STRUCTURAL ENGINEERING

QUARTERLY JOURNAL OF

INDIAN SOCIETY
OF
STRUCTURAL ENGINEERS

ISSE

VOLUME 12-4

Oct-Nov-Dec-2010

OUTSTANDING STRUCTURAL ENGINEER ISAMBARD KINGDOM BRUNEL

(See page 12 inside)

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STRUCTURAL ENGINEERING

QUARTERLY JOURNAL OF

INDIAN SOCIETY OF STRUCTURAL ENGINEERS

ISSE

VOLUME 12-4, OCT-NOV-DEC 2010

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(Oct-Dec 2010)

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ORGANISATION MEMBER

OM-15 Soft Tech Engineers (P) Ltd.

OM-16 Outokumpu India Pvt. Ltd.

REVISED STRENGTH AS ON 31-12-2010

Patrons : 29

Organisation Members : 16

Sponsors : 8

Members : 1054

Junior Members : 9

TOTAL STRENGTH : 1116

AIMS & OBJECTIVES

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 organisations 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.

FIELDS CONSIDERED AS ASPECTS OF STRUCTURAL ENGINEERING

- ❄ 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

ELEVATED VIADUCT FOR DELHI METRO RAIL CORPORATION IN DWARKA SUB CITY

Rajan Kataria, Haroon Shaikh and V. V. Nori

The entire stretch of 6.47-km long viaduct Dwarka City, Delhi, is free of bearings, with expansion joints located typically at 61 m. The viaduct is built using integral form of construction with precast post-tensioned girders. The authors describe the salient design features of the viaduct and some of the issues that were considered while adopting integral from of design. The construction methodology of the viaduct is also briefly given.

Keywords: *Elevated viaduct, integral construction, span configuration, deck slab, precast parapets, open foundations.*

The Delhi Metro Rail Corporation Ltd. (DMRC) has gained vast experience in the few years in the construction of elevated viaducts using innovative methods, such as segmental box girders, segmental U-girders, full span I-girders and incrementally launched prestressed box girder.

The elevated viaduct in Dwarka sub city was constructed on a 30-m wide strip of land made available for MRTS. This presented opportunities for reviewing possible solutions so that an optimum solution could be evolved. The paper describes the broad features of design and construction of this viaduct, for which integral form of construction with precast post-tensioned girders was adopted.

The elevated viaduct is required to cater for two tracks with spacing of 4.10 m on centres. The

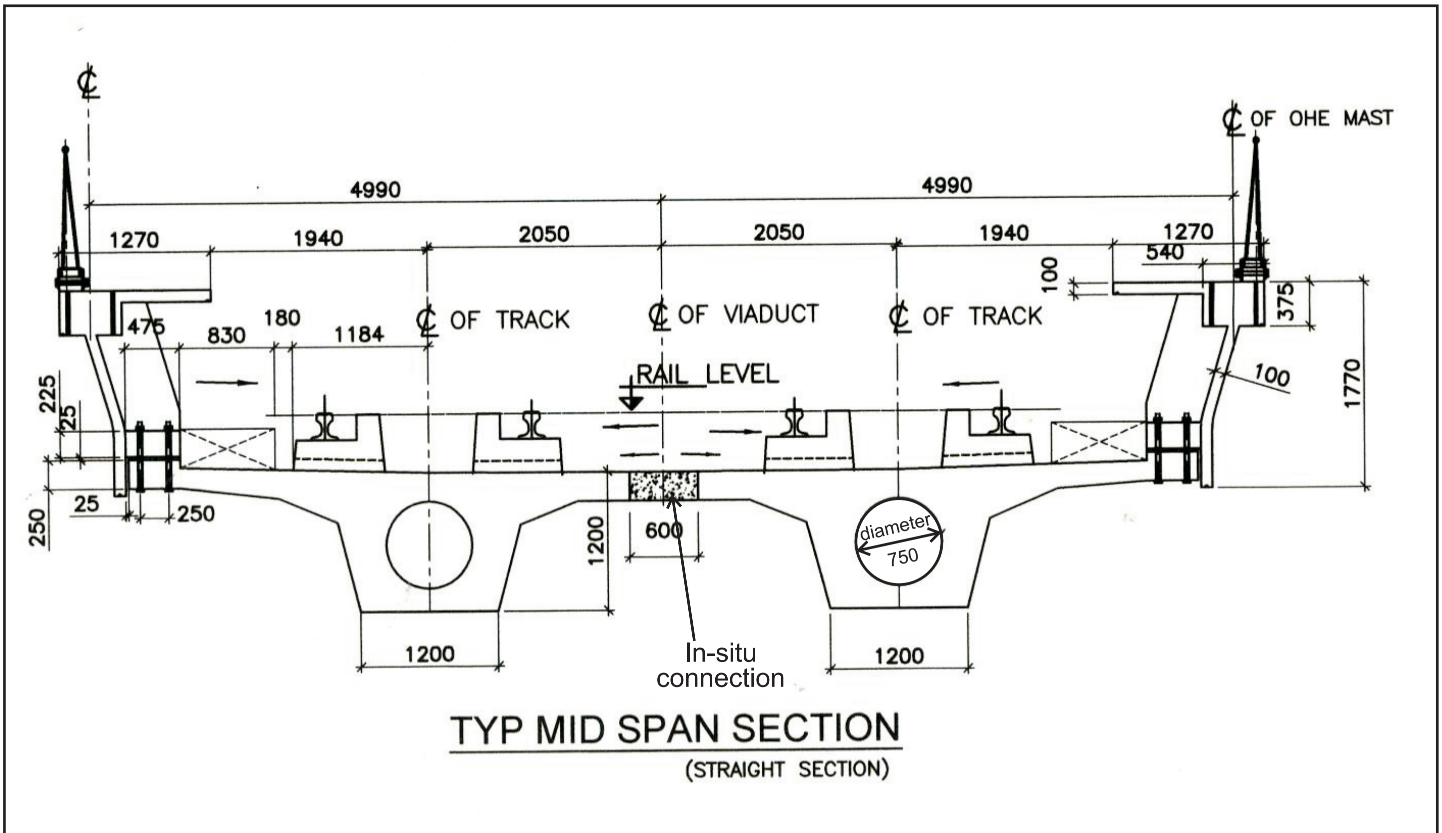

Fig-1 Typical mid span section

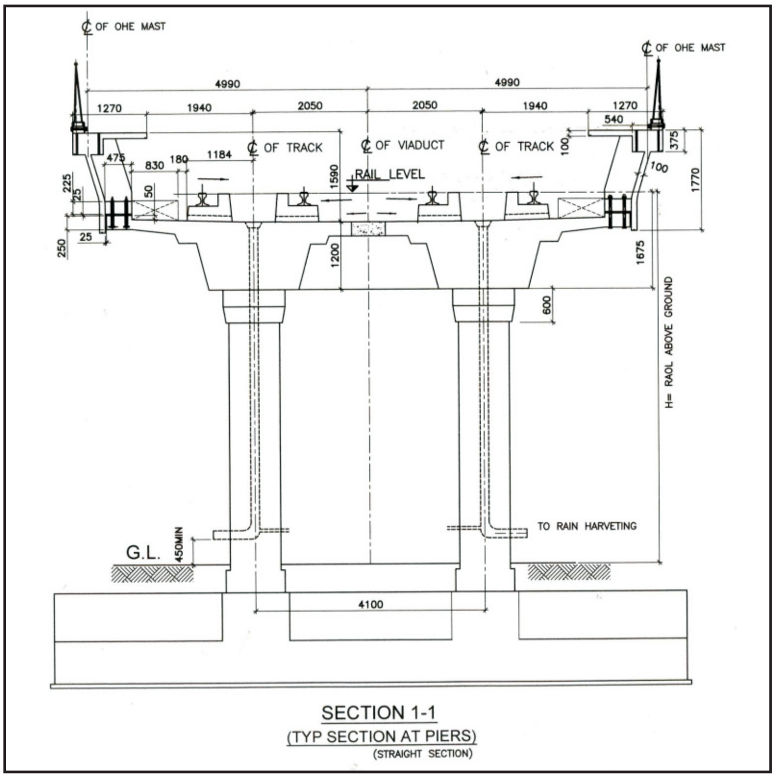

Fig-2 Typical section at piers

horizontal alignment is mostly straight. The lowest radius of curve of the alignment is 900 m. The ground is reasonably level. The alignment crosses six major roads one major drain and an oil pipe corridor. The soil investigation revealed that open foundations located at about 2.0 m below ground level could be adopted. The main consideration for span configuration was the clearance required for road crossings and bearing in mind that open foundation have to be used.

Choice of basic spans

After studying several alternatives it became clear that with open foundations the span would be in the region of 15 m. Initially, the option of simply supported span of 15 m with neoprene bearings and seismic restrainers was studied. This solution was indeed simple to design and to construct. The cost reduction obtained in this case when compared to elevated viaducts constructed by DMRC was largely due to open foundation and smaller spans. However, there would be a number of expansion joints and bearings as compared to the elevated viaducts constructed by DMRC. These joints and bearings would certainly pose problems in maintenance and possible replacements. Further, from seismic design considerations, simply-supported structure may not be desirable in the sense that spans tend to dislodge at times.

Proposed span arrangement and integral form of construction

After studying a number of alternatives, a 61-m module with span configuration of 13.5m + 16.5m + 16.5m + 13.5 m appeared to be the best choice. This configuration met with the requirements road crossings and could be used typically for the entire length so as to obtain maximum repetition. Typical cross-section details are shown in Fig 1 and 2. However, different span configurations would be required in the vicinity of the station buildings and at other locations near the Palam drain crossing and oil pipe corridor crossings. Severe restrictions at the oil pipe corridor crossing and Palam drain crossing called for much larger spans in the range of 36 m.

The height of the rail varied between 7.0 m to 9.0 m above ground level. At a few locations the rail level was 10.30 m above ground level.

Features of typical span configuration

The deck cross section consists of two 1.2-m deep voided girders with a span arrangement of 13.5 m + 16.5 m + 16.5 m + 13.5 , *Fig 1.* The deck frames were merged monolithically in to the circular piers of 750 mm diameter for end span 900 mm diameter for intermediate supports. Diaphragms at pier locations are cast-in-situ providing frame action both in transverse and longitudinal directions. The continuity of the structure over intermediate supports in the longitudinal direction is achieved by introducing prestressing cap cables at these locations. In the transverse direction the individual deck slabs get connected by overlapping reinforcement and a cast-in-situ connection. Typical structural model for longitudinal and transverse analysis is shown in *Fig 3.* For longitudinal analysis, model was prepared using line elements whereas for transverse analysis FEM model was prepared.

At some locations a span arrangement of four spans of 13.5 m had to be used to suit the site conditions. Reduction in the middle two spans for this configuration did not result in a reduction in the total cost per unit length. A typical configuration of 61 m therefore appeared to be an ideal choice.

The deck slab was required to support an evacuation walkway, parapet and duct loads. The deck slab was additionally required to support concentrated over head electrical (OHE) mast loads which can occur any where along the span.

The precast parapets were designed on a module of 2.7 m. Two diaphragms are provided at 1.35 m on centres. The OHE mast connection load get distributed between two diaphragms, thus providing a better dispersion of concentrated loads on the deck slab.

The deck slab was also designed for axle loads that occur at cross overs. Beyond the last station the track centres had to be gradually increased to 4.725 m to accommodate scissors crossing. This could be accommodated by increasing the width of the cast-in-situ longitudinal connection between the two girders. The same precast deck girder could be used without any changes for the entire stretch.

The substructure consists of open foundations comprising conventional isolated footings resting on medium sand. Corbels are provided for individual circular piers so that precast girders could directly rest on the corbels without any additional temporary supports.

Some of the issues specific to integral from of construction are briefly described bellow.

i) *Change in the structural system:* The girders are simply supported when placed on piers. These are rendered continuous by cast-in-situ diaphragms and continuity cables. Effects of creep result in introduction of support moments into the structure. These have been evaluated as per the guidelines provided in “FIP recommendation - Practical design of structural concrete”.

ii) *Modulus of elasticity:* For evaluating long-term effects due to creep, shrinkage, uniform rise / fall, foundation settlement, the modulus of elasticity of concrete is reduced by 50 percent. For all other loads such as tractive / braking, centrifugal, earthquake forces normal value of modulus of elasticity is used. The strata being predominantly sandy it is reasonable to expect that foundation settlement due to dead loads (excluding parapets and cast-in-situ concrete for transverse connection) would have already taken place at the time of introduction of continuity by stressing prestressing cables.

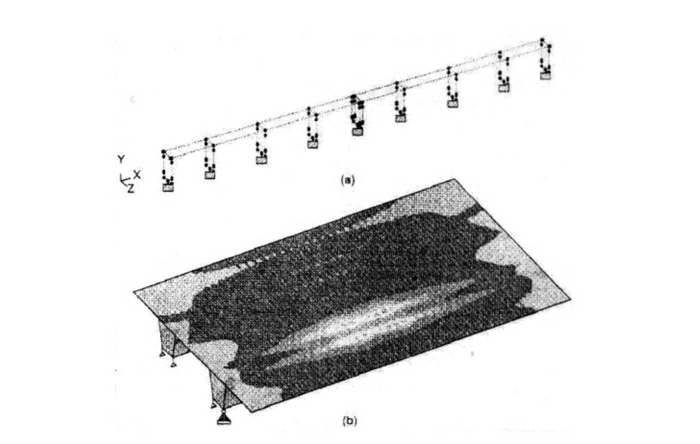

Fig. 3 Typical Strultural model for longitudinal & transverse analysis

iii) *Effects of rail-structure interaction:* Another problem specific to ballastless structures is the interaction between the structure and the long welded rails which are connected to the deck with the help of *Vossloh* 336 fastening system with standard SKL 12 clamp. Effect of rail-structure interaction on simply supported structures with bearings is to introduce forces on piers due to temperature, creep and shrinkage which would otherwise have got dissipated in case of equal spans. In case of integral form of construction the piers are already subjected to forces due to creep, shrinkage, temperature effects. The effect of rail-structure interaction is generally favourable for those components of movements that occur after the rails are installed.

Fig. 4 (a) Platform in Position for II stage Blister Stressing

Fig. 4 (b) A view of II stage Stressing Blisters

Fig. 5 (a) Precast Girder being Lowered

Fig. 5 (b) Box Girders Launched along the Curve Section

Construction methodology

The proposed method of construction was developed by the contractors. The girders are cast within the 30 m strip, erected in position using a gantry straddling across the viaduct, *Fig 5.* The moulds are then shifted to the next module.

Cast-in-situ span

At two locations, namely, oil pipe corridor crossing and Palam drain crossing, spans in the region of 36 m were required. At both these locations cast-in-situ deck construction was adopted. The structures are founded on 1.2 m diameter cast-in-situ bored piles. The piers are integral with the deck structure.

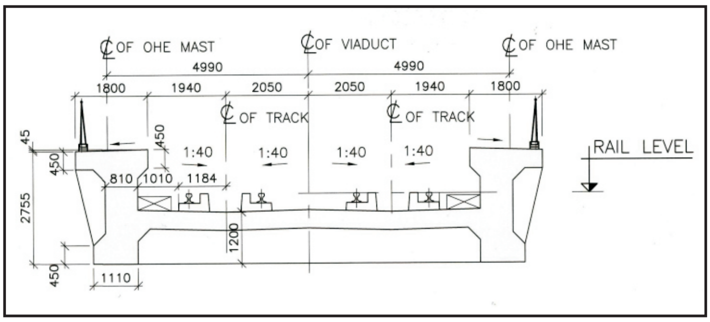

Fig 6 Typical cross section of cast-in-situ span

Fig. 7 Palam Drain Crossing

Oil Pipe Corridor

For cast-insitu spans, adoption of I-girders/box girders would have increased the height of rail above the soffit. At Palam drain crossing the elevated viaduct also crosses an existing bridge which determines the height of the rail. I-girder/box girder type solution would have meant raising the rail height of adjoining standard spans also.

The cross section adopted was derived by integrating the evacuation walkway into the structure, *Fig 6.* The rail height above the soffit remain undisturbed. Palam drain crossing has two spans each of 36 m supported on a central circular pier. *Fig 7.* The pier location was such that it was in line with one of the skew piers supporting the existing road bridge crossing Palam drain. Oil pipe corridor crossing has a single span of 38 m. Cast-in-situ construction required special connection details so that prestressing forces are not transmitted to the piers. This was achieved by supporting the structure on neoprene bearing so that elastic shortening of the girder is not restrained by the monolithic connection with the pier. After completion of prestressing operations concrete is placed in joint with protruding reinforcement for achieving monolithic connection. *Fig. 8* shows another view of the elevated viaduct under construction.

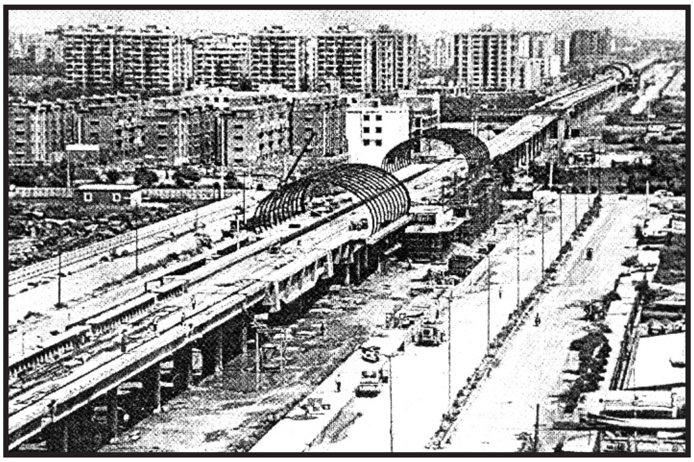

Fig. 8 Elevated Viaduct under construction

Conclusion

The entire 6.47-km long stretch of viaduct is free of bearings. Expansion joints are at 61 m typically; spacings were reduced in a few locations to suit the road /drain crossings station intersection etc. Engineering effort in the design of integral form of construction is substantial more than what would be required for traditional structures with simply supported spans resting on bearings. Integral form of construction does seem to permit cost reduction of the elevated viaducts. It is anticipated that integral form of structures will require much less maintenance efforts and are expected to perform better during earthquakes due to added redundancy.

Acknowledgments

Authors gratefully acknowledge encouragement given by Mr E Sreedharan, Chairman and Managing Director DMRC, Mr. C B K Rao, Director Projects, DMRC and Mr. Shirish B Patel, Chairman Emeritus SPA. Afcons Infrastructure Ltd. are the contractors of this elevated viaduct.

Reference

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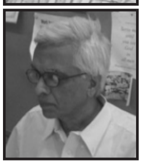


Dr. V. V. Nori
Chairman of Shirish Patel & Associates Consultants Pvt. Ltd. Mumbai

JACK-UP PLATFORMS FOR MARINE WORKS

A B Karnik

Most of the Engineers must be aware of existence of Sagar Samrat used for several years in India as a Key Platform for serving Oil Wells. It is a Versatile Giant Jack-up Platform usable in deep sea operations in Indian Waters. Author of this article has designed several Mini Jack-up Platforms for Marine Works close to Shore. Piling Gantries for Approach and Jetty Head Piles Construction, particularly starting from shore, have also been designed by the Author. For Ship Berthing, Approach Jetty extends in length upto Jetty Head where enough draft (depth) of water is available for Ship Berthing for floatation. Requirement of Jack-up Platform arises out of necessity for construction of piles and allied works away from shore for Mooring Dolphins and Berthing Dolphins away from Main Jetty. Berthing Dolphins resist impact of Ship Berthing. Mooring Dolphins facilitate pulling of Ship to butt against Jetty Head. All these structures are finally inter-connected by Structural Steel Walkways for day to day communications.

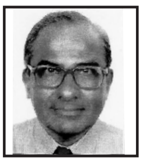
The article hereafter details three typical Jack-up Platforms designed by the Author for different requirements.

(1) Jack-up Platform at Mormugao Harbour in Goa was used in 1994 for construction of Mooring Dolphin requiring 24 no.1200 dia. piles. Working Platform size provided was 13.50 m x 9.00 m in plan. Buoyancy Tanks provided were 4 no.5 m x 2.50 m x 2 m plus 2 no.1.20 m dia. x 13 m long plus 2 no.1.20 m dia. x 10.20 m long plus 3 no. 0.80 m dia. x 12 m long. 3 no.1200 dia. Piles could be completed in one setting of Jack-up. It cannot be pitched accurately in required position. Overhead adjustable arrangement is made for placing piling pulleys in correct position. These arrangements can be clearly seen in the photograph. It is important to note that four spuds provided in four corners are lowered onto the bed and whole platform is raised by about 1 m and locked with spuds. Stationery Platform is thus available to get accurate location of piles. Sample calculations for Stability of Jack-up in floating mode are given herewith.

(2) Another Jack-up Platform was used at Dahanu in Maharashtra for Ash Disposal Pipe Line Bridge. Structural Steel Bridge with few spans of 30 m each for Pipe Line and Jeepable Road was designed by the Author. Supporting Pier Column had 3 no. piles 600 mm dia. 1.50 m apart forming equilateral triangle. Jack-up Platform was provided with Moving Frame with piling winch etc. mounted on it to align for X co-ordinate of piles and movable suspended piling pulley to align for Y co-ordinate of piles. With these provisions, Jack-up pitched near pier location could complete three piles accurately in desired location. Buoyancy Tanks provided were 2 no. 8 m x 4 m x 2 m deep with clear distance between them of 3 m. Spuds provided at four corners lowered and platform raised and locked onto them as before.

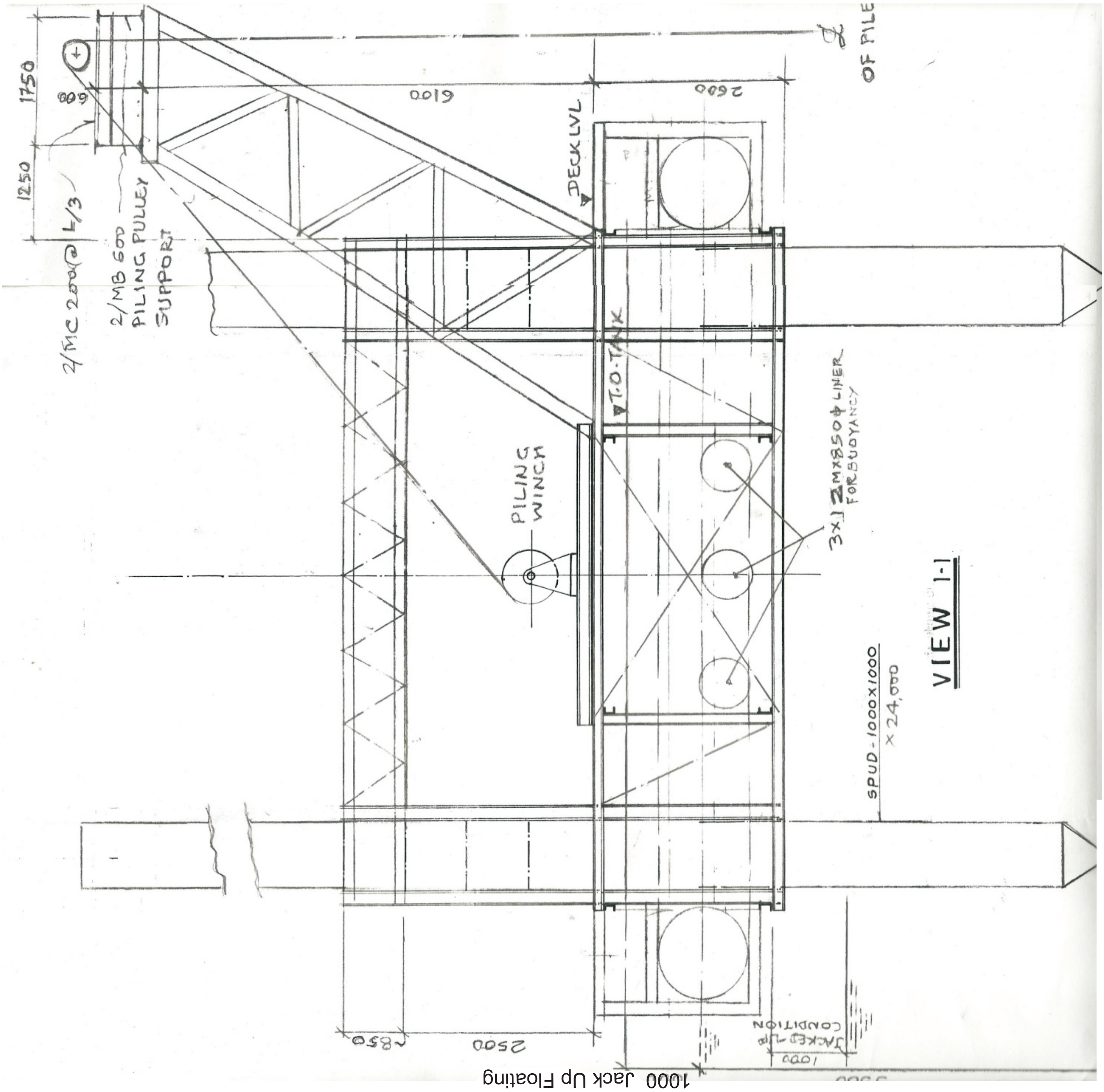
(3) One more Jack-up Platform illustrated here was for Soil Exploration near Jageshwar close to Dahej Port in Gujarat. This is in Narmada River merging into Sea. Water current 3 to 4 m per sec. Plan size of Jack-up out / out was 15 m x 15 m with open space in the centre of 7 m x 7 m. Buoyancy Tanks were 2.5 m deep. Central open space was used for handling equipment for soil exploration. Platform was steadied as before by raising platform on spuds. Spuds provided for this soil exploration were pretty long to cater for larger depths.

Author :



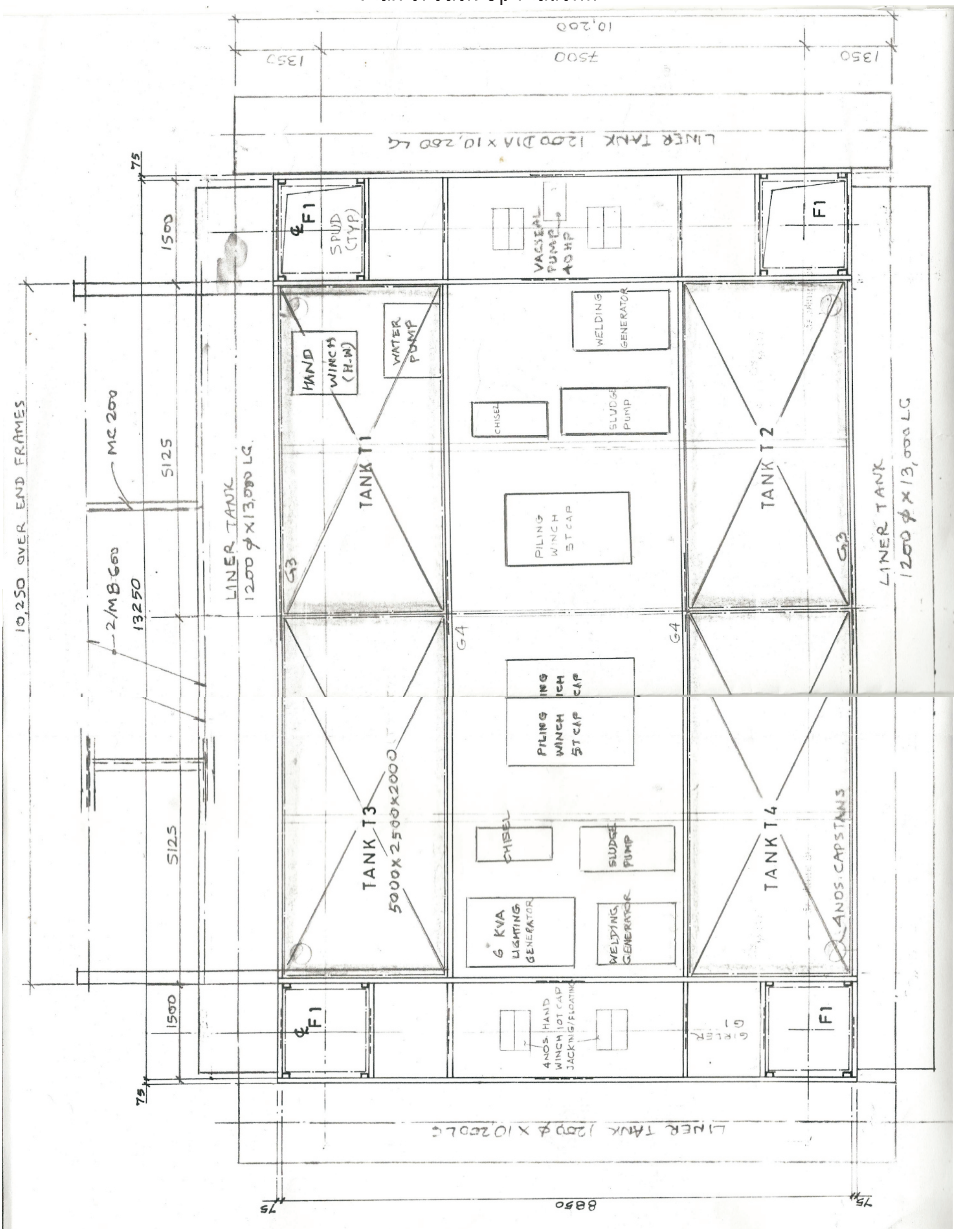
Er. A B Karnik, A senior Consultting Engineer with more than 50 years of experience.
E-mail : arunodaya22@gmail.com

Jack Up Plat form

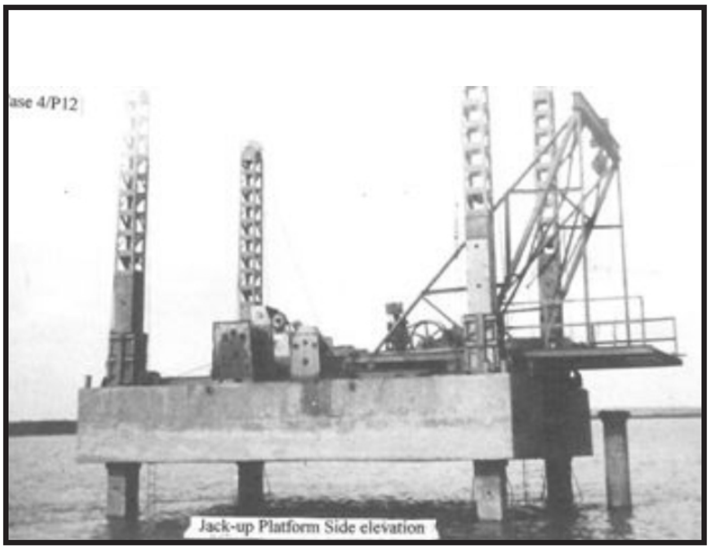


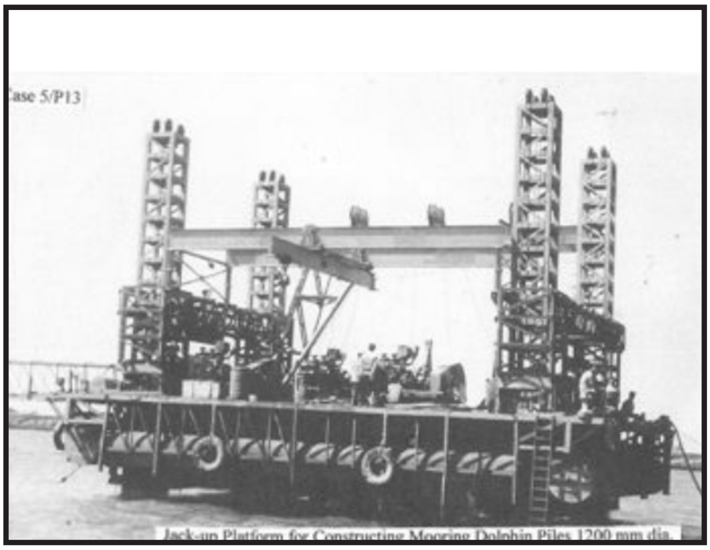
1000 Jack Up Floating

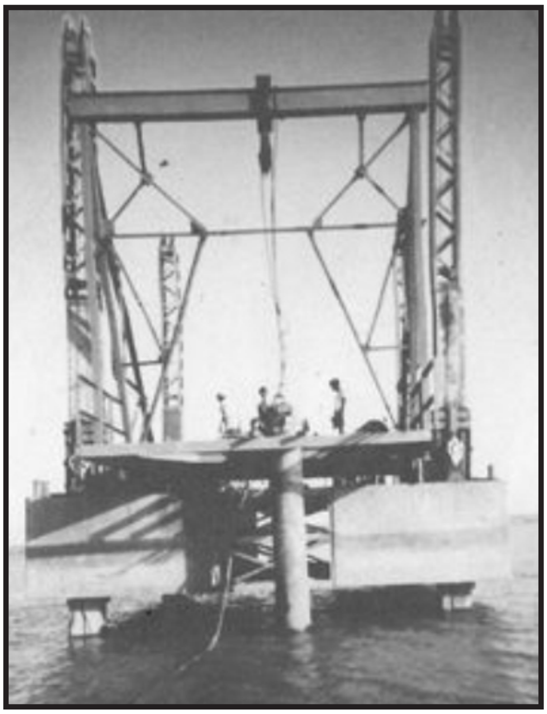
Plan of Jack Up Platform



Views of Jack up platforms







OUTSTANDING STRUCTURAL ENGINEER ISAMBARD KINGDOM BRUNEL

- Dr. B N Kale

It is an attempt to highlight the splendid works of Er. Isambard Kingdom Brunel, a Civil Engineer of the Victorian age.

During a span of just fifty three years, he could build unparall structures, standing erect even today, after over one hundred fifty years.

Those were the days when all works related to construction were done by an engineer. He would design, undertake every work related to construction including supervision, architectural, structural, civil work were done by one person, called 'Engineer'. Apart from this an engineer should have innovative ideas and calibre to complete the work satisfactorily. Brunel was possessing all these professional qualities. Even after such a long time, all the projects of Brunel, enumerated below, are still in nation's service.

Brunel is remembered for variety of bridges, gigantic ships, railways, and tunnels.

His father Marc, also an engineer, migrated to England from France, before his marriage with Sophia. Marc sent Isambard to France for education when he was fourteen years of age. After finishing his basic education and apprenticeship, Brunel returned to England. He was just nineteen years then and his father Marc was executing the job of Thames tunnel. This job was indeed hazardous. To construct a tunnel under ever-flowing Thames river was the first job Brunel was entrusted with. This work was twice suspended earlier, as the water rushed into the excavated area.

Brunel also failed twice while the work was in progress due to water logging. He was also seriously injured and had to take rest for six months. At last, this half-completed tunnel was rendered serviceable. It is now being used for underground railway, though its name is 'overground'. This is a very wide and sturdy tunnel as could be seen from both the ends.

Brunel is best remembered for bridges and gigantic ships. Clifton suspension bridge near Bristol, the widest and flattest Maidenhead bridge constructed with the help of bricks, on the Thames, having its one pillar in the midst of the riverbed, Hanwell bridge also of bricks, Royal Albert Bridge - oval shaped iron bridge, Bowstring bridge near Bath island - one of the oldest Bridges, to quote a few. Except Clifton suspension bridge, all other bridges have been constructed for railways.

For Great Western Railway, one of the longest railways, Brunel's contribution is by far the greatest. It is only he who could complete the railway's work against all sorts of opposition. He had to convince even the members of the Parliament, the importance of railways. Paddington station, the terminus of the GWR, has been his creation from first to last. Brunel's statue has been erected on the platform to commemorate his contribution. On many locomotives "ISAMBARD KINGDUM BRUNEL' is conspicuously written.

Suspension bridge at Clifton is indeed a marvellous job. It is about 700 feet long, 80 feet wide and 250 feet over the riverbed. This bridge was constructed mainly for pedestrians and light carts' traffic. Motor cars, automobiles and other speedy vehicles had not been invented till then. The same bridge is able to sustain the pressure of today's speedy vehicular traffic, which speaks a lot about Brunel's engineering skills as well as his foresight. No one would have imagined of such a fast development in vehicular traffic, 150 years ago.

Great Western Ship, Great Britain Ship, and the Great Eastern Ship have been his creations, in the ascending order. All these achievements rightfully bear the word 'GREAT'. The passenger capacity of Great Eastern Ship was over 3500, four times that of a railway. Out of these three, only one, Great Britain Ship, is existing now and has been converted into a museum. It is now an attraction for tourists and students, as well. Over one lakh fifty thousand visitors pay visit to this Ship in a year. The Ship has been honoured with four awards in 2008 for his achievement.

Crimea War was thrust upon England by Russia. Britishers were caught unaware. War means casualties and wounded soldiers. To nurse them, Florence Nightingel rushed to the battle field. The first thing she observed was lack of sanitation and hospital facilities. Barracks converted temporarily into hospitals could not deliver the goals.

Brunel undertook this job of creation of a makeshift hospital i.e. folding canvass tents and did it in record time. Florence Nightingel had a word of praise for Brunel. His innovative ideas paved way for creating such hospitals for army and during emergency in subsequent years.

After his untimely death, Brunel was honoured with many prestigious awards. In 2002 BBC conducted a survey to find out 100 Great Britons who are respected most. First rank was snatched rightfully by Sir Winston Churchill while the second one was taken away by Brunel. After his name, Shakespeare, Newton etc. were placed in that list. The government as well as private bodies honoured Brunel by issuing a series of postal tickets, two coins and many other ways.

On seeing the list of honours showered on Brunel, one feels happy that the hero did not go 'unsung'. But one wonders how was it possible for Brunel to complete so many important projects in such a small span of life. Nation is built by such dedicated engineers whose life and work show the next generation, the path to trod.

Brunel passed away on 15th September, and Bharat Ratna Mokshagoondam Vishweshwarayya born on the same date is indeed a coincidence. Year is ofcourse different.

Britishers honour this "builder of their nation".

I hope the outstanding work of Brunel will go a long way to inspire the future generations of Civil Engineers.

Career Graph of Brunel

Birth : 9th April 1806

Death : 15th September 1859

Place of Birth : Portsmouth England

Profession : Civil Engineer & Structural Engineer

Parents : Sir Marc Isambard Brunel
Sophia Kingdom

Education : Lycee Henri IV
University Of Caen

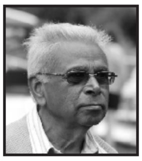
Significant Projects :

- **Bridges** :
  - Clifton Suspension Bridge - one of the biggest bridges
  - Maidenhead Railway Bridge - the flattest & the widest brick arch Bridge
  - Hanwell Bridge
  - Royal Albert Bridge - Oval shape
  - Bath Bowstring Bridge - one of the oldest iron bridges
- **Ships** :
  - Great Western Ship
  - Great Britain Ship
  - Great Eastern Ship - the biggest ship of the time.
- **Tunnels** :
  - Thames Tunnel
  - Box tunnel - over two miles long one of the longest of the time.
- **Railway** : Great Western Railway - the longest of the time.
- **Hospital** : Pre-fabricated Hospital for Crimea War

Acknowledgement :

The article is based on recently published Marathi book "Asa Hota Brunel" by Dnyanesh Prakashan, Nagpur.

Author

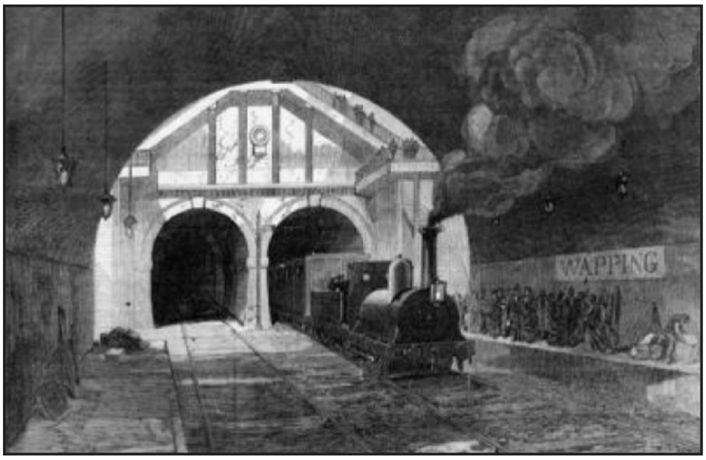


Dr. B. N. Kale

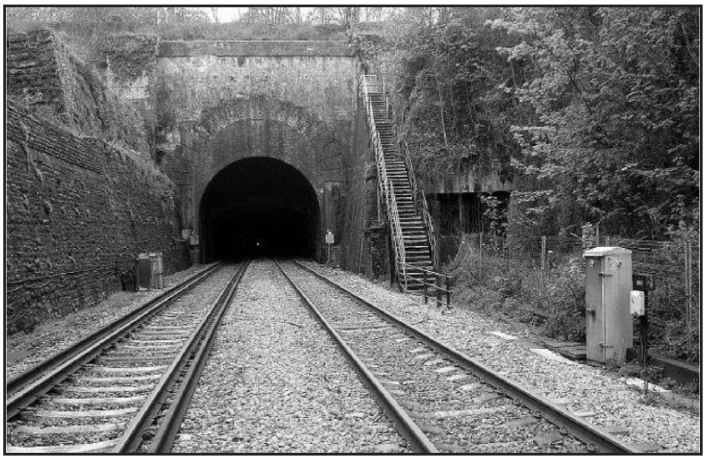
The author is a doctorate in Economics. During his visit to United Kingdom, he was fascinated by the works of Brunel. He visited various sites in U.K. and gathered information which has been compiled in his book - "Asa Hota Brunel".

Tel. : 0712-2227479 Mob : 9823366609

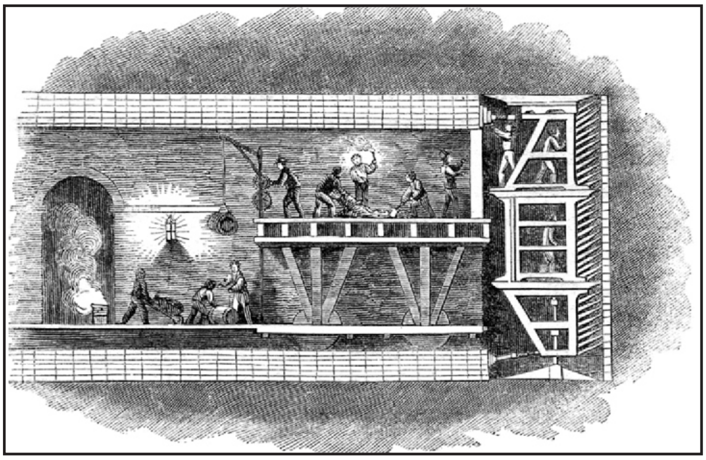
(1) Tunnel under Themes - One Side



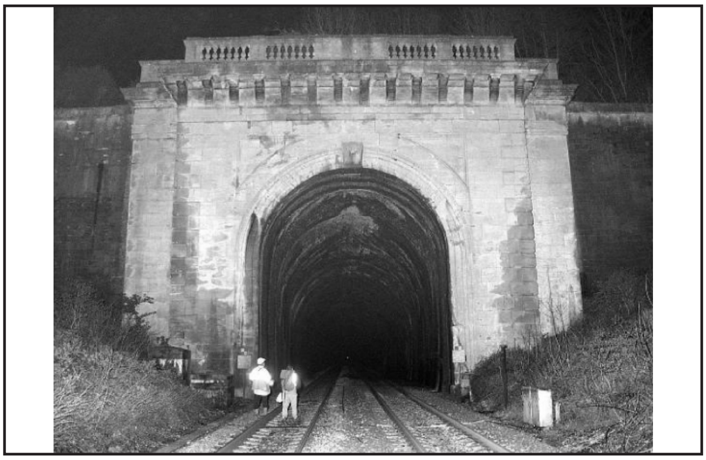
(2) Tunnel under the Themes river - used by Over ground railways.



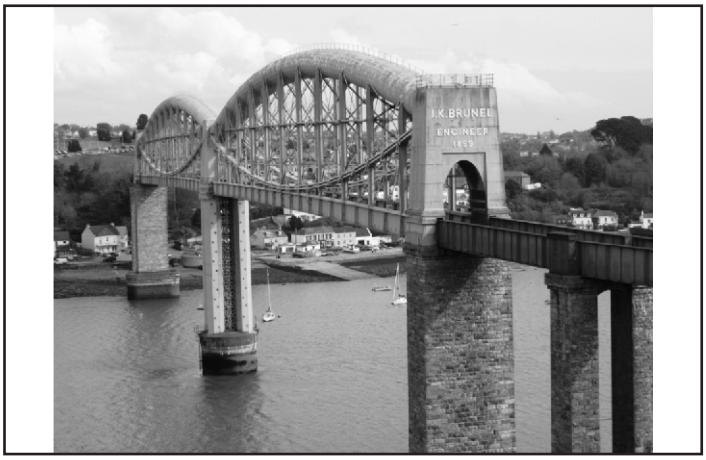
(3) Bath Tinnel



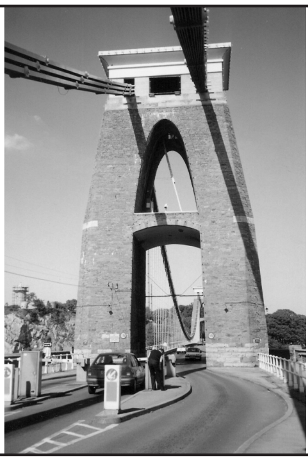
(4) Work in progress of the Themes tunnel



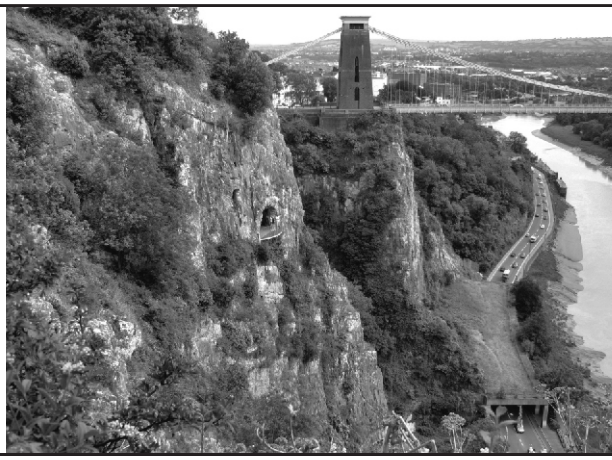
(5) BATH Tunnel - used by Railways. One of the longest tunnel of the Time.



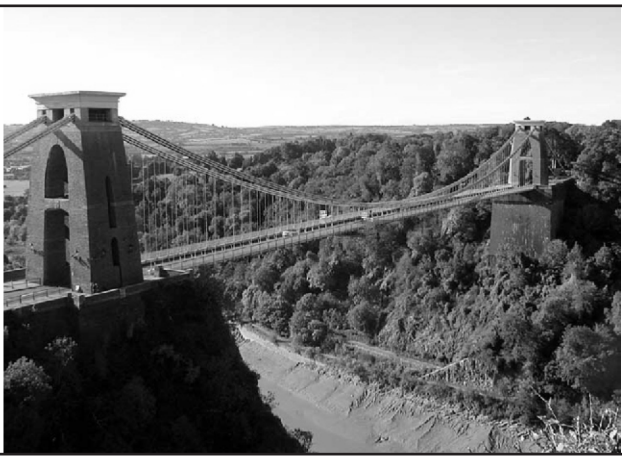
(6) The Royal Albert Bridge - OVEL BRIDGE



(7) Clifton Suspension Bridge - Other side



(8) Clifton Suspension Bridge - Over Avon River - View on one side



(9) Clifton Suspension Bridge - Full view

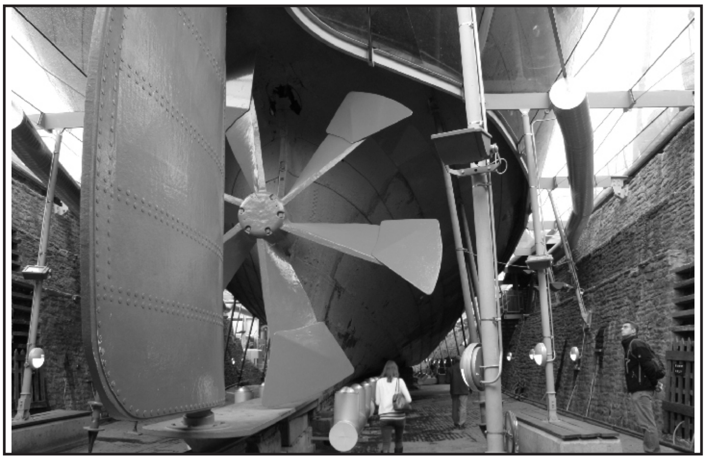
(10) Maiden head bridge - Flattest and Widest Brick Arch Bridge.

(11) Royal Albert Bridge - Work in progress

(12)Paddington Station of GWR

(13) Full view of the Clifton Suspension Bridge

(14) The Grand Western Ship - Presently museum. The only ship in existence.



(15) Propeller of the ship.

(16) Grear Western Railway

(17) Fastest Train

(18) Isambard Kingdom Brunel inscribed on many locomotives to cherish his memory.

INBUILT FERROCEMENT STRUCTURAL FORMWORK

J A Desai

Reinforced cement concrete requires formwork of certain dimensions and shapes to contain concrete at the time of construction for foundations, columns, beams, slabs of buildings and other structures such as bridges, water towers and many others. It is a very important feature right from the time Portland cement was invented because cement requires certain time to gain strength. RCC cannot be thought of, without shuttering. The time factor to provide shuttering and removing the same is significant for time bound BOT projects. Certain time has to be allowed for concrete to acquire design strength. The cost of providing shuttering, blockage of shuttering till concrete gains strength and deshuttering and time consumed is significant aspect of RCC construction. It is generally thought how it can be reduced. Various methods, materials, designs are thought of and adopted to achieve this.

In-built FERROCEMENT STRUCTURAL FORMWORK has been developed to cut down the cost, time required to manufacture, erection, leftin position till concrete has gained required strength and deshuttering for casting of column, beams, slabs. All the same the time of shuttering shall be reduced and activity of deshutterig shall be eliminated totally. Similarly for any structures such as bridges, irrigation structures, water towers, jetties and many other structures. Ferrocement shuttering for slabs and beams is manufactured on machinery set-up under controlled conditions as plates, beams in the shape of 'U' and columns as box. The reinforcement required for columns, beams, slabs shall be incorporated in the shuttering itself. The activities of reinforcement, cutting, bending placing at site shall be eliminated totally and shifted to manufacturing area Some reinforcement if necessary can be added at site.

The units are cast in parts or in full length depending upon the method of installation of shuttering. If the shuttering is to be installed by manual handling, then the shuttering shall be cast in units possible to be handled by 5 – 6 persons assembled at site for full size of slabs and beams and columns. If mechanical method of installation of shuttering is adopted the full size shuttering units can be manufactured, erected and installed in position.

After Ferrocement shuttering is placed in position, necessary connection with adjacent members are made mainly by welding, wiremesh lapping and cement matrix application. If necessary additional reinforcement is placed. The concrete at the joints, beams, columns is finished in line level and surface configuration as per requirement. After this plain cement concrete of required strength is poured in the hollow of relevant members.

The system is ready to take up next further work. The work can be strong enough for taking up the

Elaborate steel formwork as above is totally eliminated.

Concrete surface as seen above shall be surface of Inbuilt Ferro-cement Structural Formwork.

Inbuilt Ferrocement Structural Formwork

- Thin section Formwork for slabs, beams, columns
- Manufactured on machinery set-up
- Reinforcemet of slabs, beams, columns incorporated in Formwork body
- If required, additional reinforcement can be provided
- Time saving by about 10-15% and Cost saving about 10%
- The wiremesh in the formwork makes the structures strong with no/negligible requirement for repairs and retrofitting in the life of the structure
- It makes the structure best earth-quake and cyclone resistant with least damages
- The structure shakes like jelly and comes to its original position after Earthquake and cyclone is gone.
- The structure shall not require repairs almost for life time.
- The structure shall resist fire upto 75°C for 48 hours temperature and duration can be increased

Ferrocement High Rise Buildings

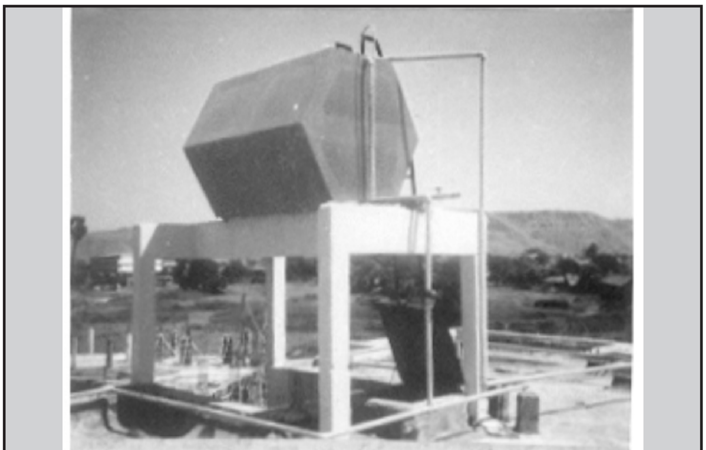
- reduce cost by about 10% of R.C.C.
- reduce time of construction by about 10% of R.C.C.
- eliminates formwork of columns, beams, slabs
- environment friendly
- inbuilt structural formwork
- is more durable, water-proof than R.C.C.
- do not require major repairs in its life time
- remain almost in tact during earthquake and cyclone
- can swing by a metre or so with no damage
- resist fire for almost 48 hours 750° C and can be made to resist higher temperatures.
- has less self-weight by about 50% of R.C.C.

construction of the next floor after 2-3 days. Similarly works on the floor below such as walls, doors, windows flooring can be taken up. There will be no props to create hindrances.

Our method of in-built ferrocement shuttering has many advantages from the point of time convenience cost and strength and time as below:-

There will be saving in time for installation of shuttering for beams, columns, slabs as compared to the time for wooden or steel shuttering and provision of props. Since the re-inforcement of beams, columns, slabs shall be within the body of ferrocement shuttering mass, the pouring of concrete and vibration or self-leveling concrete shall be very much easy and fast.

All the props and Wooden Fromwork shall be eliminated by Inbuilt Ferrocement Structural formwork.



Structural ferrocement Fromwork used for portals, beams, columns for above representative structures.

- Cost of shuttering is eliminated. Some additional reinforcement, if required, is placed within the hollow of shuttering. The next below and floor above can be taken up after two-three days.

- Cement matrix of Ferrocement shuttering will be structural integrated with the concrete of slabs, beams, columns. To that extent concrete for the member is saved. There shall be saving in concrete by approx. 10 – 15%.

- In addition to the normal strength of the structures, the skin strength will enhance the strength to a large extent.

- The time element of de-shuttering is eliminated totally and the area below is ready for other items of works such as wall, doors, window, floors, to be taken up. Similarly further work at next floor can be taken up soon.

- The surface of shuttering shall have wiremesh reinforcement which will make structure durable, strong waterproof and crack resistant. Repairs required in concrete after some years shall be eliminated for almost life of the structure. Thus performance of the structure shall be most efficient.

- The structure is most durable, fire resistant upto 750$_o$C, waterproof, better earthquake resistant and can be guaranteed.

- The FINANCE employed to execute the project shall start giving returns early. This is most important for BOT Projects.

- CONSTRUCTION OF BRIDGE, WALKWAYS, piers and beams and decks will cause least DISTURBANCE to road and pedestrian traffic. All aspects of wood and steel shuttering at site are ELIMINATED. Construction TIME AND SPACE occupied on road will reduce.

The RCC structures constructed with Inbuilt Structural Ferrocement Formwork shall get damaged the least and resist effectively all types of disasters such as earthquake, cyclones, fires and floods. The structures may get deformed but shall not collapse. This phenomena shall prevent loss of life because the people trapped can conveniently come out of such structures. Such contribution of RCC building with Inbuilt Structural Formwork shall be most invaluable. Such structures can be repaired and restored with least expenditure. Thus there will be considerable saving in prevention of loss of property.

The most important and significant contribution of inbuilt Ferrocement structural formwork is that it saves lakhs of square meters of wood, plywood and steel formwork. Thus this system is most environment friendly.

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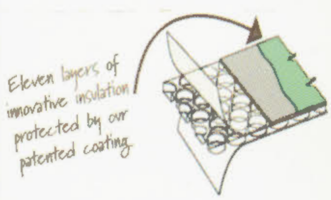

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