GROUND IMPROVEMENT FOR SEAWALL AND RECLAMATION AT MUMBAI COASTAL ROAD PROJECT PACKAGE-1

Municipal Corporation of Greater Mumbai proposed to develop Mumbai Coastal Road from Princess Street flyover to Kandivali junction over a length of approximately 29 km to ease traffic congestion in Mumbai and to create recreational spaces. This project is being implemented in two phases, namely South and North. The south phase is divided into 3 packages. Among that, Package 1 of the project includes the construction of a 3.82 km long section over reclaimed land. Read more about it in the Cover Story on Page 3.

Picture Courtesy:

Volume 10 Book 1, Jan 2024

DFI of INDIA News

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

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GROUND IMPROVEMENT FOR SEAWALL AND RECLAMATION AT MUMBAI COASTAL ROAD PROJECT PACKAGE-1

Cover Story

- *Shrikar Nayak, Vipul Dobhada, Raj Kumar K, K S Bhat, T Vijayakumar,* L&T Construction

The Mumbai Coastal Road Project Package 1 includes the construction of a 3.82 km long 8-lane road section over reclaimed land. To create green spaces, in the congested city, an area of approximately 75 hectares from the sea is reclaimed and protected from the sea by seawall. The challenge for reclamation in the Haji Ali Bay area is the presence of marine deposits of thickness varying from 1m to 6m on rock stratum. Shear strength requirements of marine deposits are not satisfied, and settlement issues will be observed during service. Hence ground improvement by stone columns was suggested with the design of stone columns being done to restrict total residual settlement at 100 years to 65mm.

Figure 1: Area of Haji Ali Bay showing presence of marine clay in low tide.

Parameters Affecting Design

Design Life:

The design life of sea wall is 100 years. Further, the design life of rigid pavement and flexible pavements are considered as 30 years and 15 years respectively.

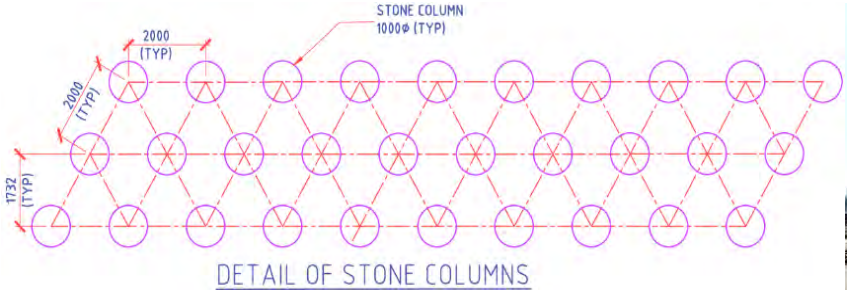

Figure 2: Layout in plan for stone columns (left) & Granular fill for stone columns (right)

Design Load

Uniform surcharge of 25kPa is considered on reclaimed area.

Settlement Limits

Settlement of reclamation fill

- Within the design life, total settlement of reclamation under the uniform surcharge including creep due to self-weight of reclamation fill shall not exceed 300mm.
- Angular distortion (differential settlement) to be less than 1 in 200 over a10m length (50mm in 10m length).
- In case of any ground improvement, the residual settlement shall not exceed 10% of the estimated total ground settlement.

Settlement of seawall

- ·Total settlement shall not be more than 50 mm over 100 years; and
- Angular distortion shall be less than 1 in 500 over a 10m length (20mm in 10m).

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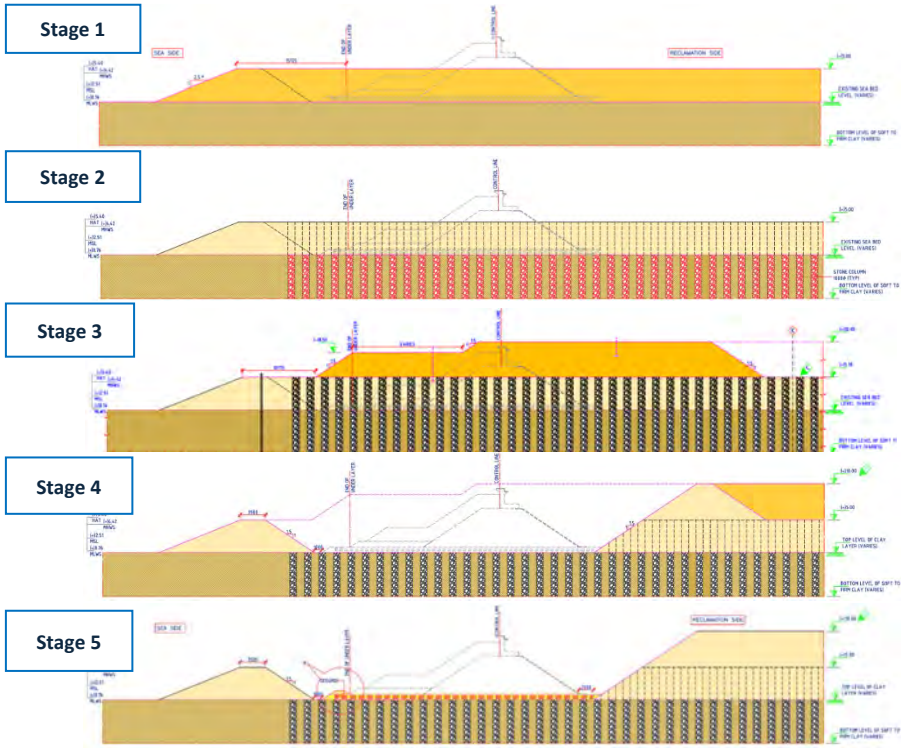
Figure 3: Driving of stone columns with vibrofloat



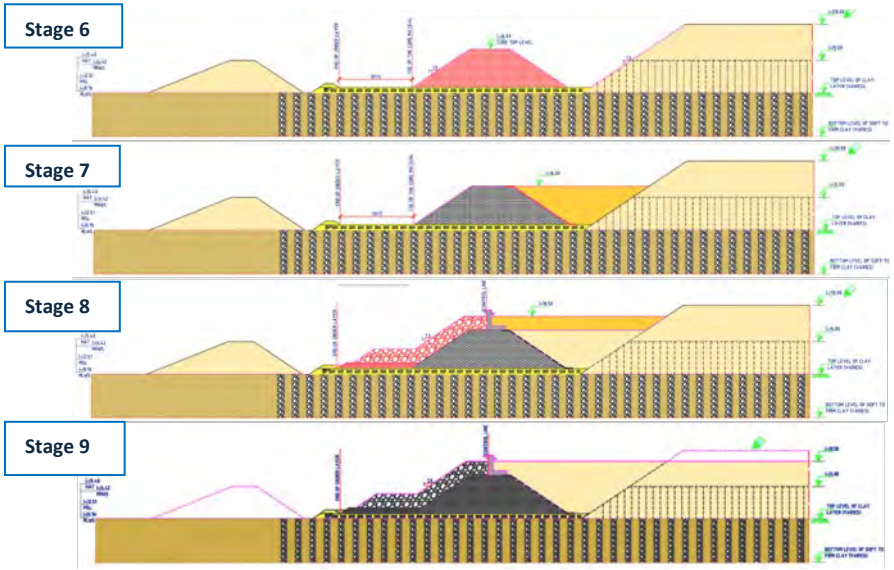


Figure 4: Construction sequence of stone column

The time required to achieve 95% consolidation without ground improvement is too high. Hence ground improvement by stone columns is proposed to accelerate the consolidation process and to improve the bearing capacity of soil.

Design methodology of Stone column Ground improvement proposed is in the form of stone column of 1m diameter at 2m centre to centre spacing in triangular pattern.

Construction sequence of stone columns is as follows:

Stage 1:

- Placement of reclamation fill up to (+)5.0m CD.

Stage 2:

- Installation of stone column.
- Post installation of stone columns, a waiting period of 72days shall be maintained before proceeding for further filling the material.

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- MASW testing at (+)5.00m CD to ensure 70% relative density of the fill below MHWS.
- For formation of stone columns above seabed level, the stone column material or crushed rock fill can be used.

Stage 3
- Raising of reclamation fill top level to (+)10.00m CD.
- Post filling, a waiting of period of 72 days shall be maintained to allow the 95% consolidation of the subsoil.
- Installation of instrumentation at (+)5.00m CD to monitor the deformations and pore pressures to ensure 95% of consolidation.
- Increase in shear strength and progress of settlement shall be monitored through instrumentation and monitoring.

Stage 4
- Excavation of surcharge fill for the construction of seawall.
- Placement of excavated material on the reclamation side as surcharge from (+) 5.00mCD to (+)10.00mCD.
- Sequence of filling shown above (+)5.00 m CD is tentative and can be modified to suit the construction methodology and schedule.

Stage 5
- Placement of 250mm thick granular material.
- Placement of first layer of geogrid.
- Placement of 250mm thick granular material over the first layer of geogrid.
- Placement of second layer of geogrid.
- Placement of 250mm thick granular material over the second layer of geogrid.
- Placement of additional 500mm thick granular material on the seaside of the under layer.

Stage 6
- Placement of core material up to the core top level.

Stage 7
- Laying of geotextile over the landside slope of the core material and levelling the gap between core and the reclamation fill.

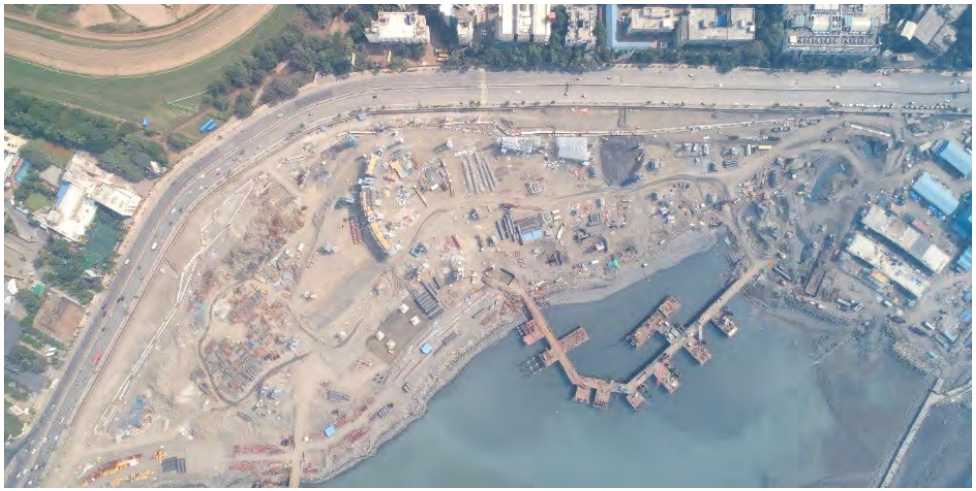

Figure 5: Reclamation post completion of ground improvement

Stage 8
- Construction of toe and armour of the seawall.
- Positioning of wave wall followed by the placement of reclamation fill up to (+) 8.50mCD.

Stage 9
- Removal of temporary reclamation on seaside.
- Removal of surcharge fill of about 1.5m thickness.to achieve the design formation level of (+)8.50mCD.

For the different construction stages, time required for 95% consolidation, improved cohesion, bearing capacity of the improved ground is checked.

The estimated maximum residual settlement at the reclamation is 65.46mm, which is less than the allowable residual settlement of 300mm. The estimated maximum residual settlement at the seawall location is 29.49mm, which is less than the allowable residual settlement of 50mm. Hence meeting the employer's requirements.

My Journey with DFI Family

Annapoorni Iyer, *Executive Committee Member, DFI of India*

I would like to start the article with a quote '*EVERY MOMENT IS A NEW BEGINNING*'. The quote is in context to a phone call that I received from Dr. Kumar Pitchumani somewhere in August 2019, asking me if I would be interested in getting connected with DFI, especially with Women in Deep Foundations (WiDF) India. That one call and the connections that were built up was a perfect start to something which turned out to be a beautiful association with DFI. My professional career started in the year 2002 and I was definitely a little late to team up with DFI, but once begun it has been a vibrant association. The first WhatsApp call with Lucky i.e., Sri Lakshmi Nagarajan seemed to be as if we had been friends for long, such is the aura of DFI team and that's the level of comfort the institute extends to the members. DFI is indeed a wide platform that accommodates professionals and academicians having interest in deep foundations and provides them with enormous growth opportunity.

My first personal interaction with DFI was in the conference held in year 2019 at Hyderabad. It was the 9th Annual Conference on Deep Foundation Technologies for Infrastructure Development in India. I was an invited panelist for a discussion on the topic 'Challenges for Women in the Industry', it was my first experience as a panelist and I enjoyed the event thoroughly in the company of Theresa Engler (Executive Director, DFI), Lucky Nagarajan (Geocomp), Supriya Marathe (Mumbai Municipal Corporation for Environment), Dr. Yogini Deshpande (Renuka Consultants), Sangeen Naik (Keller Ground Engineering), Akhila Manne (Unirac Solar India). Gradually, I understood the objectives of WiDF and what fascinated me most was the collaborative working of men and women to foster the growth of women in construction industry. The kind of encouragement the male professionals render to the growth of women engineers never ceases to amaze me and that is what encourages me to keep my contribution benchmark towards DFI high.

The WiDF of India group was motivated by the Webinar series 'Converting Crisis into Opportunities' launched by the Metro NYC WiDF group. With strong support and inspiration from Lucky, WiDF India group was charged up and launched the webinar series under the topics 'Civil Engineering Careers - Connect and Grow' during the covid years of 2020-21. The sub topics were finalised after lot of internal discussions so as to bring the best for the student and the young engineering community. Webinars were held on topics like 'Bridging Academia and Practice', Beyond the Classroom', 'Foundation for Future', etc. Recent one being in 2023 titled 'Opportunities & Experiences for Women Engineers Outside India'. The webinar series brought the members of WiDF even closer and our regular meetings used to start anywhere after 7pm and

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would extend for about 90 minutes, such was the passion and interest to connect with fellow members even towards the end of day (in India). This was definitely fueled with high energy level from Lucky, Theresa, Mary Ellen Large (former DFI director of technical activities) and Sayantani Ghosh (LANGAN) who used to join from different time zones and that was absolutely inspiring! The platform of webinars provided me with a lot of opportunities to learn technical topics as well as improved soft skills and moderating capabilities. Every year WiDF India team conducts a one-hour program in DFI-India Annual Conferences. The first being in 2018. This program has always received great appreciation from the delegates.



'*Educate a Woman and she will educate a family*', in DFI family we have quite a number of women engineers willing to contribute towards the institute in different ways. Retaining women in the construction industry is essential and creating a conducive environment for the retention is equally important. Representing the WiDF India task force, along with my colleagues and senior professionals, I pledge the support and care towards this society requirement through relentless efforts and inclusive working. I would like to take this wonderful platform to invite each and every woman civil engineer to be a part of this wonderful family. I'm sure if you are not yet here, then you are indeed missing something very beautiful.

Along with WiDF (India), I am happy to be part of two other DFII Technical Committees. The first one being DFII Student Outreach-Groundwork Committee, chaired by Dr. B. Uma Shankar, IITH, where we formulate several activities that benefit young professionals and students. The famous Groundwork webinar series is being conducted under this committee. This series brings out technical talks, panel discussions that benefit the deep foundation fraternity. The first webinar of Groundwork 2024 webinar series was conducted in January. I encourage everyone to register for the same. Also, every year, this committee awards students in Deep Foundations and Ground Improvement Fields under best PhD Research and Masters Project Category. The committee is also planning to arrange a few site visits for students collaborating up with major geotechnical firms.

The other technical committee is "DFII Helical Pile Technology Implementation Committee" chaired by Mr. Mohan Ramanathan, recently formed in December 2023.

DFI is a family which is built with elements of deep technical knowledge put into practice as strong foundation, innovation, diversified skills and expertise, above all love, care and respect towards fellow members. I strongly call upon all the practicing engineers, student engineers, academicians, professional experts to be a part of DFI family and celebrate your professional growth in the company of the DFI family.

Investigation on Dynamically Installed Foldable Torpedo Anchor for Offshore Structures

- Keerthi Raaj S, Bentley Systems, Inc; Nilanjan Saha, R. Sundaravadivelu, Indian Institute of Technology, Madras, Chennai

Introduction

Deep foundations are not only limited to the onshore structures but also extended to the near shore and offshore structures. Compared to the onshore structures, the offshore structure's foundation design and analysis are challenging due to the increased water depth, hostile weather conditions, requiring special installation techniques and also being far away from onshore. In recent times, offshore structures foundation systems are re-emerging due to the shift of offshore industry from shallow waters to deep waters, where shallow water resources are depleting rapidly. These deepwater offshore structures are usually designed as a floating system, which often requires an efficient anchoring system to moor them safely to the seafloor. There exists a wide variety of anchoring systems like pile anchors, drag anchors, plate anchors, suction anchors and gravity anchors. Torpedo anchors are a new kind of gravity-installed anchors where no external installation energy is required and independent of water depth. Additionally, owing to the gravitational force for installation made them easier, faster and simpler to install compared to other anchoring techniques. Though these anchors are easy to fabricate, install, and maintain, they are still not used widely due to the following reasons. i) Their ability to withstand ample horizontal loads made them primarily used with a catenary mooring system, but in the case of a taut mooring system, their performance is less. ii) Despite the simple installation technique, the conventional torpedo anchor concept is rare in practice because of its relatively low short-term pullout capacity, even though they are good enough in the long term in normally consolidated clays. In addition to the above reasons, the fins generally get damaged during transport, leading to stability issues. The motivation of the present work is to develop a new type of dynamically installed anchoring concept and experimentally analyse this concept.

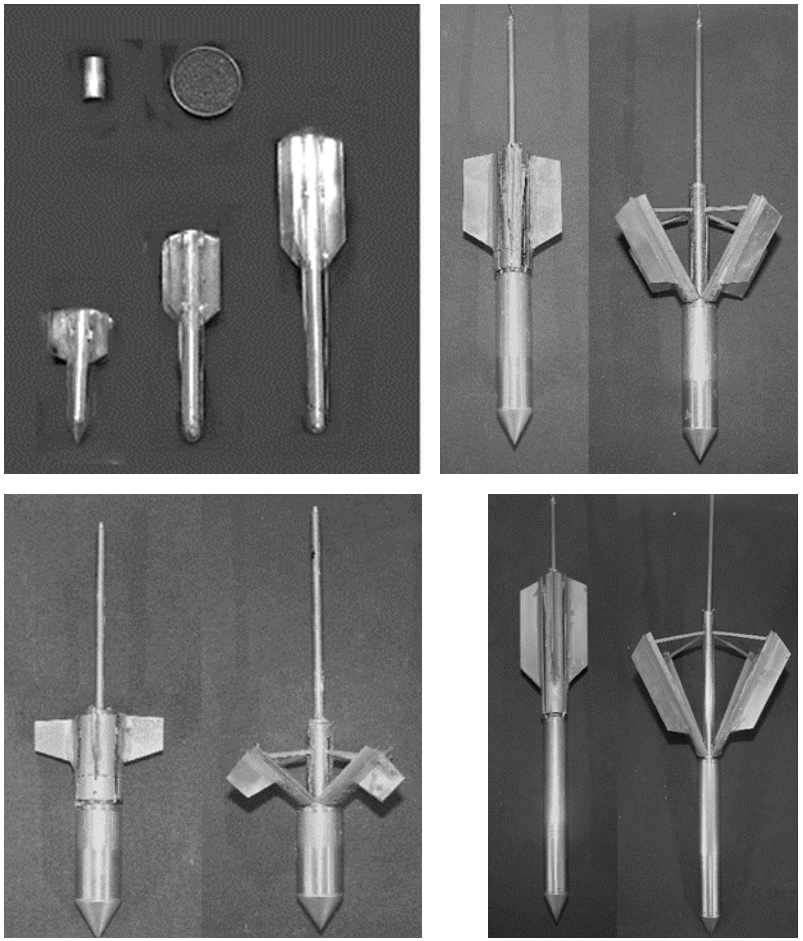

Figure 1: 1:50 scaled anchor models (a) conventional torpedo anchor (b – d) FOTOAN©.

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Proposed anchor

A novel foldable torpedo anchor (FOTOAN©) has been proposed as an efficient technique for deepwater anchoring applications, especially in taut mooring systems. Since the conventional torpedo anchor performances in the taut mooring system are not as much of a catenary system, very few works have been done to improve the vertical pullout capacity. This paper presented a novel proposal for a high vertical bearing resistance anchoring concept from a simplified installation and keying process. These anchors are more effective for deep waters with soft, normally consolidated clay strata. The FOTOAN© is similar to the conventional torpedo-shaped anchors but comprises of foldable wings and fins, which extend laterally to increase the pullout resistance. The FOTOAN© is installed to the target embedment depth into the seabed by free fall in the water column (similar to the conventional torpedo anchors).

After the embedment, the central shaft is tensioned, making the anchor wings extend perpendicularly in the soil with minimal loss in the embedment depth, as illustrated in Figure 1. The wings consist of fins and hinges, which act as an inclined plated anchor and support the load eventually. Thus the FOTOAN© combines the functions of conventional torpedo anchors for easier installation and plate anchors for increased load-bearing resistances.

Experimental Program

This study aimed to assess the geotechnical performance of the novel FOTOAN© through 1g laboratory experimental studies. The 1g laboratory study was conducted with 1:50 scale-down models with both conventional torpedo anchor and FOTOAN©. The scale-down models of both the torpedo anchors are subjected to drop tests in the water column and test beds. All the 1g laboratory tests are performed in the Department of Ocean Engineering at IIT Madras. The reduced scale-down model anchor is instrumented with the Inertial Measuring Unit (IMU) to record the anchor acceleration profile during the free fall and subsequent penetration into the soil. The water column drop test is conducted with the instrumented anchors in a 4.5m

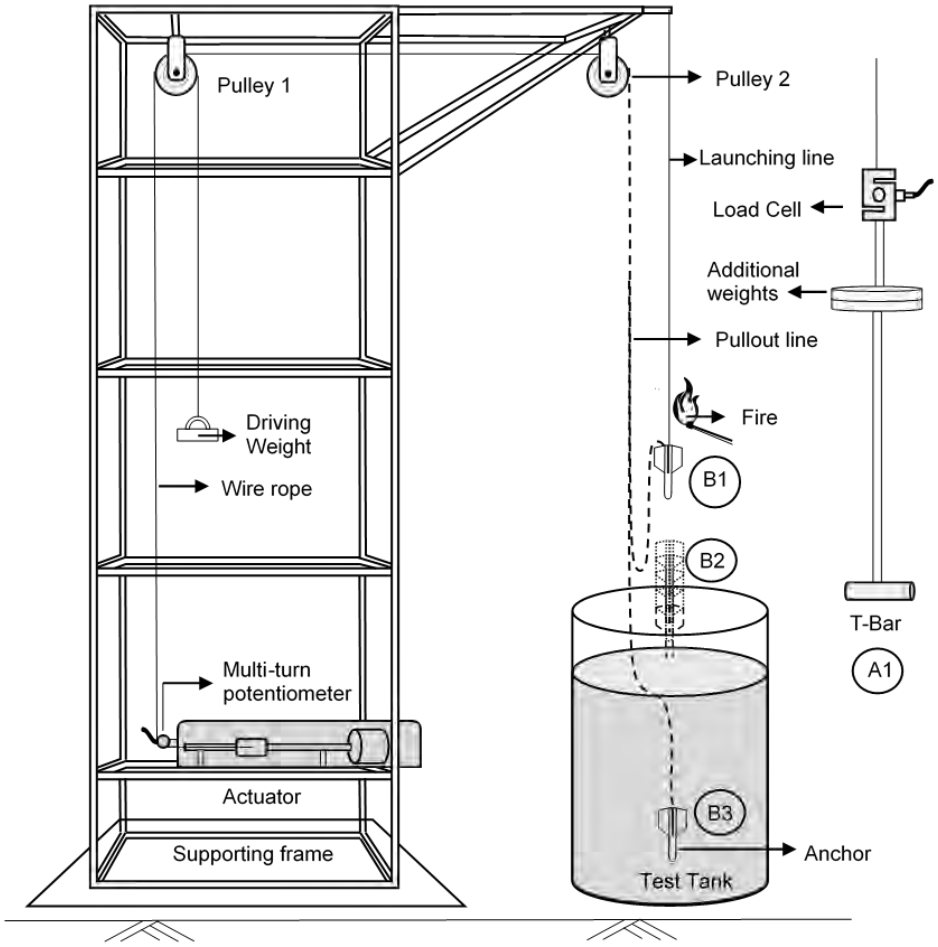

Figure 2: Schematic representation of T-bar and drop test experimental arrangement. A1 – T-bar test procedure, B 1 to B3 Drop sequence (B1 - Anchor positioned and all set for launch, B2 - Freefall and B3 – Final penetration depth).

deep water pit to study the hydrodynamic behavior of these anchors. From the drop tests, the anchor freefall velocity, drag coefficient, and

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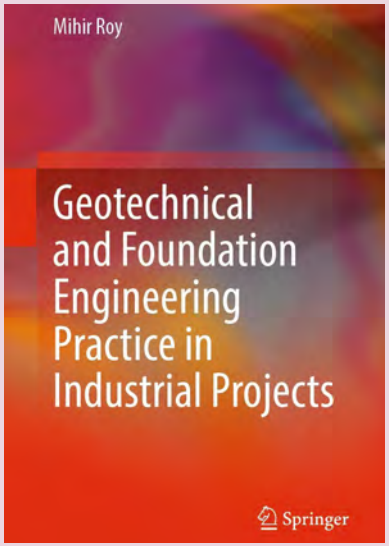
hydrodynamic force variation due to the change in the ballast weight, nose shape, and fin length effects are investigated experimentally. In the lg drop tests in four different test beds, the conventional anchors are made to fall freely into the testbeds at different drop heights, and the corresponding anchor tip embedment depth is measured. Accounting for the following parameters like nose shape, fin numbers and ballast weight, their effects on the tip embedment depth were examined. In the case of the FOTOAN©, drop tests in the different test beds are conducted to study the anchor unfolding mechanism, loss in the embedment depth during the keying process and the ultimate pullout capacity.

Conclusion

It is observed from the present experimental studies the conical nose shows inferior performance due to its significant lateral displacement in the water column. But at the same time, sharper conical-nosed anchor models end in larger tip embedment depth. Numerical simulations also showed that long elongated cones (tip angle <60°) were more efficient. A limited comparative laboratory study of the FOTOAN to the conventional torpedo anchor in soft clay was performed. FOTOAN© in the vertical mooring systems, the performance is improved on an average by 3.5 – 5 times compared to the conventional torpedo anchors. Thus, the FOTOAN has been promised as an efficient technique for deepwater anchoring applications.

DFI of India 2023 "Lifetime Contribution Awardee" **Dr. Mihir B. Roy** summed up all his professional experiences in a book titled ***"Geotechnical and Foundation Engineering Practice in Industrial Projects".*** This book is an important resource on the topics of geotechnical and foundation engineering for practicing engineers and consultants. In the book simplified analytical & practical approach to foundation solutions for steel, power, marine & mining industries; dam, earthquake and other disciplines have been compiled in 15 chapters. This book will be of interest and useful to foundation & civil engineers and academicians practicing in industrial projects.



You can buy your copy of the book here:
https://link.springer.com/book/10.1007/978-981-99-7906-6

Dr. CR Parthasarathy to chair DFII DCGCF Committee supported by Mr. Sorabh Gupta as Vice-Chair

Dr. CR Parthasarathy has taken charge as the chair of DFII Committee for Geotechnical Characterization for Foundations (DCGCF) for 2024-26. Mr. Amol Shingarey, the immediate past chair stepped down from the responsibilities of the Committee Chair after serving the committee for three years supported by Dr. Partha as Vice-Chair during 2021-23. Dr. Parthasarathy is the Founder Director of Sarathy Geotech & Engineering Services Pvt ltd., Bangalore. He is instrumental in promoting quality testing of deep foundations in India. To support the chair, the committee selected Mr. Sorabh Gupta as the Vice-Chair for the committee. Mr. Sorabh is a Director at CENGRS Geotechnica Pvt. Ltd., Noida. He is instrumental in promoting good work practices in the field of Ground Characterization.


Dr. CR Parthasarathy


Mr. Sorabh Gupta

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 technical@dfi-india.org

DFI - India 2024: 13th Annual Conference on Deep Foundation Technologies for Infrastructure Development in India

Sept 19th - Sept 21st, 2024

DFI of India (DFII) is preparing for its 13th annual conference in collaboration with Indian Geotechnical Society (IGS) Goa Chapter during 19-21 September 2024 at GOA, the party capital of India.

Join us for the most loved conference by the industry.

The call for abstracts for original technical papers is open now!!! The deadline for the same is 19 Feb'24.

Submit your abstracts here: https://dfi-events.org/india24/

DFII & DFI Upcoming Events

GROUNDWORK

Laying the Foundation for the Next Generation of Foundation Practitioners

DFI of India Student Outreach Committee 'Groundwork' restarted its popular monthly webinar series from Jan'24 onwards.

These webinars are developed for students in civil engineering and particularly with geotechnical engineering interests. The program will focus on supplementing academic coursework with practical design, construction, and QC/QA topics, describe various types of careers and introduce companies in geotechnical and foundation industry, raise awareness of DFI and resources available.

Registration is free and applicable for all the upcoming webinars in this series. Working professionals from industry can also join the program.

For more details, visit: https://dfi.org/events/upcoming-events/

Event	IFCEE 2024	Conference on Foundation Decarbonization and Re-use	SuperPile 2024	S3 2024	DFI-India 2024	DFI49
Date	May 07-10, 2024	May 28-30, 2024	June 12-14, 2024	Aug 6-8, 2024	Sept 19-21, 2024	Oct 07-10, 2024
Venue	Dallas, Texas	KIT, Amsterdam, Netherlands	San Francisco, California	Aurora, Colorado	Goa, India	Aurora, Colorado

Deep Foundations Institute of India is regularly conducting workshops and conferences in association with other organizations with similar interests

Women in Deep Foundations (India) Corner

WiDF (India) in collaboration with IGS Bangalore chapter visited Indian Institute of Science (IISc) on 8th Dec'23 for a meet up event with the student community and to share key learnings, exciting career path opportunities, and thrilling stories from the experiences of civil/ geotechnical industry professionals. The speakers of the session were Dola Roychowdhury, GCUBE Consulting Engineers LLP, Lucky Nagarajan, Geocomp/Chair WiDF/DFI Board of Trustees, Akhila Manne, Unirac Solar India LLP, Sushma B, Tata Consulting Engineers India Ltd., Dimpu Chindappa, Mobility Agenda, Sangeetha K.M., SGES and Devika Somanna, Jacobs. Session started with introduction by Prof. Madhavi Latha and the HOD of civil engineering department, IISc Bangalore.

Lucky Nagarajan introduced WiDF to the audience and highlighted on how the students and young professionals can benefit from this session. She also addressed the impact of WiDF initiatives within the industry.

Akhila Manne shared how her choice of civil engineering career was inspired from natural disasters in India, technical lectures by academicians and female professor that helped her find the way in earthquake engineering. She also shared the opportunities available for geotechnical engineers with computer skills and the future of software in geotechnical industry. During the interaction with audience, Akhila highlighted that knowing several geotechnical software is not the key to finding a job, rather focusing on the core concepts and acing the interview with confidence gained through knowing the concepts is the key.

Sushma gave a brief insight on the job options in geotechnical engineering based on the individual interest. She highlighted the career options available in site work with contracting firms or with the geotechnical consultant. She also emphasized on the need to visit site even while doing design work as finally the design done needs to suit the site requirements. Sushma emphasized that the confidence and determination of the candidate is very important and they need to

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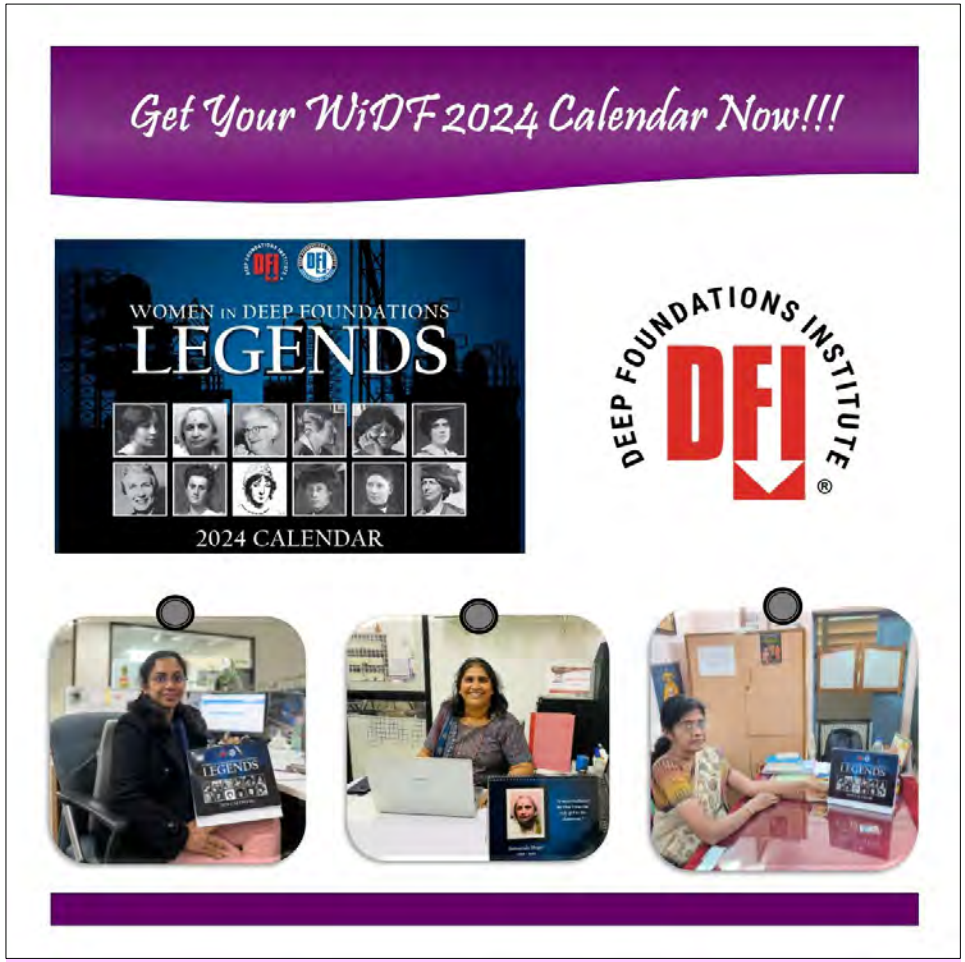
clearly explain their capabilities and assurances on responsibly handling the job if they are selected.

Sangeetha, highlighted that stepping out of ones' comfort zones is crucial for advancing ones' career. Establishing a personal brand is key to standing out in a competitive environment. She also mentioned that leveraging resources on LinkedIn and other social platforms, along with networking, can significantly impact both career and personal development.

Dimpu Chindappa highlighted that finding oneself and knowing what ones' heart wants really helps in choosing the right path professionally. The process may take 5-10 years or even more and patience is the key. Exploring different career paths in initial years of career helps in understanding ones' strengths and accordingly one can take a call. It's okay not to have everything figured out in early 20s. Dimpu also suggested the students that the key to success is being original, patient and consistent with one's efforts.



WiDF 'Legends in Civil Engineering Calendar 2024' is selling out fast. This calendar celebrates the accomplishments of female engineers throughout history, and aims to support the activities of WiDF Committee. Order your copy Now!!

Place your order here: https://forms.gle/ZePEhhvKzrrr4vF49

DFII Technical Committee News & Reports

DFII Committee for Geotechnical Characterisation for Foundations

DCGCF committee conducted first 5-days workshop of 2024 (sixth overall) for Geotechnical Investigation laboratory Testing, at L&T Construction Research and Testing Centre, Chennai during 08 - 12 Jan'24. The program received excellent feedback from all the participants who joined the program from all across India. More workshops are planned in different regions of India.

The committee is also working on different activities focused on enhancing the adoption of good work practices and tender practices related to geotechnical investigation. Details will be rolled out soon.

DFII Training Committee on Foundation Technologies

The two training programs on Support Fluids for Foundation Construction and Tremie Concrete for Deep Foundations in 2023 gained a lot of popularity. DFII Training committee is now working on the next program on the topic "Ground Improvement". This program is being planned as an in-person event in Chennai. More details about the program will be shared soon. The Committee is planning to have more programs on Working Platforms, Tool Management for Construction Equipment, etc.

DFII Student Outreach Committee—Groundwork

DFII Groundwork committee started the Groundwork Webinar series 2024 and conducted the first webinar of the series on 23 January 2024. Mr. Rudolf D'Souza, Knowledge Management Consultant, AFCONS Infrastructure Limited was the Speaker for the webinar. He delivered a technical presentation on 'Sustainability Considerations in Foundation Construction from Design to Execution'. The webinar received a very good feedback from the attendees. The monthly webinars will continue till May 2024.

The Committee is also planning to have a few site visits for students. More details will be rolled out soon.

CFA Pile Technology Implementation Committee

BIS formed Panel 20 under CED 43 to develop CFA Guidelines. Dr. Sunil S Basarkar, Chair, DFII CFA Committee, is the co-convener of P20 group. DFII is represented by Mr. I V Anirudhan in P20. The draft of the guideline is prepared taking inputs from DFII Guidelines for CFA Pile Construction. P20 members gave their comments on the draft document. Same are being implemented and the revised document will be sent to CED 43.

The committee is also planning a workshop on CFA Pile construction with IGS Chapters/institutes in different parts of India, starting with IGS Kolkata Chapter.

DFII Helical Pile Committee

A new DFII committee on Helical Piles is formed, chaired by Er. Mohan Ramanathan. The committee is working on finalizing its goals and activities.

Follow DFI of India on social media for updates & announcements

DFI India Technical Committee Members

DFII Committee for Geotechnical Characterization for Foundations (DCGCF)

Dr. C R Parthasarathy, *Sarathy Geotech* (Chair)
Mr. Sorabh Gupta, *CENGRS* (Vice-Chair)
Mr. I V Anirudhan, *DFII*
Mr. K Bikshapati, *NAC*
Dr. Yogini Deshpande, *Renuka Consultants*
Mr. Aloke Samantha, *Fugro Geotech*
Dr. Ravi Sundaram, *CENGRS*
Dr. A Murali Krishna, *IIT Tirupati*
Dr. Arindam Dey, *IIT Guwahati*
Dr. Sreevalsa Kolathayar, *NIT Surathkal*

DFII Training Committee on Foundation Technologies

Mr. Ravikiran Vaidya, *Geo Dynamics* (Chair)
Mr. I V Anirudhan, *DFII*
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