STRUCTURAL ENGINEERING

QUARTERLY JOURNAL OF
INDIAN SOCIETY
OF
STRUCTURAL ENGINEERS

ISSE

VOLUME 21-4

OCT-NOV-DEC 2019

GEM 22 PROF. JAI KRISHNA - A DOYEN OF STRUCTURAL AND EARTHQUAKE ENGINEERING, SEE PAGE - 3

TALL AUTOMATED STORAGE RACKS NEW CHALLENGES TO STRUCTURAL DESIGNERS, SEE PAGE - 8

VASUDEV V. NORI
PRECAST CONCRETE PILES, SEE PAGE - 15

17 DEC 2019 : HEMANT VADALKAR AT ISSE SOLAPUR FUNCTION

29 NOV 2019 : ISSE BELAPUR CENTRE, CHALLENGES IN MULTIPLE LEVEL BASEMENT CONSTRUCTION BY PROF. G. B. CHOUDHARI

17 DEC. 2019 : MADHAV CHIKODI AT VES POLYTECHNIC, CHEMBUR STUDENT CHAPTER PROGRAMME IN MUMBAI

LET US BUILD A STRONG STRUCTURE OF INDIAN SOCIETY

ISSE EVENTS

ISSE NAVI MUMBAI LOCAL CENTRE
29 JAN 2019

ISSE STUDENT CHAPTER MIT PUNE
15 FEB 2019

INAUGURATION OF STUDENT CHAPTER
CHAMELI DEVI GROUP OF INSTITUTIONS,
INDORE 26 FEB 2019

WORKSHOP ON WIND ENGINEERING

Site visit to Sardar Sarowar Dam and
Statue of Unity 9 Mar 2019

LECTURE ON Role and Responsibility
of Structural Auditor at VJTI 9 Aug 2019

LECTURE ON Concrete by
Mahesh Tendulkar at Virar 19 Sept 2019

13 Dec 2019 : Lecture on Precast Concrete Piles
By Dr. V. V. Nori at SASMIRA, Mumbai.

STRUCTURAL ENGINEERS

INDIAN SOCIETY OF STRUCTURAL ENGINEERS

ISSE

VOLUME 21-4, OCT-NOV-DEC 2019

Head Office : C/O S. G. Dharmadhikari, 24 Pandit Niwas, 3rd Floor, S. K. Bole Road, Dadar. (W), Mumbai 400 028 ● Tel. 91-22 24314423 / 24221015
I E-mail : issehq@hotmail.com ● Website : www.isse.org.in
Regd Office : The Maharashtra Executor & Trustee Co. Ltd., Bank of Maharashtra, Gadkari Chowk, Gokhale Road (N), Dadar (W), Mumbai 400 028.
Charity Commissioner Reg. No. E 17940, Mumbai Donations are exempted from Income under 80-G

Contents

Editor : Hemant Vadalkar

Fraternity News

WELCOME TO NEW MEMBERS

(OCT-NOV-DEC 2019)

1	M	1779	Sameer Mahipat Jadeja
2	M	1780	Ajinkya Kishor Mapari
3	M	1781	ChaitanyaAnnasaheb Badave
4	M	1782	S. Ramraj
5	M	1783	Pradnya Voikanth Sambary
6	M	1784	Chandata Tejakiran
7	M	1785	Sachin Dattatray Agnihotri
8	M	1786	C. Murugeshan
9	M	1787	Saba Bano Abdul Hafij Ansari
10	M	1788	Narayanswami A. Naidu
11	M	1789	Sanket Shrimant Jagdale
12	M	1790	Sachin D. Bhalerao
13	M	1791	Sanjay B. Khot
14	M	1792	SarishZiqddin Khan
15	M	1793	OmkarGokulNagare
16	M	1794	VirupakshGanpatiKhurd
17	M	1795	AshishRatanchandKondekar
18	M	1796	Mohan HanumantTulpule
19	M	1797	MadhukarDashrathBalate
20	M	1798	NitinkumarHiralal Jain
21	M	1799	Ajay Narayan Jadhav
21	M	1800	Manikandan P.
22	M	1801	DarshanGoplaraoGaidhankar
23	M	1802	AjinkyaMakrandMalkar
24	M	1803	OnkarnathGopaldasSaeda
25	M	1804	SandipVasudevWarang
26	M	1805	Vijay Rajman Singh
27	M	1806	Anand Ramanth Katti
28	M	1807	Rahul Sanjay Mistri
29	M	1808	H.P. Yogesh
30	M	1809	Narayan Laxman Mane
31	M	1810	Kumar Shamrao Hunkare
32	M	1811	Nandkumar Raghunath Patil
33	M	1812	Avinash Pandurang Shepur

Patrons : 38 | Organisation Members : 28 | Sponsor : 8

Members : 1812 | Junior Members 51 | IM : 01

Student Members : 159

TOTAL STRENGTH : 2,097

- ❄ Structural; Designing & Detailing
- ❄ Computer Software
- ❄ Materials Technology, Ferrocement
- ❄ Teaching, Research % Development
- ❄ Rehabilitation of Structures
- ❄ Construction Technology & Management
- ❄ Geo-Tech & Foundation Engineering
- ❄ Environmental Engineering
- ❄ Non Destructive Testing
- ❄ Bridge Engineering & Other related branches

1. To restore the desired status to the Structural Engineer in construction industry and to create awareness about the profession.
2. To define Boundaries of Responsibilities of Structural Engineer, commensurate with remuneration.
3. To get easy registration with Governments, Corporations and similar organizations all over India, for our members.
4. To reformulate Certification policies adopted by various authorities, to remove anomalies.
5. To convince all Govt. & Semi Govt. bodies for directly engaging Structural Engineer for his services.
6. To disseminate information in various fields of Structural Engineering, to all members.

GEM 22 PROF. JAI KRISHNA - A DOYEN OF STRUCTURAL AND EARTHQUAKE ENGINEERING

By Prof. Jai Krishna

Prof. Jai Krishna was an eminent civil engineer, educationist, researcher and academic administrator, who specialized in earthquake engineering. He is known for his illustrious service at the University of Roorkee, from 1939 to 1971, going on to become its Vice Chancellor between 1971 and 1977, and, continuing as its first Professor Emeritus till the end of his life. Dr. Jai Krishna made many pioneering contributions as an educator, researcher, innovator and institution builder. A doyen of Structural and Earthquake Engineering, Prof. Jai Krishna is credited with pioneering teaching, research and practice in Earthquake Engineering in India. He was a gifted and motivating teacher, an imaginative and original researcher, a prolific author of books (co-authored two volumes of a book on Plain & Reinforced Concrete, which has served generations of Indian engineers) and technical papers, and, above all, an intelligent and warm person.

Early Life

Prof. Jai Krishna was born on February 14, 1912, at Muzaffarnagar, a small district town in Uttar Pradesh. After obtaining his Bachelor's degree in Science from the Agra University, topping the list of successful students, he entered the Thomason College of Civil Engineering (now IIT Roorkee) in 1932, with first position in the merit list. He passed with honours from the College in 1935. As a student, he won several awards such as Thomason Prize, Cautley Gold Medal and Calcott Reilly Memorial Gold Medal. He obtained his Doctoral Degree in Civil Engineering from the University of London in 1954, which he completed within two academic years (less than two calendar years).

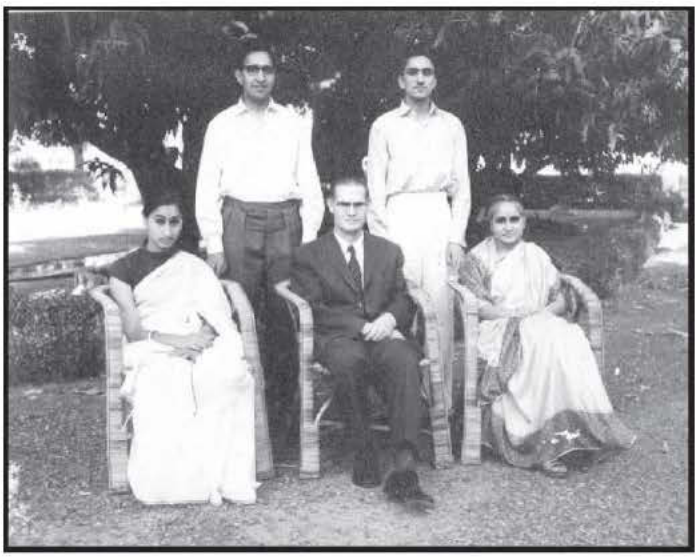
Professional Career

After working for a brief period in the State Public Works Department, Prof. Jai Krishna joined Thomason College of Civil Engineering in 1939 as Lecturer where he rose to the rank of Professor in 1960. In 1971, he was appointed the Vice Chancellor of the University of Roorkee, thus becoming the first teacher of this institution to be elevated to this high office.

As a young member of the faculty, and, as a keen teacher, he made two significant contributions. With his former student and protégé, Dr. O.P. Jain, as co-author, he produced a book in two volumes on Plain and Reinforced Concrete, in the late 1940s (also mentioned in a paragraph later), which has continued to serve Indian engineers till date. This also inspired many Indian academics to produce texts on different aspects of Engineering, in the years to come. Besides this, a not so well known contribution of him was to introduce a course in Soil Mechanics for the first time in the country, in 1948-49. Later in the 1950s Prof. Jai Krishna made the path breaking foray into the development of Earthquake Engineering in India, which is described in the following section.

Work in Earthquake Engineering

Prof. Jai Krishna, while he visited the California Institute of Technology, USA, in 1956, developed close association with Profs. G.W. Housner and D.E. Hudson, who were renowned experts in Earthquake Engineering. This association resulted in the starting of a teaching and research program in Earthquake Engineering at the University of Roorkee in 1960. This was the only program of its kind in India for several years. He pioneered the study and application of structural dynamics and established the School of Research and Training in Earthquake Engineering (later converted as the Department of Earthquake Engineering) at the Roorkee University. This is the only department of its kind in India even today.



Dr.Jai Krishna & the family at their residence with Prof. D.E.Hudson, 1958

He was the first in India to introduce a course on Structural Dynamics in 1958. He was the prime motivating force behind the formulation of an Indian Standard on Earthquake Resistant Design of Structures that was brought out by the Indian Standards Institution (now Bureau of Indian Standards). This standard (IS 1893), is one of the most comprehensive in the world, and, has been used extensively. This standard has since undergone many revisions and diversification (the sixth revision of this code was released by BIS in 2016 and is now published in 5 parts). Dr. Jai Krishna's work brought in original ideas in the design of earthquake resistant structures and led to the evolution of economic and safe construction practices.

Prof. J. Krishna along with Honorable Prime Minister Pandit Jawahar Lal Nehru during the latter's visit to the University in 1958

In developing the R & D programme, his first concern was the solution of problems in India. Thus, while other institutions in the world worked on seismic safety of tall or large engineered structures (in steel or RCC) in the 1950s, Dr. Jai Krishna initiated research on the seismic safety of brick buildings, which were built extensively in India, at that time. This won recognition of the work in India. It was for the first time in the country that seismic studies on feasibility of a Nuclear Power Plant at Narora was taken up and eventually detailed seismic analysis of various structures in this project were also carried out using the expertise available within the country. Subsequently, work on a number of other nuclear power plants was also carried out fully through indigenous know-how. He has also been responsible for earthquake resistant design of a large number of major and important engineering projects in India.

President Fakhruddin Ali Ahmad being shown the hous model tested for earthquak shocks, 1976

The widespread application of the results of his research investigations in India and abroad is evidence of his great scholastic abilities. Since there was hardly any seismic data available for the design of structures in India till the 1960s, Prof. Jai Krishna initiated work on the design, fabrication and installation of structural response recorders and accelerographs in India to collect such data. This activity, later picked up momentum and began to yield very useful database, which would go a long way in guiding engineers to adopt appropriate attenuation relationships for seismic design of important engineering structures.

His outstanding contribution on the development of facilities for laboratory and field testing has led to independence from foreign equipment and consultancy on such problems and has greatly helped import substitution.

Group Photograph during 6th World Conference in Earthquake Engineering 1977

Books, Papers, and Awards

Prof Jai Krishna had authored text books on reinforced concrete as well as earthquake engineering which served as basic reference material for engineering studies all over the country. He published extensively in various national and international journals as well as conferences and won many prizes and awards from national and international organizations. Some of the notable awards are Shanti SwarupBhatnagar Award of CSIR (1966), National Design Award (1971) of the Institution of Engineers (India), Moudgil Award of Indian Standards Institution (1972), International Award of Japan Society of Disaster Prevention (1988) and award for life time contributions in Earthquake Engineering by Indian National Academy of Engineering (1997). ISET honoured him by bringing out a reference volume on earthquake engineering to commemorate his 60th birth anniversary. Prof. Jai Krishna was awarded Honorary Degrees of Doctorate by Agra University and the University of Roorkee. For his meritorious services to the nation, he was conferred Padma Bhushan by President of India in 1972.

Receiving PADMA BHUSHAN (1972) from H'onble President of India, Sri V. V. Giri

Prof. Jai Krishna (1912-1999)

Association with Professional Societies

Prof. Jai Krishna traveled far and wide and visited many countries all over the world. He held several

important national and international assignments in various capacities. Prof. Jai Krishna was a Fellow of several professional bodies and academies. Some of the important amongst these are the Indian National Science Academy, Indian National Academy of Engineering, Institution of Engineers (India), American Academy of Engineering, Third World Academy of Sciences, and the International Association of Earthquake Engineering of which he was the President during the period 1977-1980. He was also the founder President of Indian National Academy of Engineering from 1987 to 1991.

He initiated the idea of creating a platform for engineers, geologists and seismologists to focus the attention of professionals towards the problems associated with earthquake disaster mitigation. Thus came into being the Indian Society of Earthquake Technology (ISET) with Prof. Jai Krishna as the founder President. He remained actively associated with the activities of ISET throughout his life.

His Legacy

Guru and mentor to generations of earthquake engineers, Prof. Jai Krishna epitomized the human spirit of enquiry and unflinching loyalty and devotion to academic pursuits, so very essential for development of knowledge. The School of Research and Training in Earthquake Engineering, now a full-fledged academic department of IIT Roorkee, stands today, as a testimony to the creative genius of Prof. Jai Krishna who was not only instrumental in its creation, but also nurtured it till he breathed his last. He was recognized as "Legend of Earthquake Engineering" at a reception during the 14th World Conference of Earthquake Engineering held in Beijing, China in October 2008. His life and work will guide the future generation of engineers inspiring them in the path of creative pursuit of profession to enrich human endeavor for knowledge.

Dr. Jai Krishna, as Vice-Chancellor of University of Roorkee, with H'onble President of India, Dr. Fakruddin Ali Ahmad, the Chief Guest at the Convocation of the University, December,1976.

Dr. Jai Krishna, a keen sportsman himself, was also the Honorary President of the Sports Association of the University of Roorkee. Photograph shows the University Cricket team with him & the then Vice – Chancellor, Dr. A. N. Khosla

It is notable that his son Dr. Prem Krishna, also become an renowned teacher and researcher like his father and retired as a professor from IIT, Roorkee.

Epilogue

Prof. Jai Krishna passed away peacefully on August 27, 1999, in Roorkee, Uttar Pradesh.

Source:

- IIT Roorkee Website
- http://iset.org.in/iset/

Author :

Dr. N. Subramanian

Dr. N. Subramanian is a Civil/structural consultant and Author, currently based at Maryland, USA, with over 40 years of experience in Industry (including consultancy, research and teaching). He was awarded with a 'Life Time Achievement Award' by the Indian Concrete Institute and many other awards for his contributions towards Structural Engineering. He is the author of 26 books, including the famous books on 'Design of Steel Structures', 'Design of RC Structures' and 'Space Structures' (email - drnsmani@yahoo.com).

ISSE team congratulates ISSE family members for their accomplishment !

Jayant Kulkarni and his team at Epicons Consultants received the IEI Industry Excellence award in Nov2019.
Congratulations !!!

TALL AUTOMATED STORAGE RACKS --- NEW CHALLENGES TO STRUCTURAL DESIGNERS

By Prof (Retd) Manohar Ganesh Gadgil

1. INTRODUCTION

Modern age Manufacturing industries need enormous storage space for raw materials, finished and semi finished goods etc. These industries also need rapid material handling. Modern day warehouses by by giant traders like Amazon, wallmart etc handle millions of products and breath taking speeds for whom fast loading and unloading of products of different sizes is key to their business success. Due to shortage of space and rapid progress in automated material handling systems these ware houses now depend on tall or super tall storage racking systems giving rise to several issues related to safety and stability of these tall storage racks, fire safety norms, tall, automated tracked cranes of large capacity etc. The storage racks need to be properly secured at ground level requiring adequate foundation system to them. The automated computerized mobile cranes handling different materials/goods require precision and strength in the storage racking system necessitating valuable inputs from structural design engineers. Conventionally the storage racking systems involve perforated/slotted section of very small thickness and very peculiar press fits cum bolted connections etc. All these and many more issues make the storage racking system a great challenge to structural designer who has to face many new challenges in terms of materials, sections, connections, site erections etc. The present article tries to address few of the important issues related to these modern day wonder structures and the challenges a structural engineer must accept.

2. HISTORICAL BACKGROUND

In the beginning of 20 th century (early 1900-1910) industry depended on corrugated boxes for handling materials. However the handling of the boxes was manual putting severe restriction on the weight of these boxes. By 1915, forklifts were introduced in the industry leading to a revolution in the material handling process and the limitation of size and weight of boxes was suddenly gone!!! Fork lifts very soon were modified to lift boxes or pallets to several meter in height leading to multi storied racking system. This accelerated material loading and unloading activities. By 1966 first automated storage and retrieval system was developed in Japan. This year also saw rack supported roofing system introduced in industry. Unmanned (remotely operated) stacker cranes were introduced very soon. In few years time fully auto-mated , computerized material handling system was introduced leading to demand for tall storage racking system of the modern days. 1980s saw wide use of racking systems in manufacturing industry across all sectors. By 1990s many other sectors like agriculture, retail etc started using full potential of the automated racking systems. With development in electric motor technology and its control systems, speeds of cranes is increased to 200 m/min in horizontal, 100m/min in vertical direction and 60 pallets per hour. Developments in robotics, control systems, expert systems, AI etc have added tremendous pressure on industry to go for taller and taller racking system.

3. TYPES OF STORAGE RACKS

There are mainly 5 different types of storage racking systems. They are

i. pallet racking
ii. Shelving
iii. Mobile shelving
iv. Multi tier racking
v. Mezzanine flooring

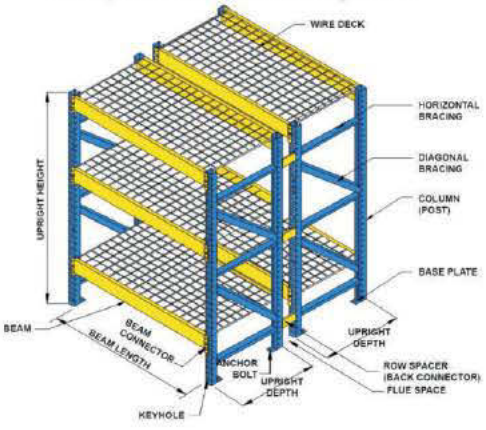
There are many sub groups and variations in many of the above referred racking system. However from structural designer's angle the type of rack does not matter much as the main structural system remains more or less the same.

4. MAIN COMPONENTS OF STORAGE RACKING SYSTEM

Main structural components of the racking system are

i. Upright – the vertical, main load carrying columns
ii. Load beam
iii. Diagonal bracing
iv. Horizontal bracing
v. Row spacer or back connector
vi. Beam connector
vii. Anchor bolt
viii Wind bracing

Components of a Rack System



5. FLOORING FOR STORAGE RACKS

The flooring of storage racking system in a ware house plays a very important role in smooth functioning of the material handling system and racking system. Any settlement at base leads to loss of verticality and alignment of racks which lead to serious consequences. The flooring system rests directly on soil foundation and hence proper understanding of settlement characteristics of soil is very important. Strong and thick flooring needs to be provided so that maximum reactions under worst load combination should not result into cracking or settlement of the flooring system.

6. ANCILLARY SYSTEMS IN STORAGE RACKING WARE HOUSES

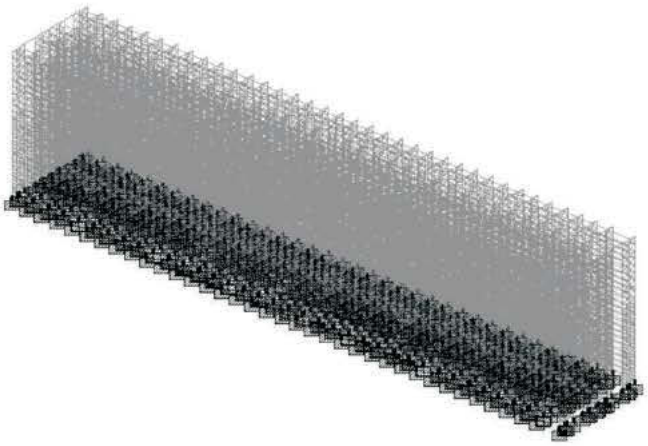
Storage racking system needs several other systems like fire fighting system, cabling, top bracings for racks, sprinklers, lighting etc. structural designer needs to properly provide supporting system for all the above systems as per the requirement of the end user.

7. MODELLING,ANALYSIS AND DESIGN OF STORAGE RACKING SYSTEM

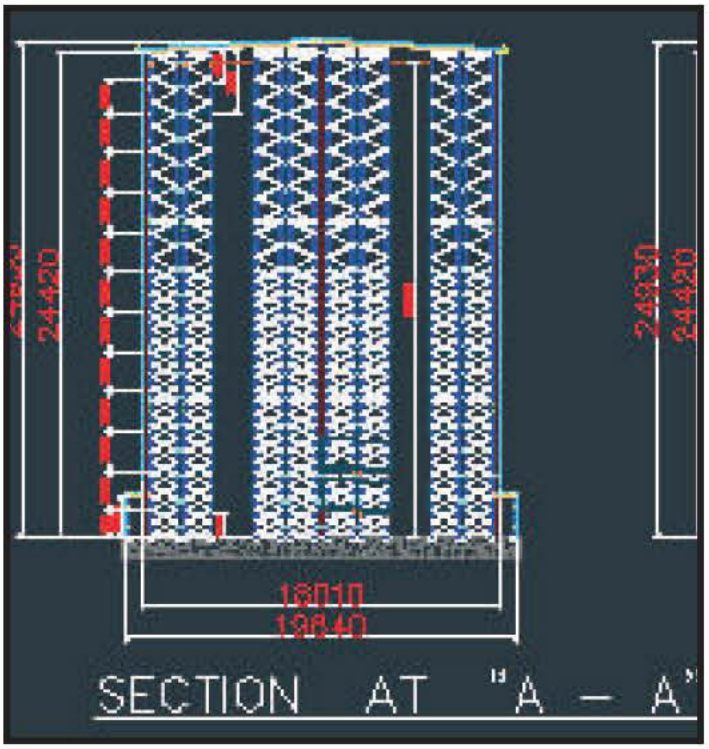
Racking system is generally modeled as a three dimensional space frame incorporating all the structural components mentioned earlier. At most of the joints generally two bolts are provided except at frame bracing and wind bracing (where single bolt is used to connect members at joint). The support is also taken as fixed. The racking structure being generally an internal structure and hence is designed for seismic load only in addition to gravity load and handling crane load (in terms of accidental push or pull). The structure is then designed for the forces coming on the members

under various load combination. A typical structural model is shown below.

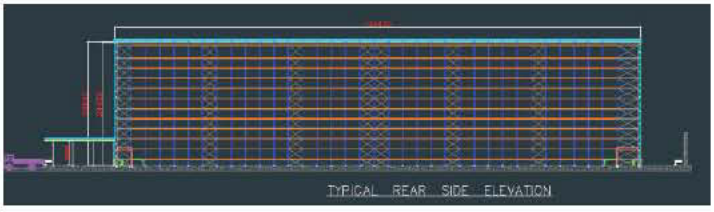
3D view



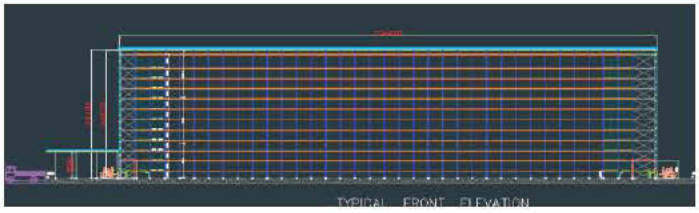
Side elevation cum section

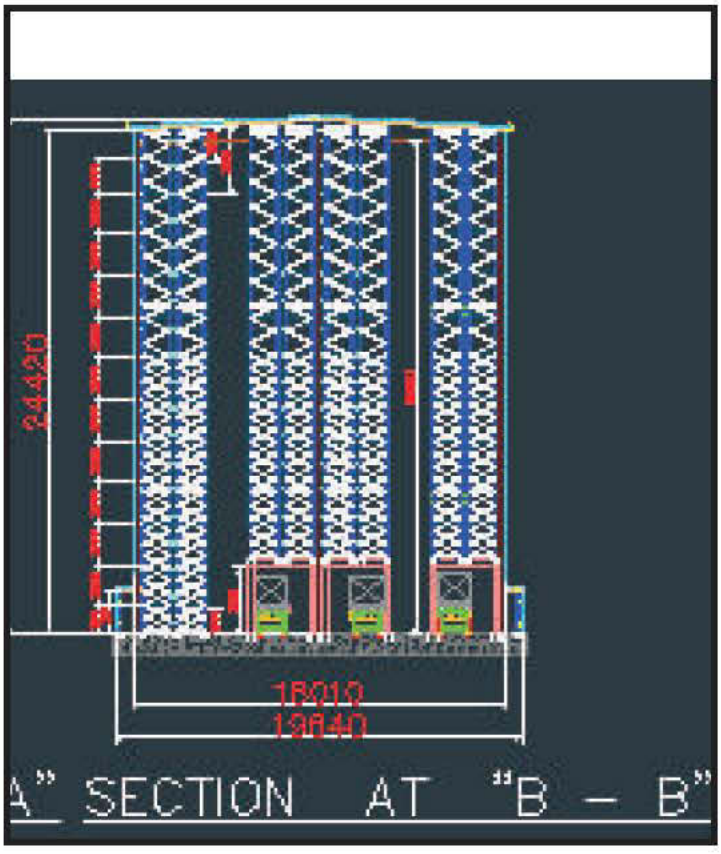


Rear Side view

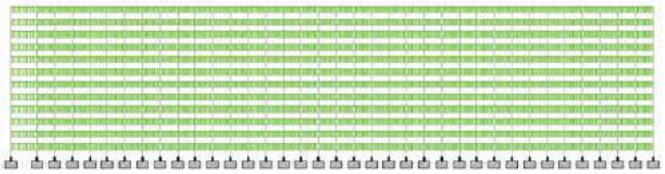


Front side elevation





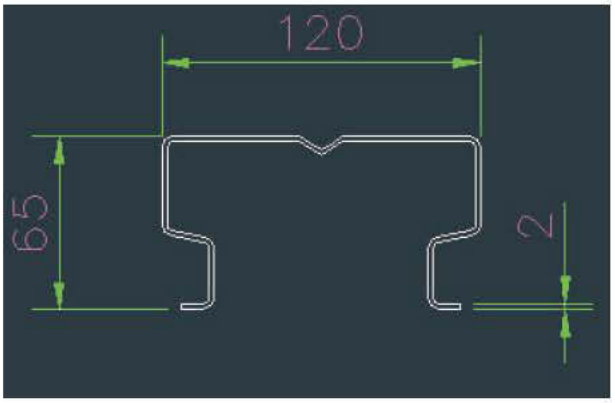
Loading diagram



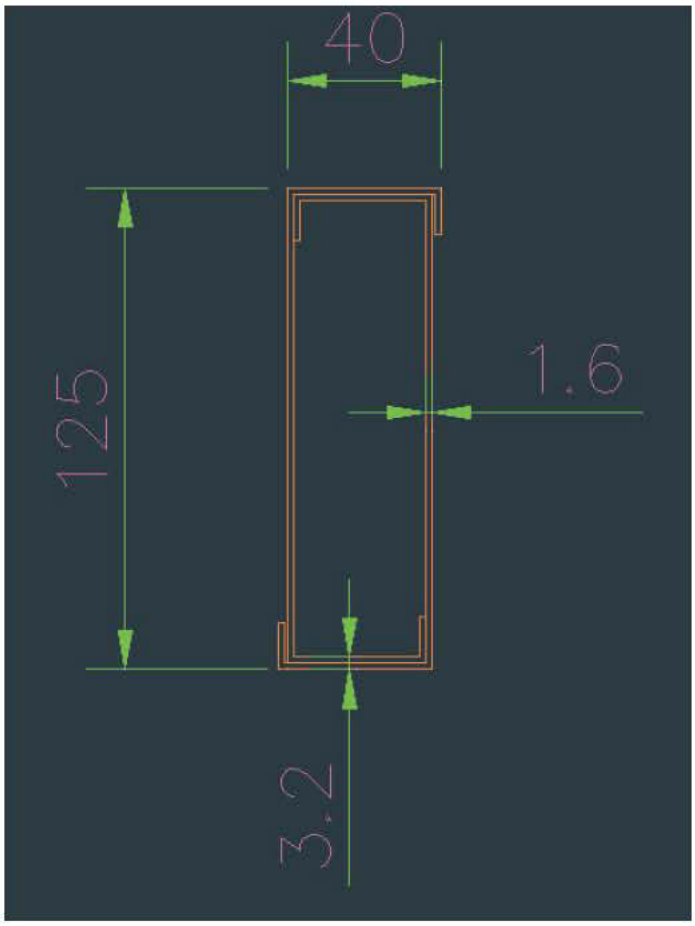
8. MAIN ISSUES RELATED TO ANALYSIS AND DESIGN OF STORAGE RACKING SYSTEMS

Sections used for different categories of member are very peculiar and are the manufacturer's proprietary products. There is hardly any standardization in the sizes of the members. Each racking agency manufactures its own sections of different members. For having ease of connections, these sections are converted to perforated members about which there is no standardization. Generally gross sections are used to analyze and design members while actual sections are somewhat weaker than the original sections. Further the axial load on the columns keep on increasing on lower storey section. To determine strength (i.e. load carrying capacity) of such members is a big challenge to the designer. Different codes give different formulae for determining the load carrying capacity of such columns. Typical sections of various members are as shown below.

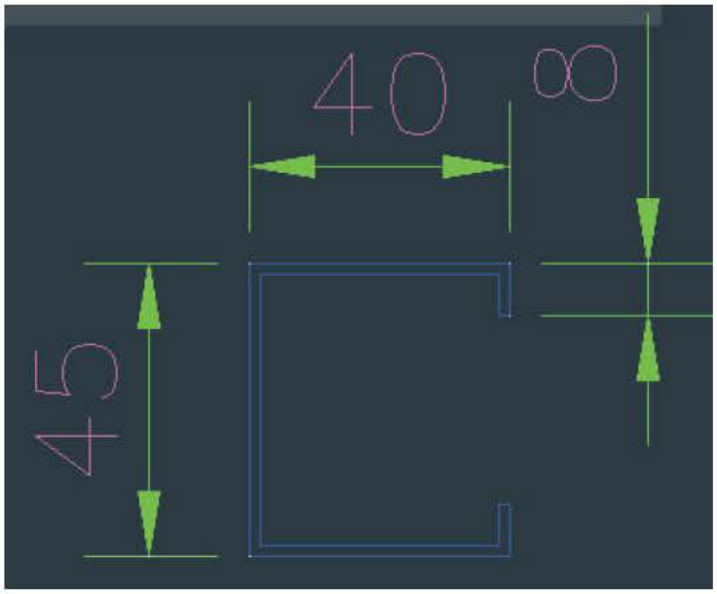
Upright / column



Load Beams

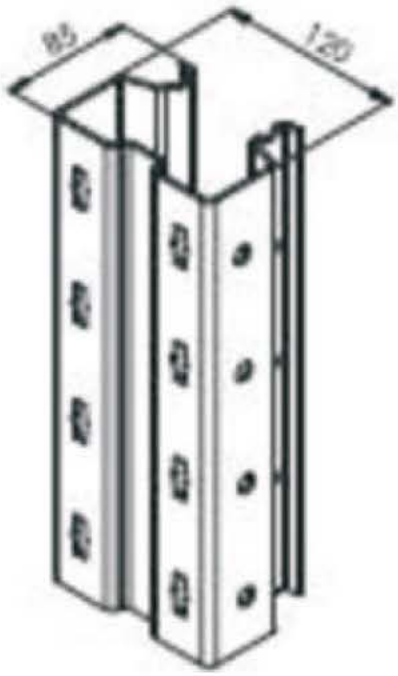


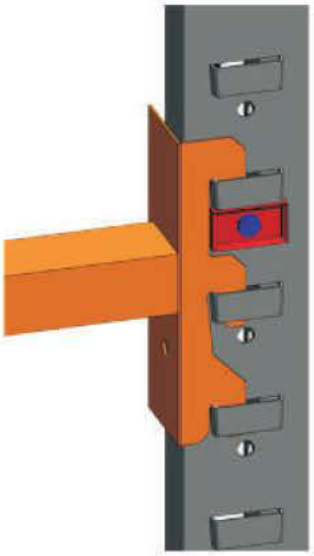
Frame bracing member

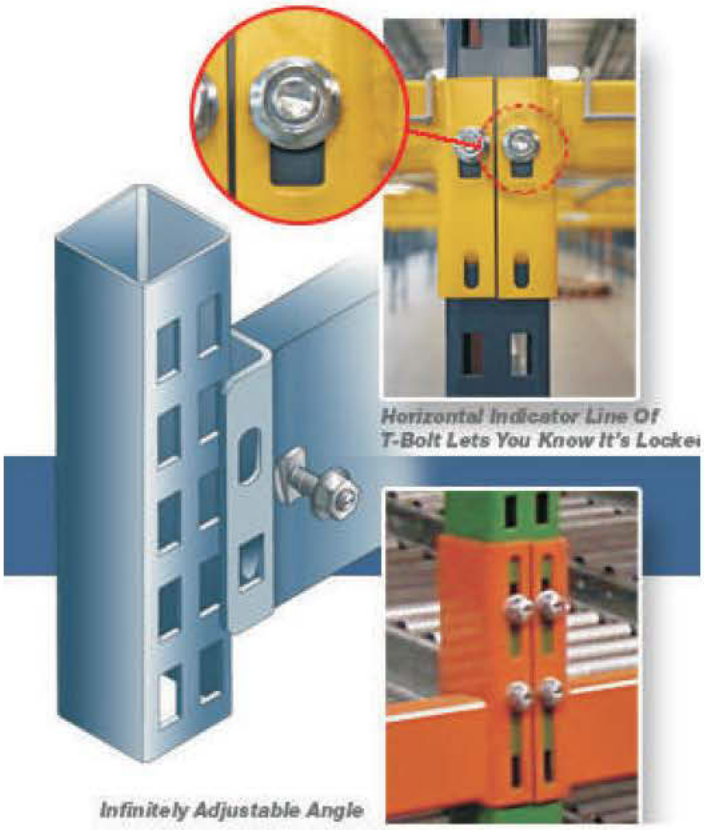


The above referred sections are made from thin plates of thickness ranging from 0.75 mm to 2.5 mm. Further, to facilitate using bolted connections they are provided with openings throughout the length at regular spacing. These issues make them vulnerable to local buckling impairing their load carrying capacity. Typical openings in the upright sections, angles and chanels are shown below

The connection between load beam and upright is very critical in racking system. This is a press fit cum bolted connection and theoretical determination of its exact moment rotation relation is a topic of intense research in racking system. Generally it is taken as a rigid connection but the performance of it during severe loading like during seismic is highly unpredictable. Some of the typical beam upright connections are shown below

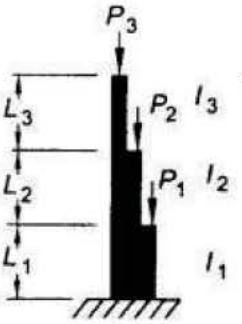






Further evaluation of the axial load carrying capacity of uprights is a very challenging problem. The axial load on uprights keep on increasing from top to bottom. There is a regular addition to the axial load on same section uprights. Though codes of practice give simple formulae for determining effective length of such columns with incremental loads the actual loading diagrams of uprigthts are very complicated. Typical formulae given in IS 800-2007 code are given below

Coefficient k_1 for effective length of bottom part of double stepped column shall be taken from the formula.



$$K_1 = \sqrt{\frac{t_1 K_1^2 + \left(t_2 K_2^2 + K_3^2\right) \times (1+n_2)^2 \times \frac{I_1}{I'_{av}}}{1 + t_1 + t_2}}$$

where

K_1, K_2, and K_3 are taken from Table 41.

$t_1 = \frac{P_1}{P_3}$, $t_2 = \frac{P_2}{P_3}$ $n_2 = \frac{L_2}{L_1}$

I'_{av} = average value of moment of inertia for the lower and middle parts

$= \frac{I_1 L_1 + I_2 L_2}{L_1 + L_2}$

Value of coefficient k_2 for middle part of column given by formula:

$$K_2 = \frac{K_1}{C_2}, \text{ and}$$

coefficient k_3 for the top part of column is given by:

$$K_3 = \frac{K_1}{C_3} \leq 3$$

where

$$C_2 = \frac{L_2}{L_1}\sqrt{\frac{I_1\left(P_2+P_3\right)}{I_2\left(P_1+P_2+P_3\right)}}, \quad C_3 = \frac{L_3}{L_1}\sqrt{\frac{I_1 P_3}{I_3\left(P_1+P_2+P_3\right)}}$$

Further the frame bracings in one plane and beams in other plane add complexity to the design process of uprights. The above formula is for general section in steel while in racking systems the load is applied at face of uprights which adds to additional moments in end column.

9. RACKING STANDARDS – INDIAN AND INTERNATIONAL

The outcome of continuous research by various institutions world over is being used by different countries in terms of prescribing standards of practice for racking systems. Some of the Important racking standards used in structural analysis and design of racking system are given below

1. IS 1883-1983 Specification for metal shelving racks (adjustable type)
2. AISI S 100-2007 North American Specification for the Design of Cold Formed Steel structural members.
3. FEMA 460-2005 Seismic consideration for steel storage racks located in areas accessible to the public
4. BS EN 15512-2009 Steel Static Storag System Adjustable Pallet Racking Systems Principles of Structural Design
5. RMI 2008 – Specification for the Design, Testing and Utilization of Industrial Steel Storage Racks

10. INTEGRATED RACKING SYSTEM AND ROOFING STRUCTURE

There is increasing trend in last decade to integrate the racking system with the roofing structure of the ware house. This has some advantages and disadvantages. Though a structural engineer can always design an integrated system of Racks and roofing structure, the stringent deflection requirement of the racking structure has to be satisfied by the integrated structure. This stringent requirement puts extra demand on the design of roofing structure but this system is reported to be more economical by several users. One such system designed by us recently in india has a height of approx 24 m and the schematic drawing of the same is shown below. The drawing shows purlins for roofing on top and also on all the sides

11. MANUFACTURING OF MAIN COMPONENTS OF STORAGE RACKING SYSTEM

As mentioned earlier that there is no standardization of sections used in storage racks. Each large storage system manufacture makes its own patented sections --- The Uprights, Load beams, bracings etc. The thickness, cross sections, opening sizes and spacing are all patented and this adds severe limitations on the structural adequacy of the sections as the section has several modes of failure and one has to properly guard against each of the type of failure. Further due to manufacturing process limitation and economics, sections are provided with fixed lengths specific to the manufacturer and the transport facility available. This further affects the economics of the overall racking system.

12. FUTURE STORAGE RACKING SYSTEMS

The racking system is a part of the overall material handling system which involves cranes, racking system (Super structure), foundation, and loading unloading system. For satisfactory working of the system a complete coordination between various agencies involved is absolutely essential. The varied agencies like crane manufacturer, structural designers involved in rack designing, foundation engineer and the loading unloading system manufacturer (conveyor system designer cum installer) should properly understand their own systems and its interaction with other systems. In the absence of a nodal agency serious problems get developed which finally affect the end user. In spite of all these problems the demand of the tall storage racks with fast loading unloading and handling system is increasing over the years and with more and more retailers like Amezon, Wall mart, and many more large industries, the industry is expanding at tremendous pace offering many challenges to the structural engineer which he/she is expected to accept

Author

Prof. M. G. Gadgil

About the author : Prof. M. G. Gadgil is a retired professor and head Structural Engineering Department, VJTI, Mumbai and independent Consulting Engineer having four decades of experience. He has designed and proof checked variety of structures

Email : mohan258@rediffmail.com

PRECAST CONCRETE PILES

By Vasudev V Nori

Pile Foundations A Brief History

Timber piles have been used extensively for buildings whenever the structures had to be founded on soils with inadequate bearing capacity at shallow depths. This is often the case for buildings and structures in coastal areas. Small quay walls and approach jetties were typically founded on timber piles. Shorter ones were end bearing. Longer ones were friction piles. These were lighterin weight requiring moderate installation machinery and therefore easy to install. But capacity and size were the main limitations. Timber piles have served well. Recently it has been observed that there has been deterioration due to marine borer attack. Such piles have been successfully retrofitted. Most of the buildings in Ballard Estate are founded on timber piles.

Precast Concrete Piles(Driven)

Demand for piles with larger load bearing capacities grew taller as the buildings grew taller and heavier with introduction od reinforced concrete as an affordable construction material for civil engineering structures. Buildings on Marine drive /Back-bay reclamation are founded on Precast concrete driven piles which became the preferred foundation solution. Such piles were driven using heavy driving machinery. These piles were generally end bearing as rock in Mumbai was available at less than 10 m below ground level.

Cast-in-situ Driven piles

On the otherhand in Chennai rock was not available at such depths. Strata was sandy and cast –in – situ driven piles with casing pipes became the preferred solution. The casing pipes were lighter to handle and therefore easy to install. Longer piles could be installed by joining additional steel casing pipes. Taj Coromandel Hotel designed by us is founded on such piles.

Precast Concrete Piles(Pre-bored)

Approach jetty to Pump house at Trombay (Canada India Reactor) made extensive use of Precast Concrete Pre-bored Piles (1958). This became the right choice since machinery required was comparatively light and could be moved into the sea resting om piles already installed. The author was a junior site engineer employed by the contractor.

Cast-in-situ Bored Concrete Piles

Precast piles could no longer compete with cast-in-situ bored piles as the later required very modest equipment. Bentonite slurry enabled safety of bore holes during boring operations. Use of such piles in our country took birth in 1965. Unfortunately many contractors started installing such piles with little understanding of issues involved. Be it tremie concreting , or gradual withdrawal of temporary casing. As expectedcast-in-situ bored piles have generated their own set of problems.

A variety of defects can occur during raising/ tremie pipe/ underwater concreting/ initial setting of concrete for long piles etc. Often such defects were very difficult to detect as methods of verifying integrity of concrete were then not available. We were singularly fortunate (God's grace) to have zeroed in locating defects in 1.2 diameter piles that supported a 16 storeyed building.(1978)

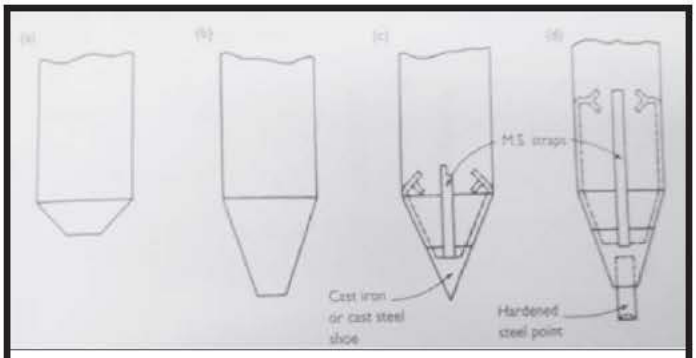
A variety of non-destructive testing techniques that are now available.It is now possible to locate such defects. With availability of modern rotary drilling machinery it has now become possible to construct even 3 m diameter piles longer than 50m .

Precast Concrete Driven Piles.

These are also known as displacement piles because soil is not removed during installation. This results in compaction of soil especially in case of granular soils. Steel consumption for such piles is heavy because they have to withstand driving forces due to hammer impact and also for handling. Pre-tensioning has been used effectively for long piles. Integrity of concrete is assured. But there have been problems because of cracks that occur during installation. Static load test will not reveal such defects. Also there is the problem of noise pollution. Most of these issues have been addressed to a large extent by adopting vibratory installing equipment. One of the main structural advantages is that such piles can be driven to a batter of 1 in 4. This is very important when large horizontal loads have to be resisted as in the case of bridges and quay walls.

Construction aspects :

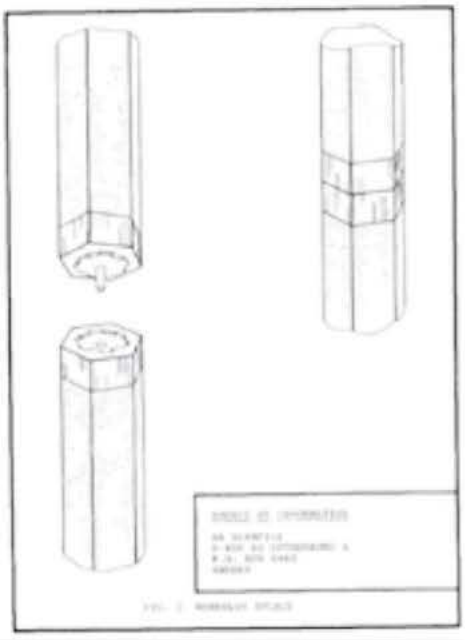
The shape of the bottom of the piles depends upon that type of strata.



a) Flat type is used when the soil is very soft
b) Steeper type is used when the soil is medium type
c) Cast iron or cast steel is used when driving into weathered rock
d) Hardened steel pin is additionally used when hard rock is expected

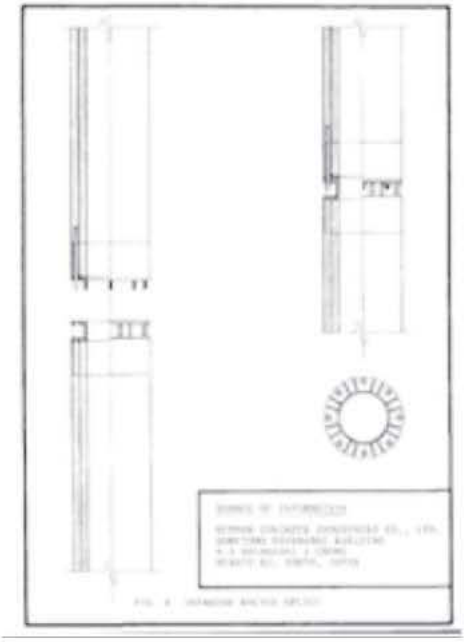
When long piles have to be installed they have to be joined by splices which are not only strong enough structurally but have to be of such make that long term durability is not compromised. These are proprietary and have been evolved after rigorous laboratory testing.

The table below shows some typical splicing arrangement for small size precast concrete piles. Fig 1 in the table show some very recent development for large diameter precast spun piles using high performance concrete in Japan



Hercules Splice for Hexagonal Piles

PCI Journal 1984



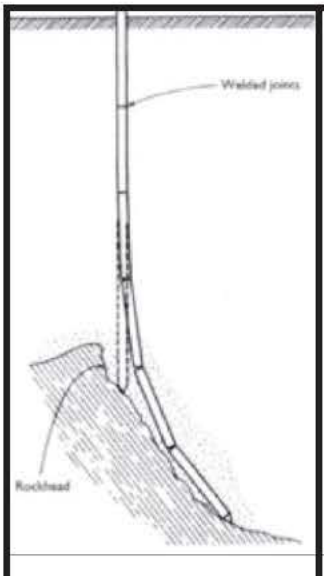
Spun Circular Piles Nippon Industries

PCI Journal 1984

(a) Transverse rebar

(b) Longitudinal rebar and concrete

Fig. 1 Reinforcement of large diameter PHC pile



Pile foundations do present engineers with unusual problems. Sudden dip in rock levels can result in piles that are driven oblivious of what is happening at the tip of the pile. The soil is quite soft in the upper layer providing little lateral resistance to concrete pile from bending. Splice points are vulnerable and permit joints to rotate !Extreme vigilance and caution is needed in installing piles whether precast or cast-in-situ . (source Tomlinson and Woodward)

Precast Pre-bored Concrete Piles

These are known as replacement piles as the soil is removed and replaced by concrete. As a consequence there is no improvement in the soil strength .One of the main advantages is lighter machinery used for cast in situ bored piles can be used. Compared to driven piles lesser reinforcement is required as driving forces are absent. It is possible to install the piles in batter but up to a maximum of 1 in 7. Integrity of concrete is assured. But grouting the space between the bore and the precast pile needs special attention.

Problems with concrete pile foundations

These problems are not confined just to the strength and quality of the concrete. Interaction between the pile and soil during driving needs to be understood. A good understanding of Soil Mechanics is a must for achieving a good application of precast concrete piles.

Load bearing capacity of Precast driven piles: For the designer capacity is based on soil parameters which is stipulated in various codes of practice. For the contractor capacity set criteria and wave equation analysis is the only guiding practice. Sequence of installation of piles in a group for sands cannot be followed for clays. This is especially so in case of friction piles. There are uncertainties concerning durability whether driven or pre-bored. These get more pronounced for driven piles. This leads to a constant tussle between the designer and the contractor. One has to work on certain amount of mutual trust. No one wants to do a bad job. Unfortunately such an approach is often lacking.

CASE STUDIES

FLYOVER AT TROMBAY (1978-1979) - TATA ELECTRIC COMPANIES

This is a 465 m two lane flyover providing a direct link between two thermal power stations that are separated by and Bombay Port Trust Road flanked by several pipe lines and a drainage channel. The basic plan of the flyover defining horizontal alignment and design and bid documents were prepared by Tata Consulting Engineers. Bids were invited on a design and construction basis.

Bid Requirement

Length of flyover 464.72 m
Carriage way width 7.5 m (Straight portion)
Central angle of the curve 90
(21.5 spiral + 47 circle+21.5 spiral)
Carriage way width 7.5 m to 9.0 m in transition spans (Straight portion)
Radius of curve 60
Minimum vertical over BPT road 6.0m
Foundations Pile foundations
East West approach is over a 4m fly ash fill underlain by 9 m of soft silty clay followed by hard rock.

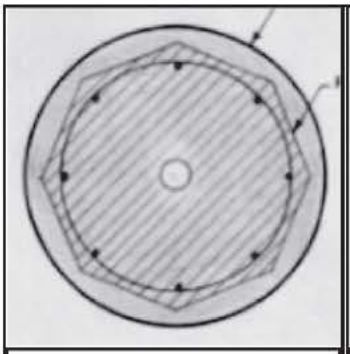
Taking into account various utilities at site 46m long balanced continuous spans (14.2m +17.6 m + 14.2m) in reinforced concrete separated by expansion joints was chosen. As it happened the length of transition spirals happened to be about 46m. 50m long circular span a two span box girder with one intermediate pier (30 m + 20m) seemed the best option for negotiating the drainage channel, BPT pipes and a road.

Foundations comprised precast concrete piles having octagonal shape (406 mm) installed in 480 mm diameter nominal bore. The piles were socketed into hard rock. The annulus between the bore and precast pile grouted with a cement grout. Piles were vertical at expansion joints and battered (1in 7) at intermediate supports which resist all horizontal loads by truss action. With this arrangement piles were subjected only to small bending moments due to lateral loads. This was a very important consideration considering poor soil conditions.

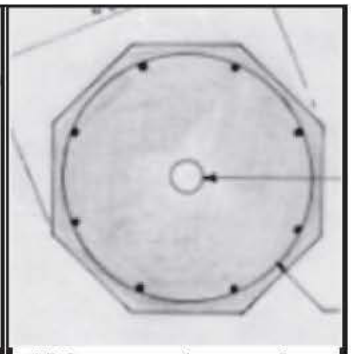
Analysis of transition spans with variable curvature and variable deck width presented new challenges for performing a detailed analysis. Using standard in house grid analysis program a comparison was made between a straight bridge with variable width with that of a bridge with variable bridge and variation for some typical load cases. Appropriate correction factors were derived from this comparison were then applied to yield the final design forces.

For circular spans continuous box with girder haunches over intermediate support girder had to be adopted because of sharp curvature. An approach similar to transition spans was adopted. Warping stresses in the box girders were evaluated using the torsion moments derived from the analysis.

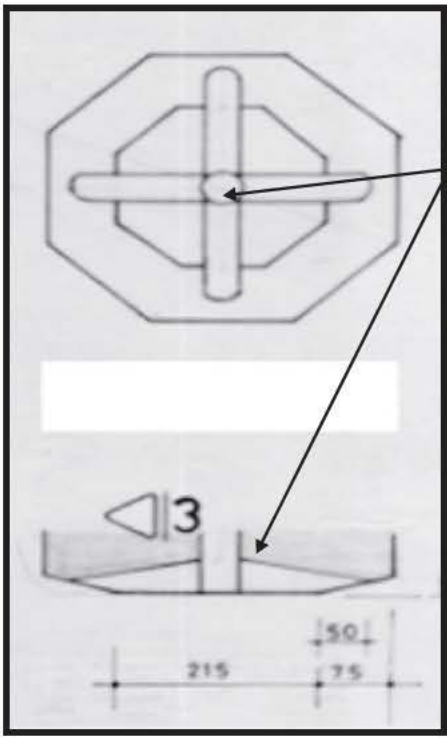
The precast pre bored piles are about 12 to 13 m long and in M35 concrete. First pile was load tested before the client accepted this technique as this was first use of such piles at that time. Some typical details of piles are shown below:



480 mm diameter bore



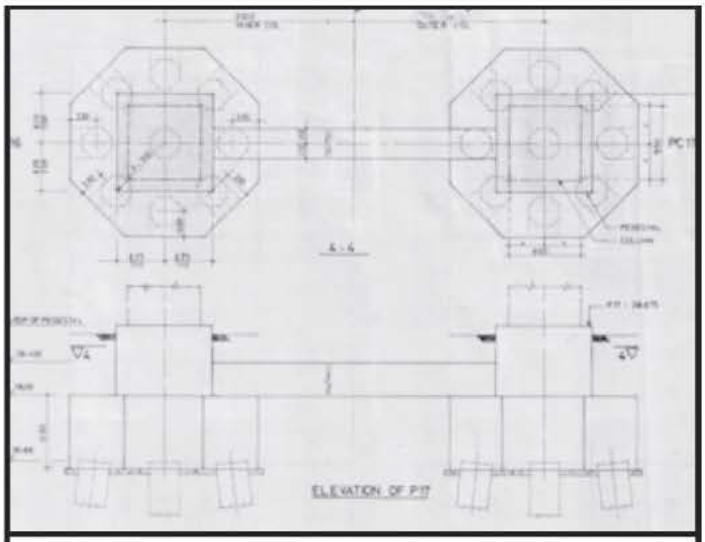
406 mm octagonal precast concrete pile. Gout hole



Bottom view showing grooves in precast pile for passage of grout .

Grout hole is 40 mm in diameter

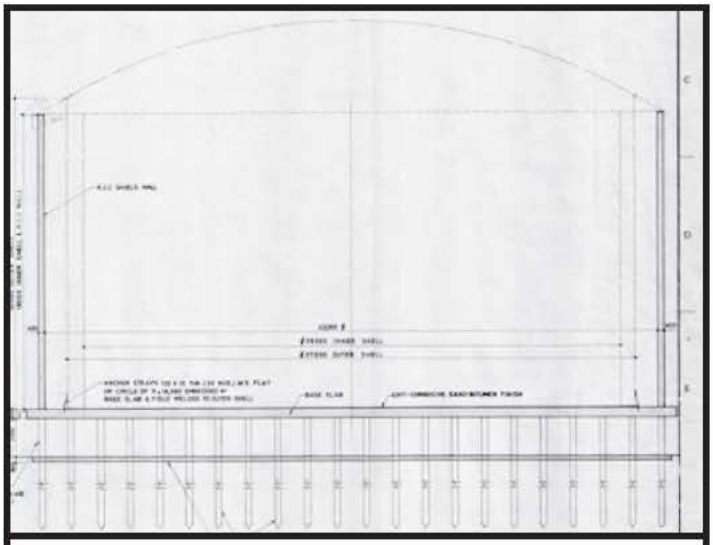
Typical details of pile cap for a group of nine piles supporting the main pan is shown below.



Because of batter the pile cap is of a considerably small size. The piers are monolithic with the super structure. There no pier caps and no bearings resulting a structure free of maintenance.

The bridge was completed at substantial saving of cost of construction to the Client.

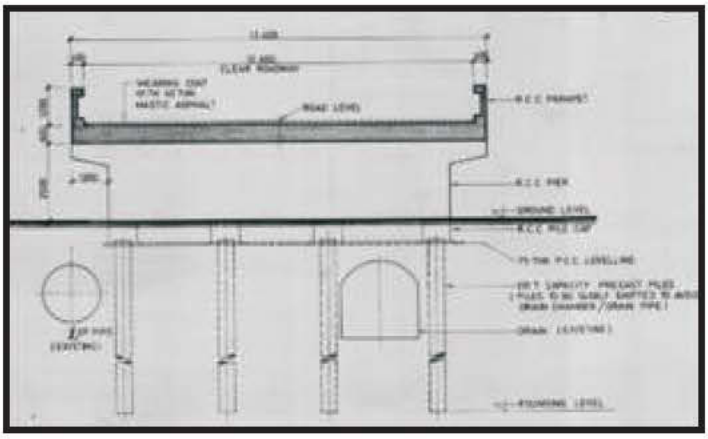
ETHYLENE STORAGE TANK FOUNDATIONS AT HAZIRA (RELIANCE INDUSTRIES) .

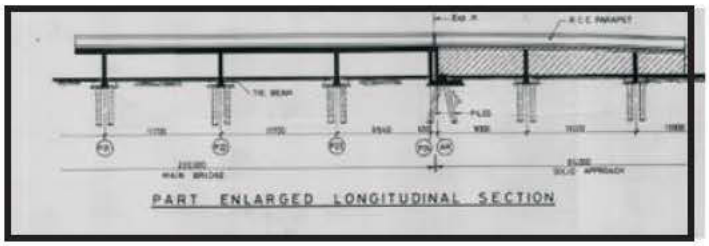


300 mm x 300 mm precast driven piles were used to support Ethylene Storage Tanks. The piles were 125 t capacity and 15 m long.
The pile length was estimated respecting provisions of Codes of Practice and many had to be broken carefully to the required cut off level..

LOW LEVEL FLYOVER AT DADAR WEST (1992)

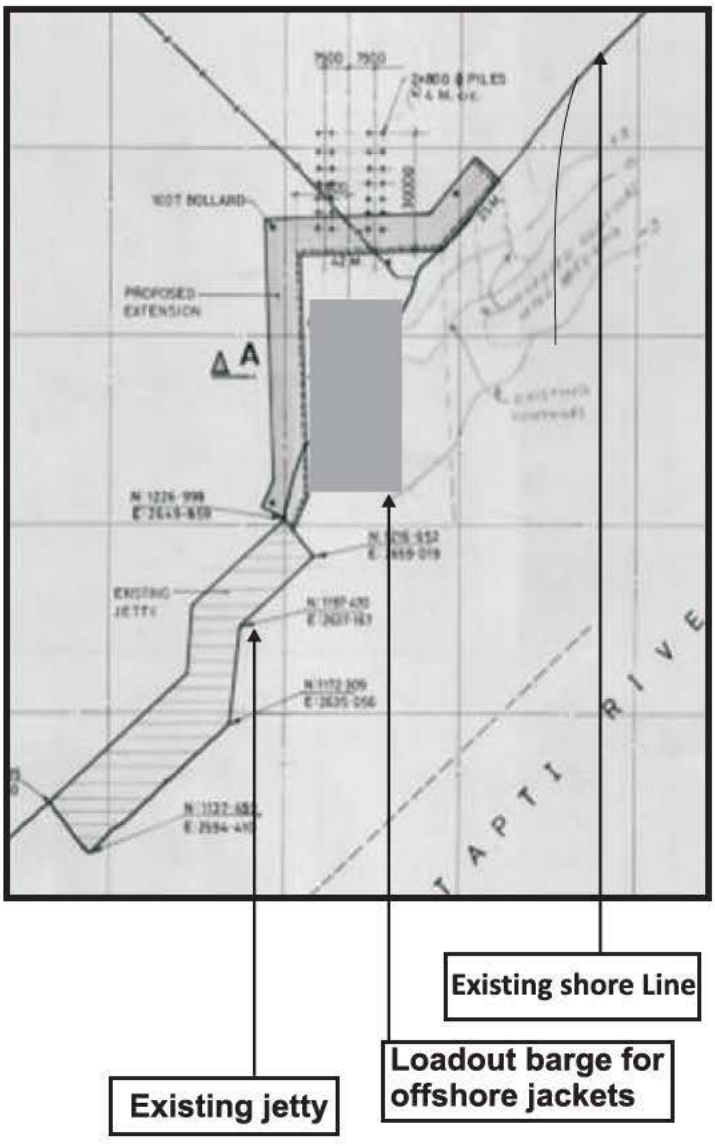
This is a 430 m long flyover had to be built in very congested area of Tulsi Pipe Road. The carriageway was 12.4 m wide.The purpose of flyover was to permit passengers at Dadar Station to cross Tulsi Pipe Road. Head room required under the flyover was just 2.5 m. The Client's original proposal was prestressed concrete super structure with 25 m spans supported on bored piles. This solution had to be abandoned as this was un executable. There are many utilities in this area which have been mapped but not accurately. The most notable of them was a large Dhapa drain which does not run parallel to the flyover alignment. And another 1800 mm diameter water pipe line runs at the edge of the flyover. The Client's decided to invite bids on a design and construct basis. Our proposal was a continuous reinforced concrete frame structure with 12 m spans. The deck was a solid slab about 600 mm thick and the wall piers just 250 mm thick. Reduced depth of super structure and absence of pier caps helped in reducing the length of the flyover



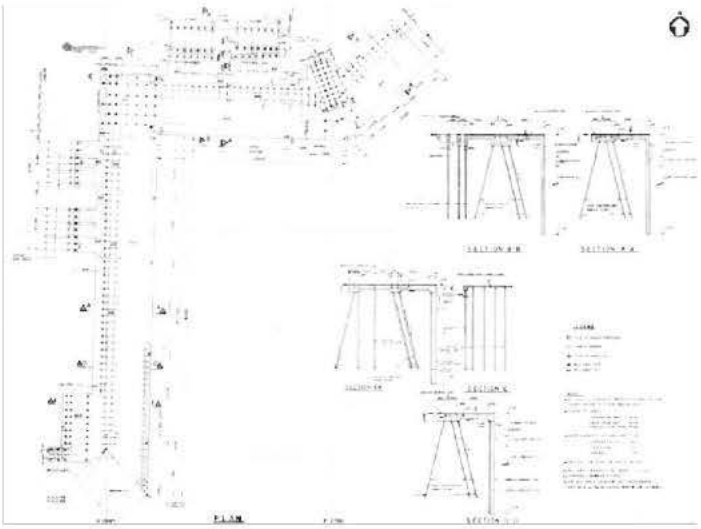


Our proposal was possible only with precast driven piles octagonal in shape about 406 mm in sizeThese could be installed very close to the utilities. Their spacing in transverse direction could be easily varied to suit the location of utilities. This is because wall piers also acted as deep beams transferring to the vertical loads to pile foundations . During execution many unchartered utilities were encountered.The most notable was a high voltage power cable that came to be known as the job progressed. Piles could be located at only at about 1.5 away from the cable.The bridge was completed in time at a substantial cost benefit to the Client.

QUAY WALL EXTENSION AT HAZIRA (LARSEN AND TOUBRO LIMITED) 1997



Larsen and Toubro was planning to fabricate and launch offshore jacket platforms at their Hazira works. It was not possible to use the existing jetty as the loadout barges about 90 m long and 40 m wide would cause an obstruction to vessel movement in Tapti river. This is what lead to designing an L shaped quay wall.



The quay wall consists of a diaphragm wall and a deck slab supported on 400 mmx 400 mm raker piles driven to a batter of 1 in 4. Since the soil consists of soft clay with low strength the load out region was strengthened with vertical piles. They were so laid out providing flexibility of load out platform jackets of a varying sizes.

The quay wall with offshore jacket platforms being fabricated is seen in the background.

Conclusion

It is worth noting in civil engineering structures optimal solutions can be evolved which are only specific to that particular site. Some of our most successful assignments have been a result of close cooperation and mutual trust between the Client, Consulting Engineer and the Contractor.

References :

FIP Technical Report Precast Concrete Piles - 1984
Pile Design and Construction Practice Tomlinson &Woodward
PCI Journal 1984

Acknowledgements
Michigan Engineers Private Limited (Trombay Flyover , Dadar Flyover)
Larsen Toubro Limited (Ethelene Terminal Hazira,Quay Wall Extension Hazira)

Author

Vasudev V Nori

About the author : Dr. V V Nori is Chairman at M/s Shirish Patel and Associates Consultants Pvt Ltd, Mumbai. He has more than five decades of experience in designing a variety of innovative concrete and steel structures.

Email : nori@spacpl.com

NEWS AND EVENTS DURING OCT - NOV - DEC 2019

by Hemant Vadalkar

9 Oct 2019: ISSE lecture for students at Bhagubhai Polytechnic , Mumbai was arranged. Software expert Mr. Prakash Bajaj made presentation on the software tools available for civil engineers like Excel, STAAD, ETAB, Revit etc. Around 30 students attended the lecture.

---

13 Oct 2019: ISSE Kolhapur Centre arranged a seminar for Structural engineers. ISSE Pune Chairman DhairyashilKhairepatil delivered a lecture on " Structural audit methodology , role and responsibility of Structural Engineers and others" . Programme was attended by many civil engineers from Kolhapur, Sangli, Satara and other districts.

---

2 Nov 2019: Workshop 79 on Assessment , testing and rehabilitation of bridges was conducted at Mumbai by Epicons Friends of Concrete. Following speakers made the presentation.
Mr. Atul Bhobe spoke about "Future of Structural Integrity Management for bridges and structures"
Dr. Mangesh Joshi talked on "Modern methods of rehabilitation material and concepts".
Mr. M G Kulkarni presented "Case Study 1 - RESTORATION OF 25mBRIDGE DECK AFTER THE
SLIDING". Dr.Sharvil Alex Faroz focussed his talk on "Risk Assessment & Management of Deteriorating Bridges" . Mr. R Soori elaborated practical consideration on "Importance of welding & joint details". Mr. S SBhonge provided Introduction to " Bridge Rehab Manual"prepared by State PWD. Dr. Gopal Rai shared his experience on "Decade performance of Construction chemical in Bridges". Mr. Arvind Parulekar discussed "USE OF ND TESTING OF CONCRETE IN ASSESSMENT OF CONCRETE BRIDGE". Mr. P P Pandey shared his views on "Understanding corrosion".

---

15 Nov 2019: DFI-India 2019: 9th Conference on Deep Foundations Technologies for Infrastructure Development in India, by Deep Foundations Institute of India (DFI) at Hyderabad was held on 15 and 16 Nov 2019. Various experts around the world participated and shared their experience in deep foundation works. All the technical presentations and case studies were very informative. Conference proceedings were published and distributed to delegates.
The pre-conference workshop was on Design, Construction, and Applications of Continuous Flight Auger (CFA) Piles in India.
The technical program included four sessions:

Session 1: Improving Current Practices with Case Histories
Session 2: Development in Safe and Efficient Geo-Construction
Session 3: Advances in Deep Foundations, Earth Retention Systems, and Ground Improvement
Session 4: Urban Development/Redevelopment
Web: www.dfi-india.orgEmail: dfiindiaoffice@gmail.com

---

26 Nov 2019: Hearing on DCR for Navi Mumbai region at CBD Belapur attended by Hemant Vadalkar and Ranganath Satam on behalf of ISSE. Presented our points on corrections required in the DCR on role and responsibility and certification formats. We have insisted that NBC2016 certification formats should be implemented.

---

29 November 2019
Indian society of Structural Engineers (Navi Mumbai Local Centre) & Institute of Engineers Belapur Local Centre in association with

Ultratech Cement organized technical Lecture (2nd of the technical series of 6) on "Challenges in Multiple Level Basement Construction "at CBD Belapur, Navi Mumbai.

ISSE wanted to conduct various technical activities in different areas of the Mumbai Metropolitan Region. This time we choose Navi Mumbai Region for the technical activities for the Benefit of Civil Engineers in that Area.

Dr. Mohan B Dagaonkar Chairman ISSE (Navi Mumbai Local Centre) Welcomed all civil Engineers for the technical lecture first of its kind after opening the Navi Mumbai Local Centre. R.S.Satam informed about the activities of the ISSE and appealed to all civil Engineers to become the Members of ISSE and Help in strengthening the organization.

Technical Lecture was delivered By Geotech Expert Prof. G.B. Chaudhari , Ex-HOD (struct), VJTI, Mumbai. In his Lecture,he covered why Multi level basement are required and they are to be designed for Ventilation, Energy, fire and safety.
Deep excavation problems were discuss in his lecture. Various forces acting on piled retaining wall during this deep excavation in various soil condition were explained.
He also explained the importance of the sub surface exploration and how the scanning of the underground soil can be carried out in relation with SPT values in various soil condition to determine lateral Load capacity of soil and depth of socketing for the piled retaining walls. He also insisted on Soil Investigation to be carried out in presence of Geologist /Civil Engineer. Also discussed various types of piled retaining wall like MS sheet pile wall, anchored sheet pile wall, precast concrete sheet piles, RCC diaphragm wall, touching RCC pile walls, Secant Piles etc. He showed various examples of multilevel basement construction in ancient India and world's deepest buildings like Sydney opera, Olympic Hall, Ukraine metro station etc.

Mr. Arvind Mahajan & Clinton Parera from Ultrtech cement Shared the dais to give corporate Overview and company Products. Mr. Clinton Parera discussed different products like light weight concrete that can be used as bedding material or filling in sunken areas, providing slopes at terrace level. Other building materials offered by Ultratech cement were also displayed at the venue.
Mr. V. C. Kamble past chairman of institute of Engineers proposed the vote of thanks.Function was attended by around 100 engineers.

29 Nov 2019: ISSE Belapur Centre, Challenges in Multiple Level Basement Construction By Prof. G.B. Chaudhari

13 DEC 2019: ISSE in association with M/s Jianhua Construction Materials Group, China arranged a technical lecture on Precast Piles at SASMIRA auditorium, Mumbai. Dr. V V Nori presented the over view on precast concrete piles , its advantages and limitations. He cited projects in Mumbai and other places where precast piles were successfully used. Engineers from Jianhua Construction Materials Group provided the overview of precast building components manufactured by their company in China. Concrete Components required for bridges, industrial structures, fencing, cable trenches, tunnel lining segments, spun piles are being produced by the company. Cardoso Lee and James Cheng made presentation on manufacturing facility for spun Piles and answered many queries raised by the engineers.

17 Dec 2019: Indian Society of Structural Engineers (ISSE) Solapur Center and UltraTech Cement Ltd-Solapur arranged a seminar on "Life Cycle Cost of RCC Structures and Extending Life Span of RCC Structures" on 17th Dec. 2019. The session was arranged at Phadkule Auditorium, Solapur.

Chairman ISSE SolapurDr. J B Dafedar welcomed the delegates with his opening remarks. Om Darak, Secretary ISSE Solapur introduced the speaker Hemant Vadalkar and elaborated on activities of ISSE.

Hemant Vadalkar of Vadalkar & Associates, Mumbai made presentation on "Life cycle cost analysis and improving service life of RCC structures". He also guided about the extending life span of RCC Structures. There were 133 attendees from industry including practicing structural engineers, architects and academicians from engineering institutes. The main aim of seminar was to throw light on Life Cycle Cost of Structures, sustainability, speed and quality which are the prime requirements of today's constructions.

Main takeaway of the seminar are as follows.

- Life cycle cost analysis must be carried out for choosing the best alternative of structure.
- Minimum life cycle cost is the best option though the initial cost of structure is more.
- Durability parameters must be implemented from planning to execution for achieving longer service life our assets.
- Reduced concrete permeability is the key parameter for extending life cycle of structure.
- It will help in achieving sustainable construction and minimum life cycle cost.

There was a huge response from local civil engineers and around 150 engineers attended the event. Balkrishna Kulkarni of Ultratech Cements conducted proceedings. Regional Head Ultratech Cements Technical Services Avdhesh Upadhyay proposed vote of thanks.

17 Dec 2019 : Hemant Vadalkar at ISSE Solapur function.

17 Dec 2019 :

ISSE HQ conducted guest lecture on " **Overview of construction material & importance of survey** " at VES Polytechnic Sindhi society , Chembur, Mumbai for the benefit of students of civil engineering department on **17 December 2019** in the seminar hall of the institute.

Mrs. Vidya s Lunge (civil Mentor) of V.E.S. polytechnic in her address welcomed guestsfrom ISSE Smt. M. M. Nandgaonkar , speaker Mr. Madhav Chikodi , Mr. K.L. Savala and Mr. R.S. Satam.

The speaker Mr. Madhav chikodi delivered informative lecture on overview of construction material & importance of survey to first year & second year diploma students. Overall Lecture for the student was informative & students got the knowledge of different methods that were used from old age to current practise of construction using latest construction materials. Speaker also covered the Basic uses of survey in planning & designing of structure. There was good response and about 60 students attended the lecture.

17 Dec 2019 : Madhav Chikodi at VES Polytechnic, Chembur. Student's Chapter programme in Mumbai.

Edited and published by Hemant Vadalkar for ISSE, C/o S G Dharmadhikari, 24, Pandit Niwas, 3rd floor S K Bole Marg, Dadar (W), Mumbai 400 028. Tel 022-2431 4423. e-mail issehq@hotmail.com Web : www.isse.org.in for private circulation and printed by S. L. Bengali, 15, Pandit Niwas, S K Bole Road, Dadar, Mumbai 400 028.

We provide services for on-site ND testing of RCC structures

Epicons Consultants Pvt Ltd

More than 35 years old multi-disciplinary civil engineering consultancy firm with "NABL accredited" laboratory.

For all your ND testing related requirements, pleas e contact:

Anil Joshi-8879664971 , Pragati Dapurkar-7506794756

E-mail ID: - ndt@epicons.com, bde@epicons.com

For more details visit our website – www.epicons.com

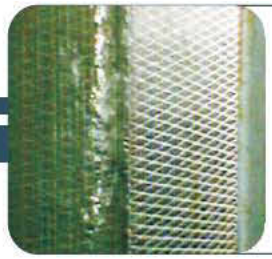
Head office: A 216, Amargyan Complex, Opp. New S.T. Depot, Khopat, L.B.S.. Rd. Thane INDIA 400601

SANRACHANA™
Structural Strengthening Pvt. Ltd.

Leaders in Structural Retrofitting

SANRACHANA™
Structural Strengthening Pvt. Ltd.

Specialty Retrofit Contracting Services
- Concrete repairs
- Structural strengthening
- Seismic retrofitting
- Historic restoration



UP GRADE

Improving Performance Of Hardened Concrete
- Specialty monomer & low viscosity grouts
- External wrapping of carbon fiber composite
- Near surface reinforcement & micro jacketing

SHIELD™

Engineering Solutions For Corrosion Damages
- Bipolar penetrating type corrosion inhibition system
- Cathodic protection system
- Execution of corrosion damaged repairs

DATA STRONG

Strengthening Data Centre & Ware Houses
- Post-tension carbon laminates
- Near surface reinforcement
- Steel fabrication
- Span shortening

E-mail:
sanrachana@yahoo.com

Tel:
+91-22-25400203,
+91-22-25440435

Web:
www.sanrachana.in