part of the committee activity DFII delivered two online training programs, first one being 'Enhancing the Performance of Pile Construction in India' conducted in Jan'22, and second one titled 'Pile Top Drilling Using Reverse Circulation Drilling Technology' conducted in Feb'22. These training programs were well attended and received positive feedbacks. More training programs on diverse topics are in pipeline and will be announced soon.




## DFII Student Outreach Committee—Groundwork

DFII Groundwork committee continued the popular Groundwork Webinar Series in the year 2022 and conducted 5 monthly webinars from Jan'22 to May'22 on various topics important to Students and young engineers.

The committee also organised a virtual visit to Asia's Biggest Geotechnical Investigation Lab set up by NHSRCL & L&T at Surat for Ahmedabad - Mumbai High-Speed Rail Project.

These webinars got more than 100 attendees each time from various parts of world.

## CFA Pile Technology Implementation Committee

The committee is actively looking for projects where CFA Piling can be adopted in real-time project, and bring together different stakeholders for the same.

Dr. Sunil Basarkar, Chair of the committee, was regularly in touch with BIS and made a presentation to CED 43 committee in their 15th committee meeting about CFA pile prospects in India. After discussion, the CED 43 Committee agreed to come up with a Guideline document for CFA Pile construction and for this formed a expert panel. Dr. Basarkar was chosen as co-convener for this committee. DFII is hopeful that the BIS Guidelines will help consultants, contractors, and owners adopt the CFA piling technology in India.

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Cover Story—Continued from page 4

During the cutting of the Kimberlite, the material was collected in big bags and stored for further processing. Several manually and remote-controlled pumps needed to work hand in hand, what required good radio communication to prevent overflows. A maximum depth of 251.1 m was reached. It was the first time a trench cutter reached this depth for commercial purposes. It was proven that the trench cutter successfully and repeatedly reached depths greater than 220 m. It could also be proven that the technology can efficiently fulfil high requirements even in high-pressure environment.

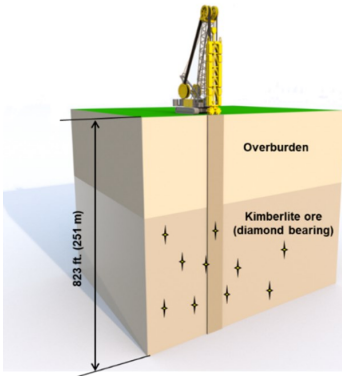


*Fig. 7. Geological situation*


*Fig. 8. Hung Hom Station*

### Construction of diaphragm wall in restricted height conditions: Hung Hom Station – Hong Kong

The aim of the project is the Construction of Hung Hom station with a Height restriction of 5.8 –6.5 m. Features are difficult job site logistics and hard-rock formations.

### Installation of D-Walls - Yunlingxi Deep Shaft - Shanghai

This involved installation of D-Walls of depth 80 – 105 m, Width 1.000 – 1.500 mm and Shaft excavation up to 57.84 m.

*Fig. 9. Yunlingxi deep shaft*

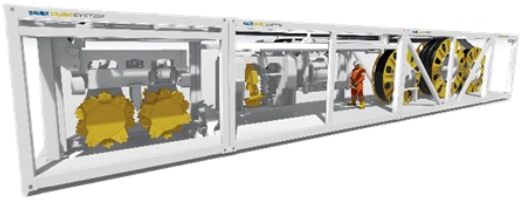

*Fig. 10. The cube system*

### Future trends and developments: Cube System

The cube system consists of a Cutter unit that enables the construction of D-walls, Underground and in confined spaces like Under bridges, on top of dams, Water storage / underground buildings,.

## Conclusions

One standard application for diaphragm walling is the construction of retaining walls. But the technique has much more to offer, as it can serve various types of different applications.

For many years, the system has provided solution for dam rehabilitations around the world. Different jobsite examples show that the diaphragm wall is a multi-purpose solution and looking back on the developments of the past, there is still more to expect.

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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, visit https://www.dfi.org/annual2023

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