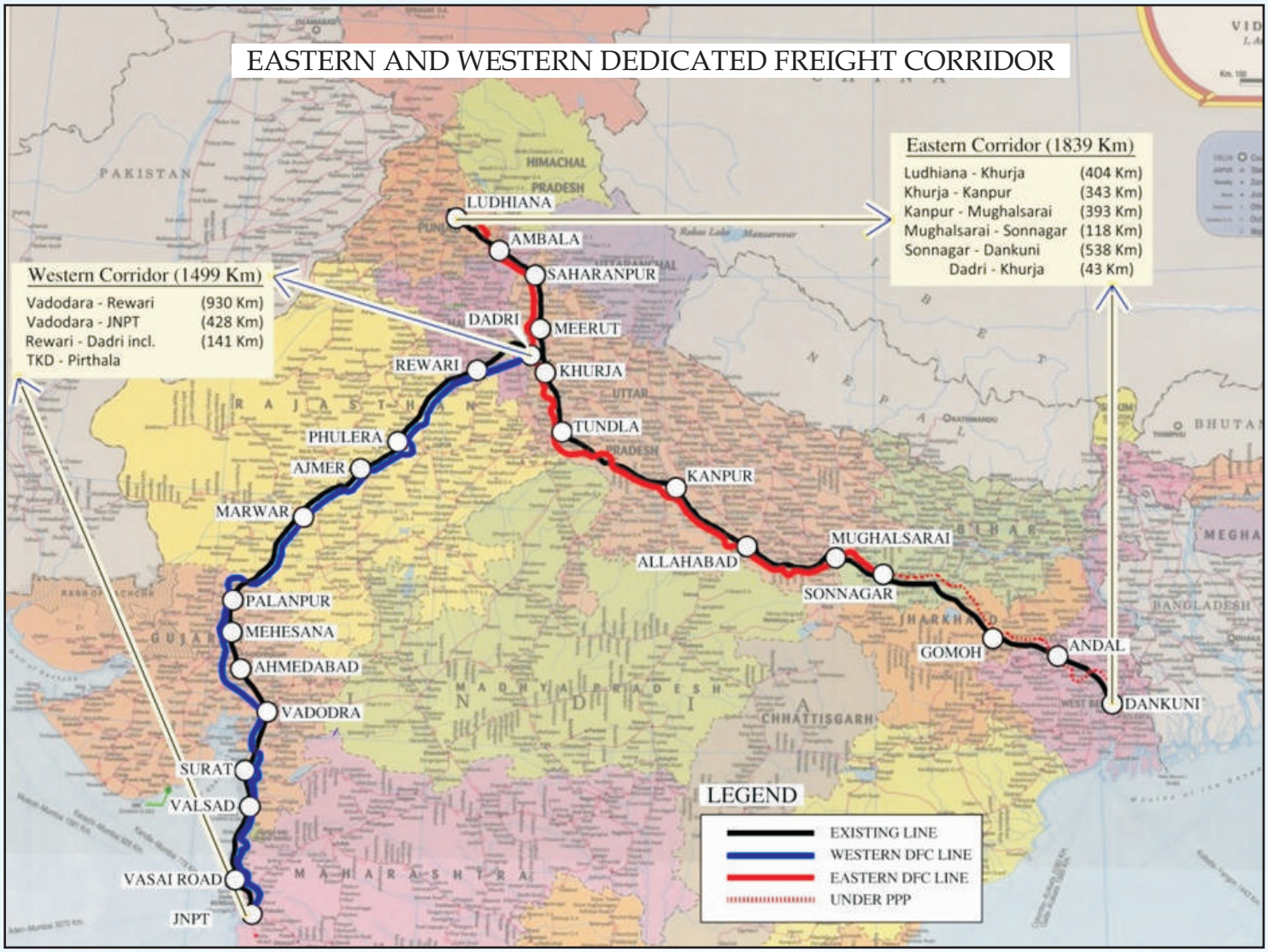
INAUGURAL ISSUE

The DFCCIL JOURNAL

ISSUE I, DECEMBER 2018



Targets

Western Corridor

SN	Sections	Targets
1.	Ateli-Phulera (190 Km)	August 18 (completed)
2.	Rewari-Madar (306Km)	December - 18
3.	Madar-Marwar (128 km)	March 2019
4.	Marwar-Palanpur (207Km)	September-19
5	Palanpur-Makarpura (308Km)	March-20
6.	Makarpura- JNPT (430Km)	March -20
7.	Rewari– Dadri(127Km)	March-20

Eastern Corridor

SN	Sections	Targets
1.	Khurja-Bhadan(200 km)	November-2018(completed)
2.	Bhadan-Bhaupur (143 Km)	January-2019
3.	Bhaupur-Mughalsarai (402 km)	August-2019
4.	Sonnagar– Mughalsarai (126km)	October-2019
5	Khurja-Dadri (46km)	December-2019
6.	Pilkhani– Sahnewal(179km)	March-20
7.	Khurja – Pilkhani (222km)	March-20

अश्वनी लोहानी
ASHWANI LOHANI

सत्यमेव जयते

अध्यक्ष, रेलवे बोर्ड
एवं
पदेन प्रमुख सचिव, भारत सरकार
रेल मंत्रालय
CHAIRMAN, RAILWAY BOARD
&
EX-OFFICIO PRINCIPAL SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

Date : 19.12.2018

FOREWORD

At the outset, I would like to congratulate team DFCCIL for publication of its inaugural issue of "The DFCCIL Journal" and express my heartfelt appreciation on Publication of highly informative periodical magazine on quarterly basis.

DFCCIL once fully commissioned, will provide a crucial backbone to the freight network of the Indian Railways which is already strained and running to more than its capacity. With the dedicated efforts of engineers, consultants and contractors, the first section was commissioned between Ateli-Phulera of Western Corridor on 15th of August, 2018 followed by Bhadan-Khurja of Eastern Corridor on 30th of November, 2018. I am confident that DFCCIL, with the renewed energy and enthusiasm, will move forward in delivering the project to the nation in March, 2020.

In its journey of realizing dream into reality and specially with this gigantic project, fast track implementation can only be possible with the use of the State-of-the-Art Technology, motivated team of engineers, consultants and contractors who are putting their best for the endeavour. Rich experience and knowledge gained during the implementation of this project, if not documented, will be lost forever and as such the decision of bringing out this quarterly journal is a much needed one.

I wish all the success to team DFCCIL.

Ashwani Lohani

विश्वेश चौबे
Vishwesh Chaube

सदस्य इंजीनियरिंग, रेलवे बोर्ड
एवं
पदेन सचिव
भारत सरकार, रेल मंत्रालय
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MEMBER ENGINEERING, RAILWAY BOARD
&
EX-OFFICIO SECRETARY,
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
RAIL BHAVAN, NEW DELHI-110001

FOREWORD

I feel privileged and proud in Communicating with all the employees and stakeholders through "The DFCCIL Journal", DFCCIL is one of the most important Public Sector Undertaking of Indian Railway created to augment freight transportation capacity in India.

Dedicated Freight Corridors are proposed to adopt world class and state-of-the-art technology. Significant improvement is proposed to be made in the existing carrying capacity by modifying basic design features. The Permanent Way will be constructed with significantly higher design features that will enable it to withstand heavier loads at higher speeds. Simultaneously, in order to optimize productive use of the right of way, dimensions of the rolling stock is proposed to be enlarged. Both these improvements will allow longer and heavier trains to ply on the Dedicated Freight Corridors.

This printed means of interface and communication is a powerful tool in a construction industry as it provides an everlasting memory of the project. I take this opportunity to exhort all of us to take a collective and determined vow to work relentlessly in accomplishing the objectives of this mega and very ambitious infrastructure project in the country. I wish all the success to "The DFCCIL Journal", in its future endeavour.

(VISHWESH CHAUBE)

New Delhi
17th December, 2018

FROM THE EDITOR's DESK

Having assumed the responsibility of Managing Director of DFCCIL recently, I feel privileged and proud in interacting with all the employees and stakeholders through the inaugural issue of "The DFCCIL Journal". The plan to construct dedicated freight corridors across the country marks a strategic inflexion point in the history of Indian Railways that has essentially run mixed traffic across its network. Once completed, the dedicated freight corridors will enable Indian Railways to improve its customer orientation and meet market needs more effectively. Creation of rail infrastructure on such a scale - unprecedented in independent India – is also expected to drive the establishment of industrial corridors and logistic parks along its alignment.

While constructing the freight corridors, crucial knowledge and experience is being acquired and I strongly feel that if the same is documented and shared then it will be possible for others to enrich themselves.The most important thing in any organisation, in addition to the product, is the information or knowledge gained in the process of its unfolding. I see knowledge sharing as an important currency and value it as the opportunity for learning for both staff and stakeholders.

This quarterly technical journal will contain rich collective knowledge that reside with our engineers, consultants and contractors and all others associated with the implementation of freight corridors. Loss of vast experience and knowledge gained has always been a concern amongst various organisation and with the publication of this technical journal, I am confident that this will go a long way in preserving and disseminating the rich pool of knowledge.

I must place on record my sincere thanks to Ministry of Railways, Zonal Railways, and other Ministries of the Government of India and State Governments, lending agencies, bankers and business associates for their support to DFCCIL. We would like to express our sincere gratitude to all our readers, engineers, consultants, and executing agencies for their valuable contribution for successful publication of the inaugural issue of a quarterly Journal.

Thanks for reading

Anurag Kumar Sachan
Managing Director, DFCCIL

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Opening of Ateli-Phulera (190 RKM)
section of Western Corridor on 15.8.2018

Back cover picture

Opening of Khurja-Bhadan (200 RKM)
section of Eastern Corridor 30.11.2018

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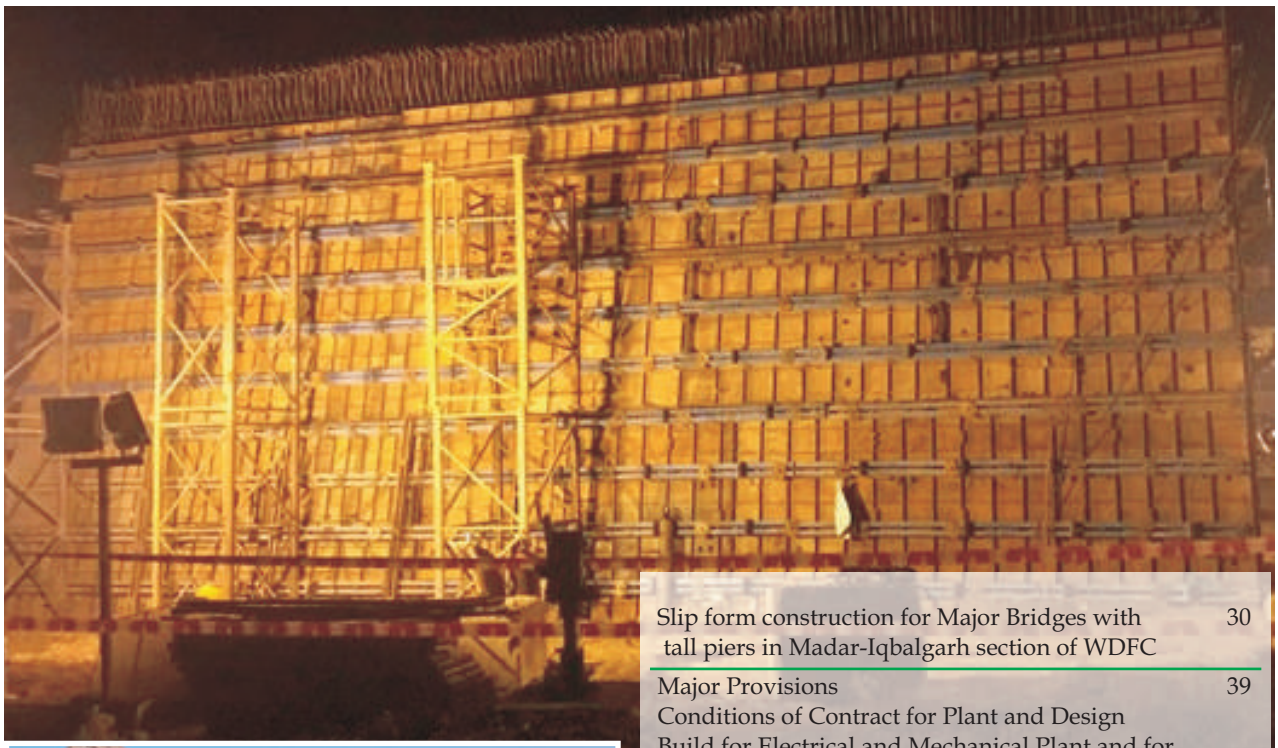

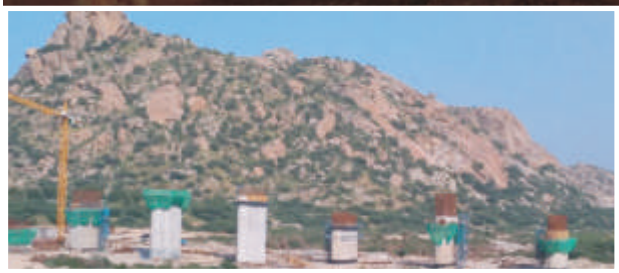

TECHNICAL PAPER FOR THE CONSTRUCTION OF ABUTMENT WALL (A1 & A2) IN SINGLE LIFT AT RFO (BRIDGE NO. 136)

Harimohan Gupta
CGM/Noida/DFCCIL

ABSTRACT:
Many construction industries prefer working the traditional way, step by step, rebar by rebar, lift by lift because that is prescribed engineering ways. But innovating new techniques is the need of the hour to complete works efficiently with reduction of time. This method follows a modular approach to save time in Abutment construction, and time is money, not just to the cost of labor and machines but also the effort. Moreover, this method combines the activities so that the whole structure is cast in single lift rather than in multiple lifts which in turn save time.

A. Introduction

DFCCIL team being committed for managing Western Dedicated Freight Corridor CTP-15C works, showed keen interest in developing alternative innovative ways to accelerate the ongoing construction activities without altering the quality of the project. After going through in detailed planning with the Contractor (IIS –L&T Consortium) of ways for construction of pier cap bypassing the conventional method, Noida unit & Dy. CRE/ZMT-4 with his team came up with an innovative thought of executing the concreting of abutment works in a single lift, free from any construction joint. However, the major concern arrived was the procedure of concreting with proper compaction. So the ZMT 4 team and PMC design team looked into various constraints of this solution and came up with a solution of using shutter vibrator with high frequency needle vibrators for increasing the efficiency. The workforce was lowered down into the abutment shutter for compaction which arose many safety concerns. IIS-L&T Consortium with the help of its technical expertise and support from PMC and officials ofCGM Noida Unit successfully completed the concreting of the abutments. This modular method of construction of Abutment paved the way to evaluate a comparison between this modular method and the traditional method in terms of cost, efficiency, effectiveness, and the time to spend during construction. One of the interesting insights in the modular method is executing the compaction of concrete of height of 7.86 m properly so that the structure is free of honeycombs and is completed in a single pour. This whole approach has a significant contribution in terms of time duration as compared to the traditional methods.

B. PROJECT DETAILS:

Design & Construction of 03 special steel bridges over existing railways & across rivers Yamuna & Hindon, involving Bridge structure, Approaches in Embankments, Guide bunds & protection works

including Testing & Commissioning on Design-Build Lump Sum price basis for Rewari - Dadri section of Western Dedicated Freight Corridor (Phase-2) – (Special Steel Bridge Works Contract Package – 15C, ICB No. CT P-15C)

C. TASK:

Construction of 02 Nos of Abutment walls (A1 & A2) in a single lift in WDFCC - CTP 15 C Project at RFO - Bridge No. 136.

Structure	Abutment A1	Abutment A2
Dimension	Non-Uniform structure with Bottom width 3.6 meterand Top width 1.5meters, Height 7.86 meter, and Length 18meter	Non-Uniform structure with Bottom width 2.5 meterand Top width 1.5meters, Height 7.86 meter, and Length 18meter
Shuttering	26MT Shuttering steel used for 324 Square Meter	25 MT Shuttering steel used for 315 Square Meter
Reinforcement	50.3 MT	29 MT
Concrete	M35 - 361 Cum	M35 - 283 Cum

Figure 1: RFO Site (Bridge No. 136)

D. CONSTRUCTION TECHNIQUE:

I. Conventional Technique:

Usually in all the construction projects, the conventional method was followed by concreting the abutment wall in stages (i.e. in lifts) with the height of 2.5Meter in each lift and the subsequent lift was cast to achieve the desired height of the abutment wall. It requires every time fixing of reinforcement, shuttering, concreting and de-shuttering which leads to involvement of substantial workforce and required enough period to complete the casting of the 8Mtr height abutment wall.

II. Innovative Technique:

By innovative thinking, the entire abutment wall (Non-Uniform Structure – Bottom width = 3.6 M and Top width = 1.5 M, Height 7.86 M and Length 18 M) was cast in the single lift/pour. The complete reinforcement of 50.3 MT was fixed & tied for the complete height of the abutment wall with required prerequisite supporting arrangement and specially designed steel shutters weighting about 26 MT. The steel shutters were placed up to 8.5Meter height with the modular casting concept and cast with appropriate planning/supervision of safety and quality during the concreting.

E. CHALLENGES ENCOUNTERED FOR IMPLEMENTING INNOVATIVE TECHNIQUE

1. Meticulous planning and preparation of the scheme with the Contractor keeping in mind the resources available at ground level. (Execution – Safety – Quality – Erection – P&M)
2. Detailed Review of whole scheme by PMC Design Team in-depth coordination with Site Team
3. Proper monitoring of fixing of dense reinforcement at height of up to 08 Meter.
4. Since it was the first of its kind in railway projects, on the suggestion of DFCCIL special rigging team had been mobilized and trained about the shutter fixing and alignment.
5. Bringing about of unique supporting arrangements for 08 Meter height shutters.
6. Bringing about to follow special mechanism required for concreting (Concrete compaction / quality requirements).
7. Ensuring safety measures and precautions required for manpower deployment inside the abutment wall for compaction during concreting.
8. Ensuring source arrangement for mass concrete in single pour with limited concreting time.
9. Ensuring safe concreting near the Live Railway track with the heavy movement of Transit mixers.
10. Ensuring Systematic de-shuttering of shutters with a specialized team.

Noida unit & ZMT-4 officials ensured proper culmination of various activities and monitored every minute details. Hence WDFC 15 C team successfully mitigated various challenges successfully under his profound guidance.

F. ADVANTAGES:

This construction methodology not only saves the time of 45 days as all the activities (fixing of reinforcement, shutter placing, supports for shutters, concreting and de-shuttering) was completed in a single go. It eliminates multi-stage concreting which leads to the incurrence of huge time in reinforcement works, shuttering, concreting and de-shuttering after the lower layer is completed in all respect. The subsequent layers/stages can be cast to complete the whole abutment wall of 8Mtr height.

Additionally – Following are the great direct cum indirect benefits from this methodology.

1. Multi-stage repetitive works stand eliminated.
2. Construction joints in the abutment wall stand abolished.
3. Quality at par for structure stands achieved with monolithic construction.
4. Temporary structures/platform required for multistage works at a height significantly avoided and reduced.
5. Utmost, engagement of workforce for multi-stage works were substantially reduced.
6. Minimization in Resource Inputs especially labors as a whole.
7. Safety – Huge risk on the safety of workers avoided by doing the entire abutment wall in single pour and movement of hydra cranes had been reduced substantially as compared with multi-stage concreting.

G. METHODOLOGY OF CASTING

a. **Rebar Fixing:** Abutment wall reinforcement fixing was completed with all links / rings up to the height of 7.86 M. (i.e. the height of abutment walls).

Figure 2: Completed rebar works

Figure 3: Shuttering work is in progress

b. **Specially Designed Shuttering & Supporting Arrangement Details:** It was designed in a special manner with sufficient factor of safety to take a load of huge concrete (361 Cubic Meter) in one go. Below mentioned are the details of the material used in it.

1. Heavy Duty Shutters Fixed = 26 MT & 324 Square Meter
2. Specially Designed through & through Tie Rods = Heavy Duty Tie Rods of 20 mm of various lengths (3982 MM – 2185 MM) were used (along with special and heavy duty washers and nuts) as supporting arrangement of fixed shutters.
3. Wallers = 40 Nos of Heavy Duty back-to-back Wallers (each of 18-meter length with various sizes - 100 MM – 125 MM – 250 MM), Total

Length = 720 R-Meter were used as supporting arrangement of fixed shutters.

4. Heavy Duty Vertical Towers (1.2 x 1.2 x 3 - Meter) = 112 R-Meter were used as an extra safety measure for supporting arrangement of fixed shutters.
5. HILTI Mechanical Fasteners (16 MM X 125 MM Long) = 56 Nos were used for rigid anchoring of vertical towers with casted pile cap. As an extra safety measure - It ensured complete stability of supporting arrangement & enough strong to take the jerk load of huge concrete (361 CUM) in a single go.
6. Extra ISMC (250-125-100-MM) = 4.2 MT fixed at various typical places as an extra safety measure with supporting arrangement for fixed shutters.
7. Especially designed Stools = 1.13 MT used as a supporting arrangement on fixed shutters.

Figure 4: Shuttering at A2 side in progress

Figure 5: Completed shutter Elevation View

Figure 6: Completed shutter Side View

Figure 7: Plate Shutter Vibrator Fixed with Shutter

Figure 8: Supporting Arrangement of Shutters

Figure 9: Supporting arrangement for Side shutters

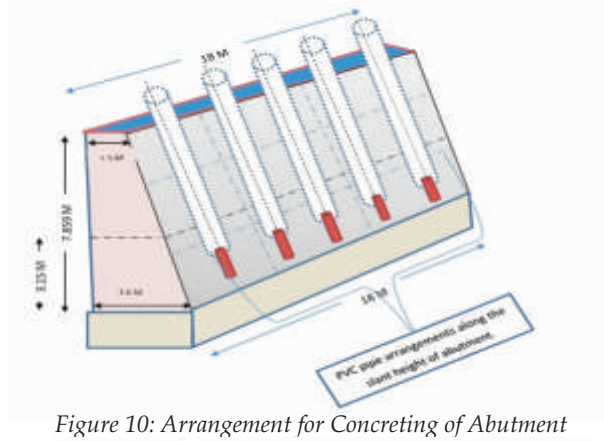

Figure 10: Arrangement for Concreting of Abutment

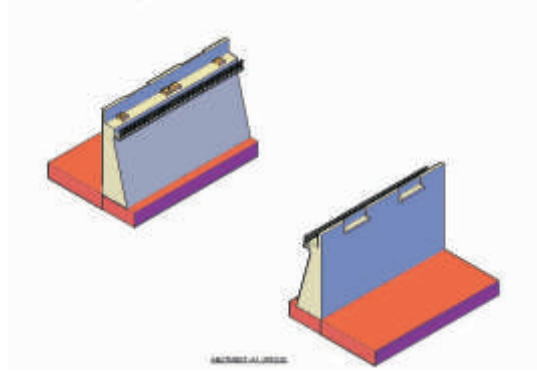

Figure 11: Completed View of Abutment Wall with Pile Cap

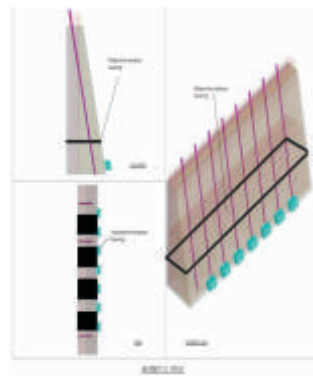

Figure 12: Working Platform for manpower lowering

c. **Concreting:** After the completion of the shuttering and supporting arrangements, safety measures/mechanismin place like, a blower for ventilation, oxygen monitor inside the abutment wall, emergency alarm for workers inside the abutment wall for compaction of the concrete. Workers lowered in four different pockets/location inside the abutment wall.

d. **Extra Safety measures and precautions were taken at the site for worker's deployment inside the abutment wall for compaction during concreting.**

1. Deployment of the high capacity blower to ensure sufficient level of fresh air/oxygen inside the abutment wall.
2. Deployment of Gas Monitoring Device to monitor the level of oxygen inside the abutment wall on regular basis.
3. Deployment of Specialist Doctor's at the site around the clock to deal with any human emergency.
4. Deployment of an Ambulance at the site around the clock to deal with any human disaster.
5. Deployment of four different alarm system with different bells (Whose remote is with workers inside the abutment wall and the bell is at top / outside the abutment wall) to raise alarm by the inside workers if they feel any un-wellness during working inside the abutment wall.
6. Typical Rescue team deployed to deal with any critical human challenge.
7. Workers lowered in four different pockets/location inside the abutment wall. Each position has a team of three workers for doing appropriate compaction in concrete. Maximum allowed time for each team to do operation inside the abutment wall is only 30 minutes and afterward another gang to maintain the comfort level of the concerned workers will replace workers.

Figure 13: Concreting of A1 Abutment in Progress

Figure 14: Concreting of A2 Abutment in Progress

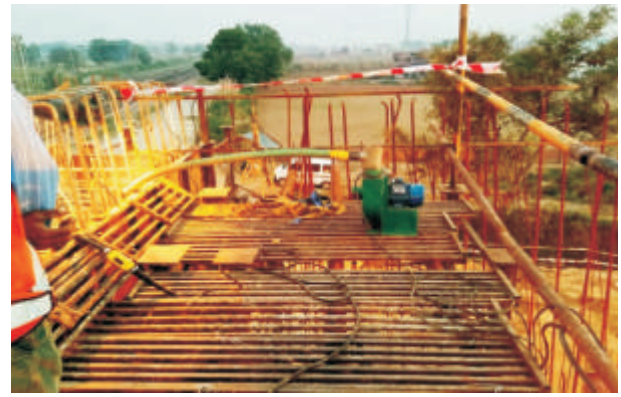

Figure 15: Blower Placed for Proper Ventilation

Figure 16: Oxygen Level Monitor Used During Concreting

Figure 17: De-Shuttering in Progress

Figure 18: Completed View of Abutment Wall after De-shuttering.

GROUND IMPROVEMENT IN DFC PROJECTS OF WDFC PHASE II

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CGM/Vadodra/DFCCIL

Sanjay Kumar
DyCPM/Vadodra/DFCCIL

Gupta Jai Singh
DyPM/Vadodra/DFCCIL

SYNOPSIS:
Any construction work in expansive soil is always a big challenge for civil engineers. DFCCIL is also facing the same in the region of Gujarat State while constructing embankment for dedicated freight corridor for a speed of 100 kmph, double stack container goods train with 32.5 tonne axle load. Through this article an attempt is made to provide a solution for embankment even in expansive soil with an object to provide stable formation.

1. Background of Project

Ministry of Railways (MOR), Government of India has planned to construct a High Axle Load Dedicated Freight Corridor (DFCC) covering about 3334 Km on two corridors, Eastern and Western Corridors. The Western Corridor is planned from Jawaharlal Nehru Port, Mumbai to Dadri near Delhi and covers a length of 1487 Km. Western Corridor is planned to be implemented in two Phases. The first phase envisages construction of 933 Km between Vadodara and Rewari. The Second Phase of the Western Dedicated Freight Corridor consists of 554 km of double line electrified track from JNPT to Vadodara (422Km) and Rewari to Dadri (132Km).

Package CTP-13, which comes under second phase, is located from Makarpura (Near Vadodara) to Sachin (Near Surat). The Works shall be carried out between Sachin and Vadodara (134km), through Surat, Bharuch and Vadodara districts of Gujarat State. The part of the proposed DFC alignment is planned basically along the existing IR tracks of Western Railway. Detours have been planned between Udhna and Gothangam (detour length of approx. 17.7 km)and between Sanjali and Vadodara (detour length of approx. 67.92 km). The proposed alignment passes through plain terrain, with continuous stretches of black cotton.

The project entails construction of double-track electrified railway lines capable of handling 32.5-ton axle load, longer trains and double stack containers. The bridges and other structures will be designed to allow movement of 32.5 ton axle load while the track structure will be designed for 25 ton axle load operating at maximum train speed of upto 100km/hr.

The package -13 is awarded to Express Freight Consortium (EFC) which consists of Mitsui, IRCON and Tata Projects Limited (TPL) by DFCC. DFCC appointed the OCG Consortium as Engineer for Project Management Consultant (PMC).

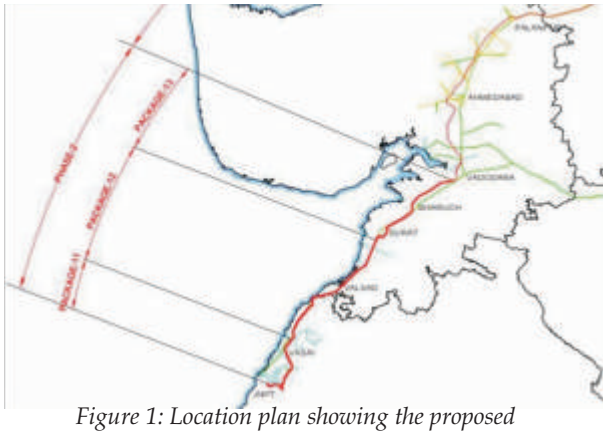


Figure 1: Location plan showing the proposed Phase -2 of DFCC alignment

A map showing the project location for Western Corridor Phase-2.

The Deep black and coastal alluvium soils are predominant in South Gujarat, medium black cotton soil is prevalent in middle Gujarat, grey brown and coastal alluvial soils are in north and north-west while the Saurashtra peninsula has calcareous medium black and to some extent coastal alluvial soils.

Typical deep black soils has been formed due to deposition of trap parent material transported through flow of rivers. The deep black soils are found in major part of Bharuch, Surat, Valsad, and the Southern part of Vadodara Districts. The depth varies from 60 cm to more than 2 m. The soils are black in color. They contain 40 to 70 percent clay minerals. The soils have sub angular blocky structure with wedge shaped structural aggregates in sub surface layers .The deep black soils in general are clay in nature

Rich proportion of montmorillonite is found in Black cotton soil from mineralogical analysis. High percentage of montmorillonite renders high degree of expansiveness. This property results cracks in soil without any warning when the . These cracks may sometimes extent to severe limit up to 15 cm width on the ground surface and 2 – 3 min depth

Figure 2: Soil Map of India

from the ground surface. So, structure to be founded on this soil may suffer severe damage with the change of atmospheric conditions.

2. Geotechnical Investigation:

Soil exploration have been carried out along the DFCC alignment at the following locations:

(a) For n- span bridge structure (1) exploratory bore hole in every (3) span in addition to two bore holes at the both longitudinal end of the structure where the abutments are to be located.

(b) In case of an Important bridge, the exploratory bore holes shall be made at every sub structure location.

(c) For the Minor bridges one exploratory bore hole.

(d) For both embankment and cutting, one exploratory bore hole in every 500 mtrs.

3. Objective of Geotechnical Investigation:

(a) To determine soil type with a view to identify their suitability for earthwork in formation and to design the foundations of other structures.

(b) To Avoid known troublesome spots.

(c) To determine method of compaction.

(d) To determine depth of various strata of soil and bed rock level.

(e) To determine ground water table and its seasonal variations.

4. Ground Improvement

As the black cotton soil is known for its expansive and shrinkage properties, ground improvement has been planned both on account of black cotton soil & other soft soils and is a part of contract specifications. and consist of following steps:

a) Confirmation of formation level, ground level, and cut/fill location along the alignment.

b) Identification of soil type based on geotechnical investigation.

c) Identification of soft ground location based on geotechnical investigation, such as N - Value less than5.

d) Identification of location where treatment is not required, such as non-expansive clay, sand, weathered rock and rock by geotechnical investigation result.

e) Identification of marine clay location by geotechnical investigation result.

f) Identification of black cotton soil by geotechnical investigation result.

Ground condition has been classified as under:

i. No treatment is required

ii. Black Cotton Expansive Soil

iii. Soft ground

Based on embankment loading and ground condition, the requirement of the ground improvement is to be selected. The required ground treatment for measures to ensure black cotton soil swelling nature are explained in below sections.

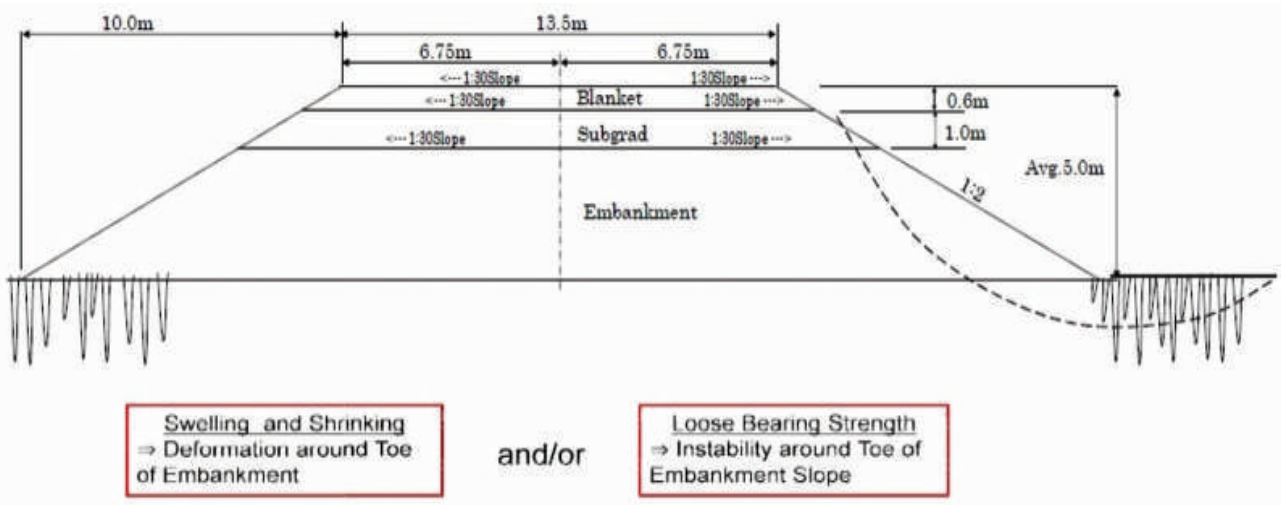


Figure 3: Causes of Track Deformation, Formation Failure

5. Treatment of Expansive Soil

Expansivesoilsareinorganicclaysexhibitinghighcompressibilityandcharacterizedby high shrinkage and swelling properties due to changes in moisture content. The expansive soil shall be identified based on following basic (prime) parameters:

a. Swelling pressure (Sw) >50 kN/m2
b. Clay content (< 2μ) >25%
c. Differential Free Swell (DFS) Index >30%

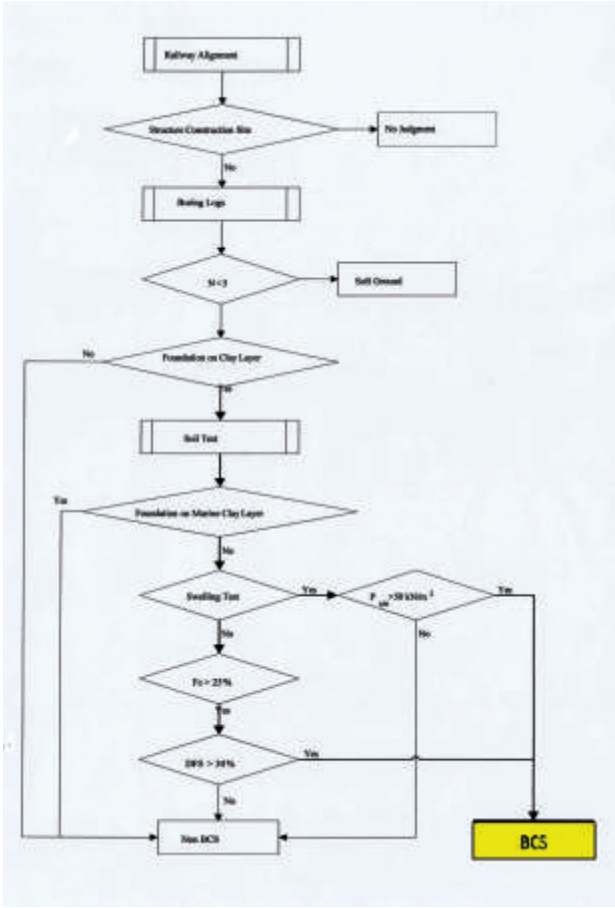


Figure 4 : Identification of Soft & Expansive soils (BCS)

Treatment proposed for expansive soils is as under:

- Treating to player of the soil with quick lime soas to reduce harmful effects.
- Consolidation of expansive soil at OMC.
- Provide drainage conditions of the formation at surface and sub-surface level.
- Provide cohesive non-swelling soil (CNS) layer, below the bottom layer of embankment fill in case of embankment and below subgrade/prepared subgrade level in case of cuttings.

The thickness of cohesive non-swelling soil (CNS) layer shall be decided giving due consideration to the overall height of embankment and swelling pressure of expansive soil. It is recommended that CNS layer treatment shall be laid based on the swell pressure and embankment height in consideration for followings:

1) To avoids welling and shrinking,
2) To keep shear strength,
3) To avoid unevenness of earthwork by providing uniform layer

Table 1: Measurement of expansiveness with respect to Differential Free Swell test (DFS)

S. No.	Degree of Expansion	DFS
1	Low	<20%
2	Moderate	20 - 30%
3	High	35 - 50%
4.	Very High	>50%

Differential Free Swell >30%

Geometry of Embankment

The geometry of embankment for the analysis is given below Top width of formation (Double lane) = 13.860m
Side Slope = 1V:2H

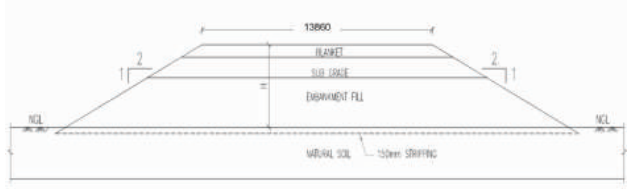


Figure 5: Geometry of Embankment

6. Treatment of Expansive Soil

Black cotton is the layer of ground soil in the entire stretch from Sachin-Makarpura covered under CTP-13. Based on the swell pressure the various methods are being used for the treatment of expansive soils.

Case A – No Treatment

For stretches where swelling pressure is less than 50 kN/m², ground treatment for expansive soil is not required.

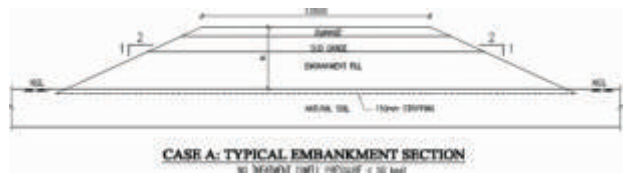


Figure 6 : Typical Embankment section with no treatment

CASE C - Natural CNS material treatment: Complete base treatment

For stretches where swelling pressures is more than0.50 kN/m² then CNS material treatment can be adopted. If natural CNS material with defined properties as per IS:9451 is available at the site location, then the natural CNS material shall be used for the treatment of expansive soil.

The properties of CNS material are defined below:

Table 2: Properties of CNS layer (IS: 9451)

Code Clause No.	Specification (Extract from IS 9451)
4.2.1	They are soils possessing the property of cohesion of varying degree and non-expanding type clay minerals such as illite and kaolinite and their combination with low plasticity and liquid limit not exceeding 50%
4.2.3	CNS material should be non - swelling with a maximums welling pressure of 10 kN/m², when tested in accordance with IS:2720 (Part-41) : 1977 at OMC and minimum cohesion (unconfined compression strength of saturated compacted soil remolded at OMC and compacted to standard proctor density) should be 0.10 kg/cm²,when tested according to IS:2720 (Part-10)1991
4.2.5	Although several soils containing non-expanding type clay minerals exhibit CNSproperties,thefollowingrangehelpsinlocatingsuchtypeswhichshould satisfy 4.2.1 and 4.2.3 Clay (less than 2 micron) : 15-20 % Silt (0.06 mm to 0.002 mm) : 30-40 % Sand (2 mm to 0.06 mm) : 30-40% Gravel (greater than 2 mm) : 0-10% Liquid Limit : >30 but less than 50 Plasticity Index : >15 but less than 30
	Further, proposed the grading of CNS material based on different case studies on CNS material referred in "Behaviour of Saturated Expansive Soil and Control Methods" is as follows. Clay (less than 2micron) : 15-30% Silt (0.06 mm to 0.002 mm) : 20-45 % Sand (2 mm to0.06mm) : 29-43% Gravel (greater than 2 mm) : 0-15% Liquid Limit : >30 but less than 50 Plasticity Index : >15 but less than 30

The thickness of cohesive non-swelling soil (CNS) layer shall be decided giving due consideration to the overall height of embankment and swelling pressure of expansive soil. Refer Table 3 of IS 9451 for CNS layer thickness for given swelling pressure.

Table 3 : Thickness of CNS layer as per swell pressure of soil

Swelling Pressure of Soil (KN/m2)	Thickness of CNS Materials (cm) (Min)
50 to 150	75
150 to 300	85
300 to 500	100

Source : IS 9451 : 1994, Indian Standard, GUIDELINE FOR LINING OF CANALS IN EXPANSIVE SOILS

The soil below the embankment shall be tested and observed the swelling pressures are more than 50 kN/m², the CNS treatment shall be provided total extents of embankment base as shown in the Figure 7.
Typical arrangement of CNS layer provided throughout the embankment width is shown below:

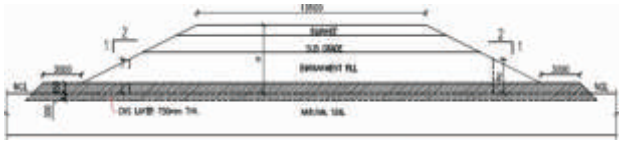


Figure 7: Typical Embankment section with complete replacement of CNS for full section

In case the reisa need to provide CNS layer because of presence of expansive clay layer, excavation shall extend for a thickness of 300mm as mentioned in above Figures 7. CNS layer shall extend at least 3 m beyond the outer edge of the toe of embankment. CNS layer shall be placed in layers with compacted thickness not more than 200 mm and each layer compacted to 97% of Standard Proctor density.

CASE C - Removal and replacement of the Expansive soil i.e. Black Cotton Soil

As per GE-14, for the stretches where swelling pressure is more 50 KPa and the depth of presence of expansive soil is about 2m, replacement of expansive soil with SQ1/SQ2/SQ3 embankment fill material may be adopted. The subsoil properties shall be ascertained at every 0.5 minter vals (0.5m, 1.0m, 1.5m and 2m) and swelling pressure values shall be identified. If the swelling pressure is less than 50 kN/m² then excavation and replacement with embankment fill material (SQ1/SQ2/SQ3) shall be adopted with controlled compaction.

For example, if swelling pressure is less than 50 kPa at depth 1.0 m and below, then excavate complete black cotton soil up to 1m depth and replace with embankment fill material (SQ1/SQ2/SQ3)

Figure 8: Typical Embankment section with removal and replacement (Case C)

Availability of black cotton soil in the entire stretch from Sachin to Makarpura and due to almost non-availability of CNS material in the vicinity compelled the contractor to adopt this method of removal of black cotton soil & then replacement by suitable soil. The implications of choosing this method of ground improvement were:

A. Excavation of black cotton about 35.00 lakhs cum up to 2 M depth.
B. Proper disposal of above excavated material.
C. Filling of the excavated space of 35 lakhs CUM with SQ1/SQ2/SQ3 material up to 2M depth.

Thus, this method has increased the quantity of earth work substantially (approximately 40%). It literally means that as such earth work could start only after doing about 70 lakhs cum of extra earth work on account of ground improvement.

8. Conclusion :

In the entire stretch form Sachin-Makarpura covered under CTP-13, the ground improvement work is being done mainly by replacement of the black cotton soil and the balance by the provision of the CNS material primarily because of limited or no availability of CNS material. While this has increased the quantity of earth work, but as the formation is now free of black cotton soil or the same has been provided with the intermittent layer of CNS material at the ground level, the DFCCIL formation is expected to be free from shrinkage and swelling characteristics unlike the Indian Railways where formation in some of the stretches is made of the black cotton soil. This is expected to reduce the track maintenance efforts substantially.

9. References:

1. *Report No. RDSO/2007/GE : 0014 November 2009 Guidelines and Specifications for Design of Formation for Heavy Axle Load.*
2. *IS 9451 : Guideline for lining for canals in expansive soils*
3. *Technical Report on Expansive Soil Treatment Rev-B (CTP-13)*
4. *Design Reference Vol-VI of 2 of 2*

DEVELOPMENT OF NON-INVASIVE RAIL EARTH CLAMP FOR CONNECTING METALLIC BOND TO RAILS IN WESTERN DEDICATED FREIGHT CORRIDOR PROJECT

Nihar Ranjan Dash
GGM/Electrical/DFCCIL

ABSTRACT:
Bonding and Earthing of all non-live metallic parts and structures in an electric traction based railway system is a mandatory requirement. The various methods used in AC traction based railway system, for ensuring a proper connection between the metallic bond and the rails in general are; welding of the bond directly to the rail flange, or connecting the bond with the rail through a fastener after drilling hole to the web of the rail. Both these methods are invasive in nature and may affect the structural/metallurgical characters of the rails. The problem is more critical in heavy haul freight railways and high speed railway systems, on account of the high impact loads on the track structure. This paper discusses a new technique for effective rail-traction bond connection, by use of a rail-earth clamp, thus completely eliminating drilling of holes unto to the rails, or welding on rails. The clamp is rigidly fitted to the rails, having sufficient contact surface area, for effective passage of the designed short circuit current. The assembly consisting of test piece of rail along with the clamping device has been subjected to 'short time current withstand test, at the appropriate value of the short circuit current in Central Power Research Institute. This is being used, for the first time, in Western Dedicated Freight Corridor (Phase-I) Project in India.

Introduction:

An electrical connection between two or more conductors or non-current carrying metallic parts is called a 'bond'. The 'bond' for such purposes is either an uninsulated metallic rod/strip/wire,or an insulated cable, of appropriate size to match the short circuit current rating of the system. In AC traction parlance, there are three mainly types of bonds, i.e. (i) longitudinal bond, for ensuring continuity of traction return current through the discontinuous portions of the track length, (ii) cross bond, between rails of same track, and also between two or more adjacent tracks, and (iii) structure bond, between rails and other non-current carrying metallic structures (such as traction masts). All these bonds are usually connected to their respective principal objects through rigid fasteners. Usually pre-fabricated holes are provided in traction masts during the fabrication stage itself for fastening of bonds. However, in order to connect the bonds to the rails, holes of a particular size are drilled into the rail

web, at regular intervals, in order to fasten the bond.

Drilling of holes unto the rail web, or welding of any metallic piece to the rail flange, in some way or other will affect the structural strength of the rail. This invasion becomes acute in case of heavy haul and in high speed railways, on account of the high impact load on the track structures.

Therefore, in the context of the Dedicated Freight Corridor, designed for heavy haul loads at relatively higher maximum speed limit of 100 kilometre per hour, it is a necessity that drilling of holes to the rail are avoided. In order to overcome this problem, an innovative and effective way has been found out in Western DFC project by way of developing a 'Rail Earth Clamp' device. This ensures a rigid electrical connection between the metallic bond and the rail, without drilling of holes on the rail web, while also ensuring a rigid and effective contact for passage of the short circuit current (as well as normal return current from the locomotive) under the most severe condition of fault condition.

Structural Details:

The Diagram and Photograph explain the structural details of the 'Rail Earth Clamp' device and how it is connected to the rail flange on one-side, and the metallic bond on the other side. Structurally, this 'Rail-Earth Clamp' is only an intermediate device to ensure a sound electrical connection between the rail and the metallic bond, without drilling hole or welding any metallic piece to the rail. The device has two clamps, which are press fitted on both sides of the rail flange, thereby ensuring a proper surface contact between the two metallic surfaces. The under-rail projection is fastened by use of a metallic galvanized/stainless steel bolt having two sets of washers, a plain r and a spring-washer. The bond is securely and rigidly fastened to the projected part of the device with the help of the fastener arrangement. A cut-out split-pin and welding of the nut and threaded part of the bold are additional anti-pilferage arrangements.

Testing:-

The complete assembly of the device, along with the test piece of the rail, the fasteners and the metallic bond have been subjected to short-time current withstand test, in accordance with BS:951:2009 at the short circuit current level of 12.16 KA rms value for 3.13 seconds, in the Short Circuit laboratory of Central Power Research Institute, Bangalore, India. The relevant pages of the Test Report shows the result of the test. The test methodology is as defined at Para B-22 of BS: 951:2009. There has been no visible damage to any of the assemblies or parts and the total impedance value of the device along with the assembly has remained within the acceptable range after conducting the short circuit test.

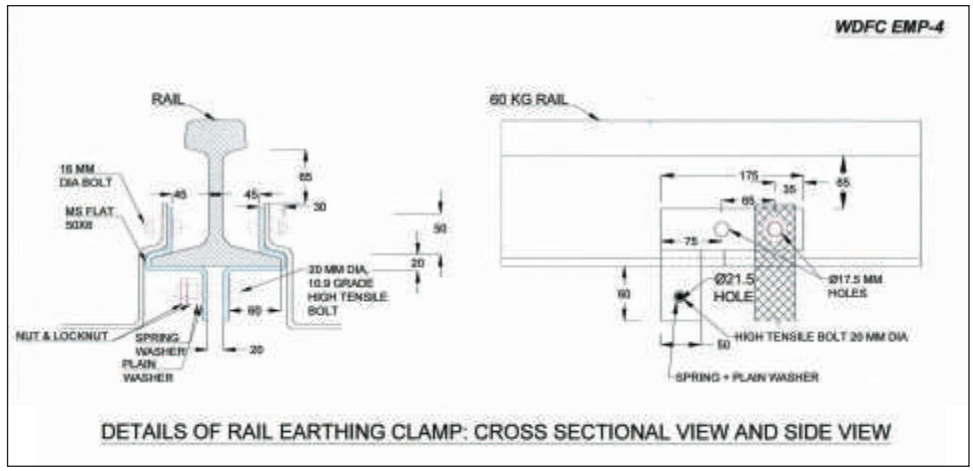
Quality Control:-

In order to ensure that the quality of current carrying parts remain unaltered during the course of the construction stage, it is imperative to check the contact surface between the clamps and the surface of the flange of the rail as well the fastening of the metallic bond to the clamp. In order to ensure that the contact between the clamps and the rail surface is effective throughout the service period of the operation and maintenance stage, it is necessary to use the soft hammer for maintaining the tightness. During the maintenance stage, DFCCIL will carry out further studies to ensure that the effectiveness of Rail-Earth clamping device throughout the service period.

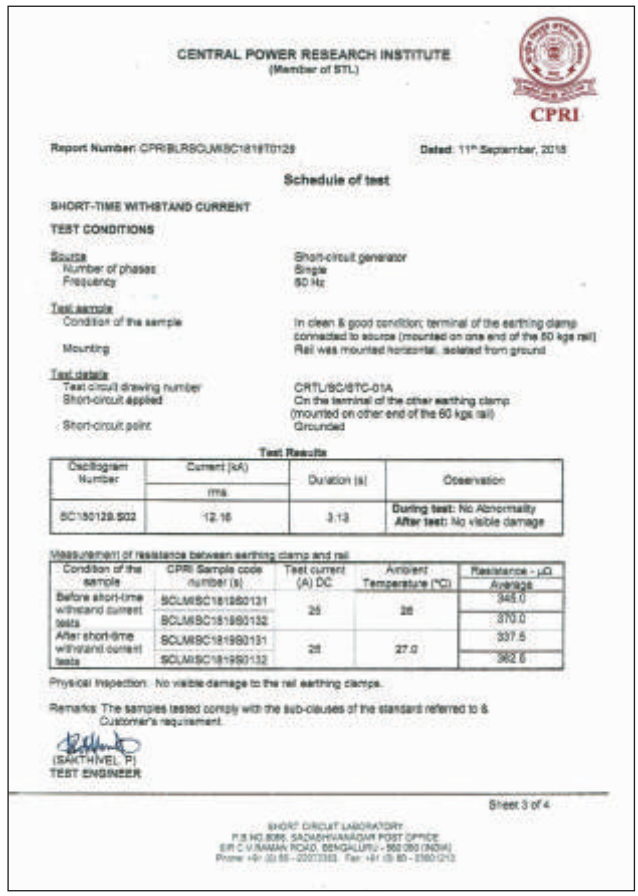
A Photographic Representation of the Rail-Earth Clamp with Rail Piece

Conclusion:-

Although it is a challenge to ensure the maintenance of the good surface contact between the clamp and the rail surface during the course of the operation phase, the loosening of the bond during operation is not anticipated, as the direction of fitment of the clamp is in 90° angle with the direction of vehicle impact force. The tests and trials, carried out so far, have been scientific, and show positive directions towards the desired goal of safety and reliability of the track structure, while meeting the mandatory requirements of earthing band bonding in AC traction system.



DETAILS OF RAIL EARTHING CLAMP: CROSS SECTIONAL VIEW AND SIDE VIEW



CENTRAL POWER RESEARCH INSTITUTE
(Member of STL)

CPRI

Report Number: CPRI/BLR/SCL/MISC/1819T0129 Dated: 11th September, 2018

Schedule of test

SHORT-TIME WITHSTAND CURRENT

TEST CONDITIONS

Source
Number of phases: Single
Frequency: 50 Hz

Test sample
Condition of the sample: In clean & good condition; terminal of the earthing clamp connected to source (mounted on one end of the 60 kgs rail)
Mounting: Rail was mounted horizontal, isolated from ground

Test details
Test circuit drawing number: CRTL/SC/STC-01A
Short-circuit applied: On the terminal of the other earthing clamp (mounted on other end of the 60 kgs rail)
Short-circuit point: Grounded

Test Results

Oscillogram Number	Current (kA) rms	Duration (s)	Observation
SC180129.S02	12.16	3.13	During test: No Abnormality After test: No visible damage

Measurement of resistance between earthing clamp and rail

Condition of the sample	CPRI Sample code number (s)	Test current (A) DC	Ambient Temperature (°C)	Resistance - µΩ Average
Before short-time withstand current tests	SCL/MISC/1819B0131	25	26	345.0
	SCL/MISC/1819B0132			370.0
After short-time withstand current tests	SCL/MISC/1819B0131	25	27.0	337.5
	SCL/MISC/1819B0132			362.6

Physical Inspection: No visible damage to the rail earthing clamps.

Remarks: The samples tested comply with the sub-clauses of the standard referred to & Customer's requirement.

(SAKTHIVEL P)
TEST ENGINEER

Sheet 3 of 4

SHORT CIRCUIT LABORATORY
P.B.NO.8066, SADASHIVANAGAR POST OFFICE
SIR C.V.RAMAN ROAD, BENGALURU - 560 080 (INDIA)
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OPTIMIZING TRACK MAINTENANCE ADOPTING STATE-OF-THE-ART INSPECTION & MONITORING TECHNOLOGIES ON DFCCIL

Praveen Kumar
GGM/Procurement/WDFC/DFCCIL

SYNOPSIS:
DFCCIL is in the position of starting with a blank slate in the design of Inspection & Monitoring processes given the infrastructure will be brand new and built to a world class standards with the prime aim to reduce the cost of Inspections, Monitoring & Maintenance. DFCCIL has been conceptualized with lean & thin organization in line with that of the advanced railways of the world. DFCCIL has the opportunity to study and learn from the international best practices and apply those that are deemed best suited to maintain its infrastructure.

1.0 Introduction

Inspection, Monitoring & Maintenance philosophy for DFCCIL include:

i) Inspection &Monitoring technologies augmented by visual inspection conducted by qualified experts;
ii) Collection and utilization of inspection, testing and incident data for the purposes of program development and predictive maintenance planning;
iii) Maintenance to have "Minimum Manual" interference;
iv) Full mechanization of Inspection, Monitoring & Maintenance of the infrastructure with State of the Art Equipments & Technology;
v) Three tiered organization with Integrated Maintenance Depots/Sub Depots (IMDs/IMSDs), Regional Mechanized Maintenance Units (RMMUs) & Corridor Mechanized Maintenance Units (CMMUs);
vi) Use of Rail-cum-Road Vehicles (RCRVs) for increasing mobility of staff in performing various activities.

This paper discusses mainly about the latest in Inspections & Monitoring technologies of **"Track & Bridges"** employed over various World Railway systems & the one to be used on **Dedicated Freight Corridor Network** spread over Western Dedicated Freight Corridor (1500 RKM) & Eastern Dedicated Freight Corridor (EDFC) (1800 RKM).

Infrastructure monitoring means the process of measuring and inspecting the railway infrastructure in order to assess its quality and thus safety. As traffic density on DFCCIL network will be very high and fewer slots will be available for maintenance, conventional methods of track inspection and monitoring will not serve the purpose. In order to achieve availability, reliability & safety from the track infrastructure, one has to

carry out maintenance at the right moment by determining whether, when, where and how to intervene "Condition based" maintenance. It is important to mention that condition based maintenance can only be accomplished by having a proper infrastructure for inspection and monitoring systems in place to support diagnostics and maintenance planning activities.

Nowadays, world over, innovative opto-electronic and vision technologies installed on dedicated vehicle allow the simultaneous monitoring of all the infrastructure parameters. Innovative inspection & monitoring systems integrates measurement of track geometry, rail profile, rail surface defects & intelligent track video inspection systems etc. Such type of systems adopts innovative techniques based on non-contact opto-electronic & vision technologies.

DFCCIL, with very lean organization during operation phase, will be adopting such systems for the inspection & monitoring of its infrastructure which will enable in trimming the cost of inspection & monitoring & finally the maintenance cost as the same will be dependent on the accurate diagnostics and analysis of such innovative systems.

2.0 Monitoring & Maintenance Strategy for DFCCIL

DFCCIL network falls in the elite category of "Heavy Haul Freight Network" with 32.5 tonne axle load, speed potential of 100 kmph coupled with high density of traffic operation through Automatic Block Signalling systems and most importantly the time tabled delivery to the customers. In order to accomplish the above stated goals at minimum cost, DFCCIL will be adopting a world class Inspection, Monitoring & Maintenance framework. Following are the key points of the framework:

i) **Safety First:** As DFCCIL network is designed with Automatic Block Signaling systems with the maximum speed of freight trains at 100 kmph, no activity, whatsoever, be allowed without block protection. Access to track will be controlled.

ii) On Indian Railways various types of patrolling is in vogue like : a) Key man's daily patrol, b) Gang patrol during abnormal rainfall or storm, c) night patrolling during monsoon, d) security patrolling, e) Hot and cold weather patrolling for LWR/CWR & f) Watchman at vulnerable locations. The above situations, however, can't be ruled out in DFCCIL network during operation phase and as such in addition to employing modern methods of inspection & monitoring through mechanized means, specialized trained manpower equipped with state of the art equipments will also be in place.

iii) Assured corridor block of 4 hours atleast for performing various activities.

iv) Separation of Inspection and Monitoring wing from that of maintenance wing.

v) Introduction of Integrated Maintenance Depot (IMDs)& Integrated Maintenance Sub Depots (IMSDs) spaced at an interval of approx. 160 RKM & 80 RKM respectively as the basic maintenance units, Regional Mechanized Units (RMMUs) spaced at about 500 RKM & Corridor Mechanized Maintenance Units (CMMUs) as one per corridor.

vi) Use of Rail-Cum Road Vehicles (RCRVs) for performing various activities at IMD/IMSD level.

vii) State of the Art Ultra-Sonic System of testing of internal flaw of rail which has always been a serious concern in Indian Railways.

viii) Scientific study of Rail wear by a separate self-propelled measuring vehicle which will gather data of rail wear so as to decide the rail grinding plan for optimizing rail life.

ix) Use of state of the art Self-Propelled Track Recording Care (TRCs)&OHE Recording Car (ORC) capable of recording at 110 kmph.

3.0 Discussion on Inspection & Monitoring Technologies Available & Employed over World Railway Systems

Track inspection methods are evolving rapidly and is being adopted by railway engineering department's world over. As these services are needed on increasing spread of track, service providers are integrating multiple technologies onto single platform, moving towards real time reporting and developing user-friendly web applications to monitor & provide access to inspection information.

Following are some of the leading service providers of the state of the art Inspection & Monitoring technologies.

DMA
DMA provides primarily non-contact, optical measurement solution for track measurement and inspection application. DMA ensures accuracy of its data and diagnostics by ulilisation of calibration tools and processes, practicing automated sanity checks on data and performs periodic field tests for spot checks & comparisons. DMA is capable of installing its optical measurement equipment on an expanding range of vehicles including Rail-Cum Road Vehicles & in service rail bound vehicles.

ENSCO
ENSCO rail provides track recording vehicles with various technologies, including digital track geometry, rail profile, rail corrugation and machine mission. Machine vision technology can also be mounted on revenue vehicles to perform such functions including rail-wheel interaction. World over, three major trends are developing. The first is ultra-comprehensive track inspection vehicles, which can house eight or more inspection systems on board due to reduced hardware size and system integration. Another trend observed is the increase in autonomous track geometry inspections on revenue vehicles. A third trend is, performing track inspections in the office, where automated inspection data is transferred to the office and can be reviewed to supplement or even replace foot –by-foot inspection.

MRT Holdings
MRT Holdings LLC has introduced its Track Geometry Systems (TGS). TGS utilizes aerospace grade inertial guidance systems paired with wireless communication between various modules. These systems can be installed on a variety of vehicles and that the open source reporting structure of its TGS allows railways to take ownership of their own data and integrate it into back office reporting infrastructure.

NxGen Rail
NxGen Rail provides and operates rail-bound track inspection services at sectional speed, combining multiple technologies to provide a holistic view of the track condition. These technologies include full track and rail geometry, machine vision and ground penetrating radars. Nx Track Cloud (TM) enables railways to perform virtual visits to anywhere on their network at the click of a mouse and view tracks, rails and other assets with high definition imagery. Advancement in technology are now allowing more data integration and analysis methods that enhance the performance of the inspection technology driving the push from reactive to condition based maintenance strategies.

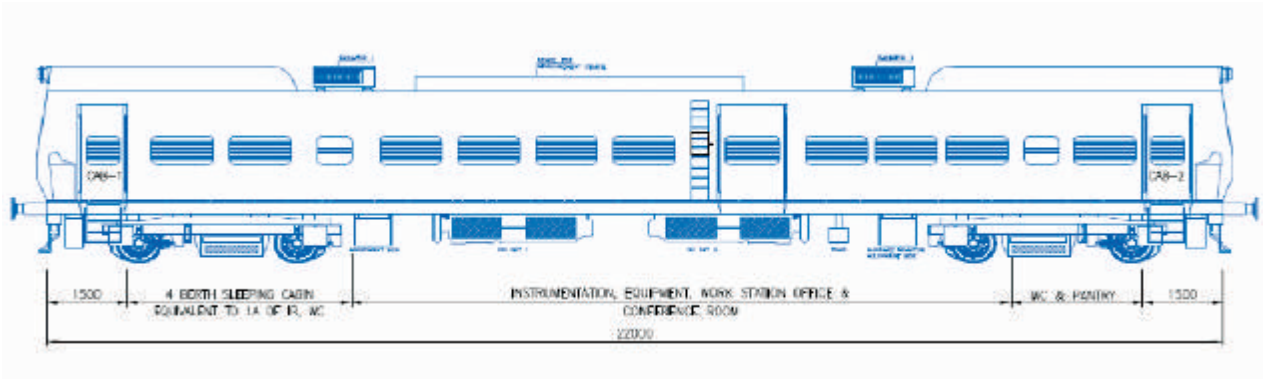
Plasser American
Plasser American Corp provides a system that provides information on a range of track inspection needs including track geometry, rail profile, corrugation, clearances, rail flaw detection and catenary measurement systems to video systems for inspection of right of way, track components, thermal imaging & more.

In addition to above, there exists several other service providers world over like Rail Works, GREX, Holland, MerMec etc. which are capable in providing world class inspection & Monitoring technologies by combining various technologies on a single platform with state of the art hardware & software for inspection, reporting and analysis.

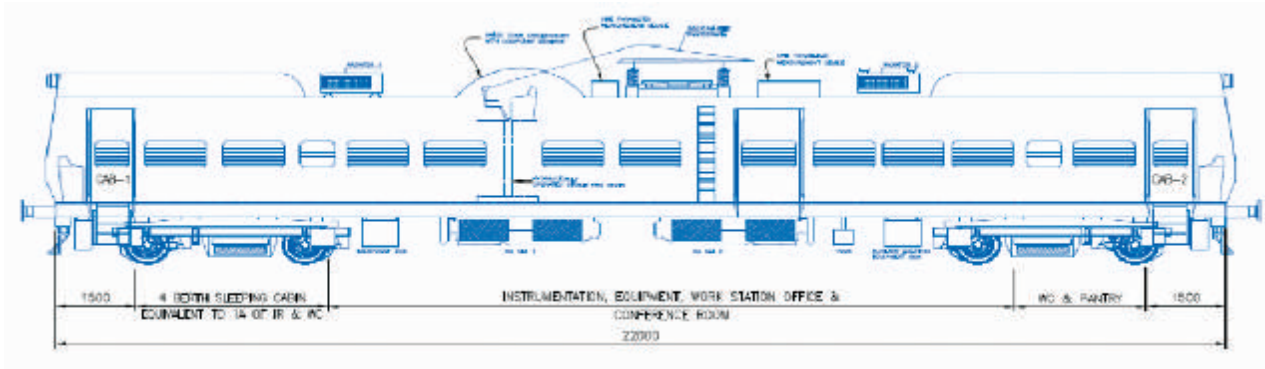
4.0 Features of Track Recording Car being Procured for Inspection & Monitoring of DFCCIL Network

After studying the world's best practices, presentations/discussions with the major & leading suppliers of the world & visit to advanced Railway systems of Europe, DFCCIL has formulated the specifications of the Track Recording Car. The system is designed as Integrated Monitoring System. The measurement and recording of track parameters, track components etc. shall be sufficiently in detail so that physical inspections and measurement by staff may be considerably reduced. DFCCIL is procuring two recording cars namely "Track Recording Car (TRC)"&"OHE Recording Car (ORC)". TRC will be equipped for inspection & measurement of Salient features of Track Recording car are summarised below: for inspection & measurement of all the parameters pertaining to track & some of the parameters pertaining to OHE & ORC will be equipped with all the parameters of OHE & some of the parameters pertaining to track.

TRACK RECORDING CAR (TRC)

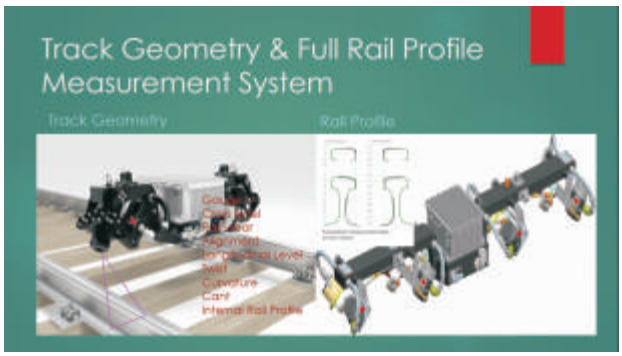


OHE RECORDING CAR (ORC)



4.1 Track Parameter Recording System

Inertial principle of measurement based on Non-Contact Opto-inertial equipment using lasers and high speed digital camera measuring technology shall be used for the measurement of vertical and lateral profiles of both left & right rails.



4.2 Half Rail profile and Wear Measurement System

LASER based contact-less sensors for recording of track geometry parameters shall be used in this sub system for measurement of rail profile and wear.

4.3 System for Identification of Infringement in Maximum Moving Dimension (MMD) Envelope of IR and DFCCIL

a) The system shall be able to scan the MMD envelop at every spot of less than 80 millimeters at maximum recording speed of 100 Kmph.

b) The system shall measure and record positions of structures within a rectangular shape of 15m of base and 10m of height.

c) The system shall have the facility to upload the standard DFCCIL and Indian Railway Maximum Moving Dimensions envelop in the system;

d) The system shall be able to evaluate the deviations of the measured envelop with respect to the standard MMD envelop. It should also be able to plot the actual profile at selected location;

e) The deviations of any obstacle w.r.t standard IR and DFCCIL MMD envelope shall be stored and printed with details and location

(chainage of obstacle in terms of last Kilometer and meter); and

f) The system shall be capable of displaying the video of clearance envelop on separate VDU and store the overlapping image of measured and standard MMD envelop along with obstacle. With this system of intelligent videography, DFCCIL also aims at monitoring of Encroachment within the RoW.

4.4 System for Video Recording of Track at Both ends of the Vehicle

a) The system shall have the facility to videography at both the end of the TRC;

b) HD Resolution Video camera shall be provided. Resolution of the captured view shall not be less than 1280X720 pixels;

c) The system shall be capable to acquire, store and print the image at track features with location of track feature e.g. Level Crossing, Curve Start, Curve End, Bridge Start, Bridge End, station etc. by using sing preloaded tack feature location file. Option to print the image at track features shall be user selectable; and

d) System shall have the capability for storage of images with localization index at least at every 2.0 meter at maximum recording speed of 110 kmph.

4.5 System for Track Vision and Video Recording of Track Components for Condition Monitoring

a) System shall be capable to identify, store and print image and description of the defects in both left and right Rail, Fastenings, sleepers, Ballast and balise;

b) System shall be capable to store image and description of defect with location in separate files for each component of track i.e. Rails, Fastenings, Sleepers and Ballast;

c) The system must be able to gather and process grey level high resolution images of the rail top surface associated with localization information in an integrated way for analysis; and

d) System must be capable of automated detection of defects and abnormalities like:
Rails: Linear defect, Area Defect, Corrugation, Joint Gap measurement, excess welding material detection.
Sleepers: Detection of cracks in sleepers, misalignment, broken sleeper, presence of objects on sleepers, dancing sleepers.
Fastenings: Detection of missing, loose, rotated, deformed & non-standard fittings
Ballast& Others: Detection of Profile, excess or deficiency, axle counters, foreign objects, SEJ, Switches & Crossing, Level Crossing, Vegetation check, position of balise.

4.6 Positioning and Localization System

a) The system requires robust and accurate measurement of speed, distance, clock, direction, synchronization with the help of event marker

b) GPS mapping of various track features

4.7 Diagnostic Kit for ETCS Level-1

Recording Cars shall be equipped with diagnostic kit for ETCS Level-1 for continuous monitoring of balise & TPWS equipments.

5.0 Self-Proposed Rail Inspection Vehicle (RIV) for Rail Grinding

Rail Grinding is the removal of a thin surface layer of metal from the rail surface by grinding machine in order to ascertain the optimized rail profile. It is an established practice on railways throughout the world.

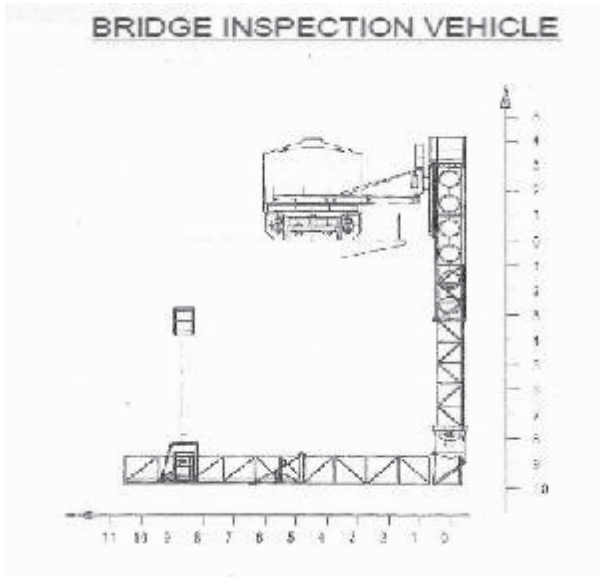
Rails are the most expensive track asset and the purpose of grinding is to prolong rail life while helping to control the risk of rail fractures. The aim of grinding is to maintain optimal Rail-wheel interface by removing fatigued rail surface metal. In order to ascertain the optimum rail grinding, one has to measure & monitor the rail wear pattern. In order to monitor the correct rail wear pattern, DFCCIL is procuring a delicated self-propelled Rail Inspection Vehicle (RIV) which will

be need for collecting digitized image of the transverse profile of rail head for detailed analysis and for generating Rail Grinding Plans to be used on Rail Grinding. The main objectives of RIV are:

a) Recording digital image of the rail head profiles for selection of optimum grinding pattern, number of grinding pass & grinding speed per pass for any section of track;
b) Assessing the grinding requirements due to surface defects on rail top after recording visuals on the rail top;
c) GPS based route data recording of the track features.

6.0 Bridge Inspection Vehicle

DFCCIL is procuring a dedicated self-propelled Bridge Inspection Vehicle for the inspection of different types of bridges on the DFC network. Bridge inspection vehicle should be provided with hydraulically operated Bridge Inspection Platform Unit. The articulated booms shall be provided is such a manner so as to provide a versatile range of movement and each part of the bridge structure approachable to the Inspection & Maintenance staff. Bridge Inspection Vehicle will be equipped with various tools & equipments like: Rivet testing hammer, Inspection cum chipping hammer, Elcometer, tapes of different sizes, calipers, feeler gauges, mirror, torch light, infrared thermometer, current meter, Echo sounder, Schmidt's concrete testing hammer, concrete cover meter, DPT, Magnetic crack detector, welding gauges, Fiber glass boat, safety helmets, safety belts etc.



DFCCIL is procuring the above systems through International Competitive Bidding (ICB) based on Design &Build methodology. The salient features as mentioned above are the starting point for bidders to submit their detailed design which will be scrutinized by Project Management consultants (PMC)& finally approval by the employer. In this method of procurement, DFCCIL will be in a position of fine tuning the design so that state of the art equipment & technology can be ensured. Idea behind formulating such a system is minimizing the human interference to the extent possible keeping in view the Indian condition so as to reduce the cost of Inspection, Monitoring & finally the cost of maintenance.

7.0 Conclusion

DFCCIL has been designed with very lean organisation with the prime objective of reduced cost of Inspection, Monitoring & Maintenance of its infrastructure. As traffic density on DFCCIL network will be very high& fewer slots will be available for performing the above activities, conventional methods of track inspection & monitoring will not be able to keep pace with the stated objectives of availability, reliability, safety & cost reduction. Today, innovative technologies allow monitoring of the most important infrastructure of railway systems. Diagnostic systems include monitoring of track, intelligent video inspection, video recognition of defects and many other. Innovative systems, which can be installed on either a dedicated vehicle or commercial vehicles, may radically reduce the on-foot patrolling of railway infrastructure, improve the maintenance management & facilitate maintenance & renewal in a more optimized manner.

DFCCIL, while studying the best practices available over the world Railway systems, chose to procure a dedicated self-propelled Track Recording CarsOHE Recording Car equipped with the above systems in an integrated manner so as to reduce the cost of Inspection & Monitoring & finally the cost of maintenance.

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SLIPFORM CONSTRUCTION FOR MAJOR BRIDGES WITH TALL PIERSIN MADAR-IQBALGARH SECTION OF WDFC

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ABSTRACT:
Formwork for concrete structures represents a critical part of concrete construction, in terms of cost and importance toward getting the job done properly and on time. As a matter of fact, concrete form work many a times costs more than the concrete and reinforcing steel combined. Therefore, any system or method of concrete placement which can significantly reduce the time and/or cost of the construction project should be of great interest to all concerned.

In general, one can minimize investment in concrete form work by:

- using the least number of forms required to maintain
- smooth workflow of the required productivity.
- maximizing the reuse of forms.
- minimizing form size to 4educe handling costs.
- minimizing form setup/dismantling costs.

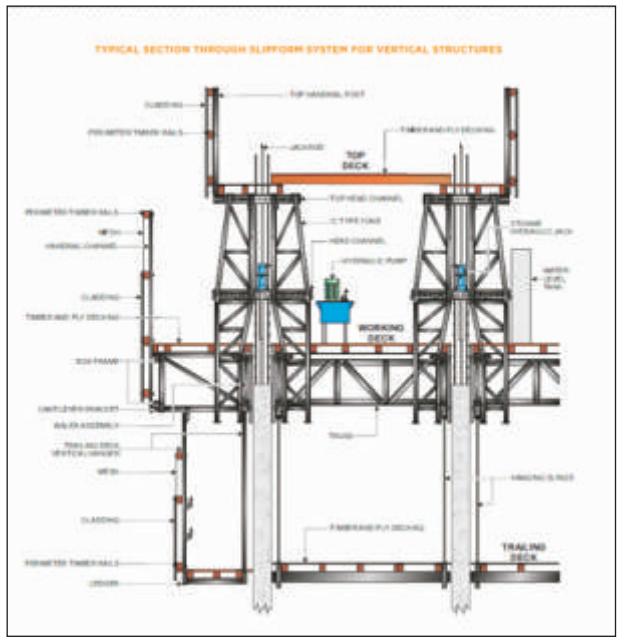
The family of concrete slip forming techniques meets the above criteria for economy and efficiency. A number of major Bridges have been constructed by slip form technique in CTP1&2 Contract of WDFC (Rewari-Iqbalgarh section) and here, the technique with specific refrence to Bridges in WDFC Contract have been discussed.

Slipform Technique Overview

In general, vertical slip form construction is the uninterrupted vertical molding of concrete walls using a 4-6 feet form which is lifted in small (1-3 inch) but continual increments while fresh concrete and reinforcing steel are placed in the top of the open form. Thus, vertical slip forming is an extrusion process where the material is stationary, and the form moves upward. Normally the setting time of concrete is 2-3 hours. Using this typical setting time and with slip forms 4 feet deep, a possible form speed of 16-24 inches per hour can be achieved. The actual median form speed however, depends on such factors as the concreting temperatures, the concrete admixtures used, the grind of the cement, the water-cement ratio, the percent of fines in the concrete aggregate, the symmetry of the structure being constructed, required variations in wall thickness, the amount and complexity of rebar placement, the jack spacing, the number of block outs required, and the depth of the forms.

Design and construction of Slipform

Vertical slipforms are composed of three basic sections: yokes, wales, and sheathing.



1. Yokes

Yokes provide two primary functions: to keep the forms from spreading, and to transfer the load of the forms and working decks to the jack.

The yokes are inverted U's consisting of two legs and a crossbeam. The legs are attached to the wales and carry the vertical loads in tension, and the lateral loads as cantilever beams. The cross arm of the yoke must be designed as a simple beam supported at the centre by the jack and subject to the moments from both the vertica land lateral leg loads.

Bracing frames called false yokes are sometimes placed between yokes to support the forms at wall intersections or whenever the wales need additional support. Hence false yokes transmit their load to the wales, and do not transmit their vertical load to the jacks.

Yoke spacing depends on several factors including the design loads of the yoke and wales, and the lifting capacity of the jacks attached to the yokes. In conventional slip-forming systems employing 3-6-ton capacity jacks, the spacing is about 7 feet.

The jacks lift the form appx 25mm per stroke generally producing a slip forming rate of 300mm to 450mm per hour.

2. Wales

Wales serve the following purposes:

- They support and hold the sheathing in position
- They support the working platform
- They support the suspended scaffolding
- They transmit the lifting forces from the yokes

to the form system.

3. Sheathing

The sheathing makes up the sides or walls of the forms and is the portion of the form work which contains and shapes the concrete.

Since slip-forms are subjected to the hydrostatic pressure of the plastic concrete, the sheathing must support this lateral pressure with beam action between the wales, and as a cantilever at the bottom of the form.

In general, the slip form should be as rigid as feasible and the top of the form slightly smaller than the wall thickness required and the bottom of the form slightly larger than

than required such that the desired wall thickness is at about the midpoint of the forms and the actual batter is between 1/32 and 1/16inch per foot of form height.

Working deck provides space for storage of limited amounts of materials such as rebar, and prefabricated block outs, a platform for workers, and lends rigidity to the form work. A well-built rigid deck and slip form will tend to remain level. The deck should be swept clean on a routine basis, and the storage of materials should be systematic and orderly.

The floor and joists of the work deck are usually designed for a dead load plus construction live load and other construction equipment loading, which ever gives the greater loading.

Slipform Concrete

The basic concrete mix used in slip forming does not vary greatly from those mixes used in other construction methods. However, because of the nature of placement the concrete is in various degrees of set from the top to the bottom of the form. Thus, with a form moving, the design and placement of the concrete becomes a critical item.

In general, any proper mix designed of required strength is acceptable. Generally, the slump of the concrete used in slip forming is higher than that for fixed form work. A slump of 4 inches plus or minus

1 inch is usually specified. In hot dry climates or when using certain kinds of aggregates and cement a higher slump than 5 inches may be required. The use of accelerators, pozzolons, "super" strength mixes, and retarders should be considered.
The higher concrete slump desired for slip forming results from the fact that the vibration is confined to each thin layer plus a couple of inches into the preceding layer, and a higher slump assures good bonding to the steel without heavy vibration. The higher slump also aids lubrication of the moving forms.
Slip forming can be performed either on continuous basis or discontinuous basis i.e. pouring upto a predetermined height.
As the form work is raised reinforcement is held in the correct position using guides fixed to the top of the yokes. Horizontal reinforcement is threaded under the yokes and tied to the vertical reinforcement.

Slipform works for tall piers of Madar-Iqbalgarh section

Following tall pier structures have been constructed using slip form technique in Madar-Iqbalgarh section

S.N.	Bridge No.	Location	Span
1	676	Km 519//0-2	10x 17.22 m
2	722	Km 543/7-8	3x 6.3 m
3	472	Km 362/4-5	3x12.2 m
4	490	Km 368/6-7	3x12.2 m
5	461	Km 358/9-359	4x12.2 m
6	678	Km 519/5-6	3x 6.4 m

Procedure

Slip-form of abutment/ pier starts from raft top of the foundation up to pier cap bottom. The slip form system consists of yoke sets with 3.5 MT capacity hydraulic slip form jack. The interval of yoke kept is approx. 1.25m to 1.35m. As per the requirement 6.0MT capacity slip form jacks were also used.

Erection of slip form equipment

The erection of slip form equipment in general is mentioned below:

- Marking layout on ground level, erection of temporary staging, laying truss members and spider beams, connect all truss members and spider beams with bolt connections.
- Bring the truss in the true level by checking it in a water level and by adjusting the temporary staging supports below the truss.
- Fixing shuttering from panels. For tapered structures form-panels will overlap. Fix wall thickness screw and radius screws to all yokes.
- Mark the position of yokes. Fix inner and outer yoke legs at the make position. Complete the yokes by fixing yoke beams to yoke legs. So each spider beam has now been provided with a yoke.
- Fix hanging frame for hydraulic pump to the working deck, place the hydraulic pump in position.
- Installation of perimeter jacks, their hydraulic connection with pumps. All perimeter jacks will be inter connected.
- Place jack rods in position and should be truly vertical.
- Fix stretching screws, fix vertical steel holders in position.
- Complete hydraulic connections.
- Adjust the slope of the form panes as per the design requirements.
- Erect the water level system. All water tubes should be interconnected. Mark the position of water level in the tube when the system is perfectly levelled.
- A leak tight jacking system shall be ensured.
- Complete calibration of spider beams with respect to reduction in radius at different elevation.
- Erect all frames and pulleys on the deck for concrete hoists, material hoists and passenger hoist.
- Complete top deck, working deck, inner and outer hanging scaffold lightning arrangement. Provide safety mesh on inner and outer hanging scaffolds.
- Complete curing arrangements. Finally check all connections.
- All arrangements of concrete mixing, transportation, placing of concrete, vibration, curing, materials transportation, movement of personnel and workers, power supply, water supply, lighting, lightning protection, signal and telecommunication systems, opening and block-outs, inserts, precision instruments for checking parameters, firefighting, drinking water, concrete testing shall be made side by side so that all of these arrangements are completed by the time the slip form equipment has been fully erected.

OPERATIONS

Starter Concrete

Once the concreting of foundation is completed the pier/abutment corner points are marked on the foundation using total station. Starter concrete is done to fix the surface of vertical wall before placing the slip form.

Starter Concrete

once the concreting of the foundation is competed the pier/abutment corner points are marked on the foundation and a starter concrete layer of 200mm was laid to fix the surface of vertical wall before placing the slipform.

Lifting

Temporary stool or bracings on which the yoke legs and shutter framework has been supported are removed just before the concrete pouring is started. Lifting of slip form starts when the poured concrete gains enough strength.

Hydraulic Controller

All the jacks to be used for lifting the assembly are connected to a central hydraulic controller.

Lifting Speed

lifting of slipform starts after the poured concrete gains sufficient strength. Rate of lifting is 1-1.5m/day (for Abutment/pier in bridges).

Checking

The vertically of plumb bob is checked using plumb bob. This is hanged from bottom of the slip form arrangement and reference points are made at ground. Frequency of plumb checking is four times a day (24hrs). Control over parameters like wall thickness, radius, verticality- Tilt, twist, levels, slope of yoke legs, extension of jack rods.

Rebar Fixing

Reinforcement is tied in position as per the approved reinforcement details. Due to the problem in handling at heights, the maximum length of reinforcement bars was not more than 6 meter. Also as it was not possible to provide diagonal bars around openings and the same was converted in to vertical / Horizontal bars as extra bars. The vertical reinforcement in yoke locations were re- Arranged to accommodate yoke beams. Dowel bar were of MS and maximum dia of bar not be more than 16mm.

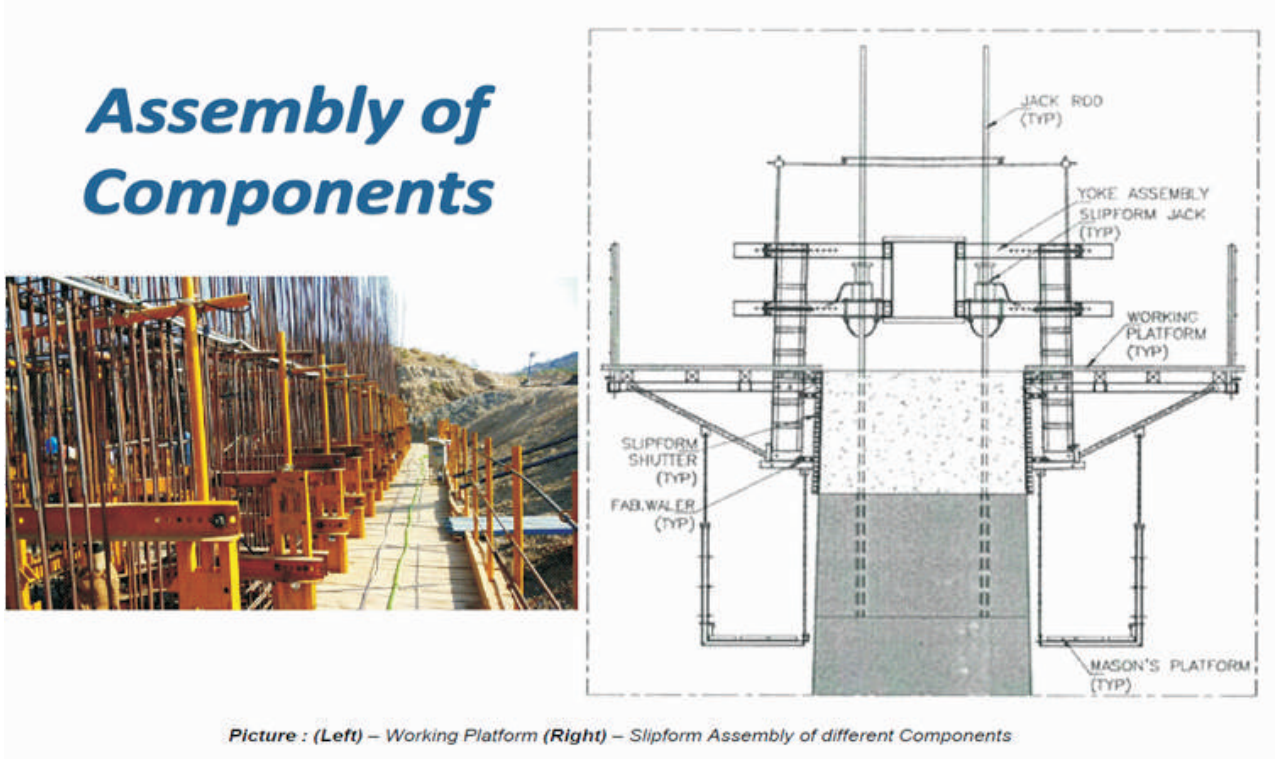
The horizontal reinforcement are tied below the yoke assembly main truss so that it can be lifted upward with and hindrance.

PROPOSED METHOD OF CONCRETING

Mix Proportion
Necessary Laboratory Trials was carried out at site to arrive at a mix proportion for different grades of concrete that are used in wall construction. Concrete shall be workable and meet the requirement of strength criteria along with durability. In addition to determination of Mix Proportion, particular attention was given to physical properties such as workability, cohesiveness, plasticity and slump. 110 to 150+25mm

Placement of concrete
Concrete was received through placer boom / pump/ crane bucket to working level was collected in hoppers and from there it was laid continuously in uniform layers of approximately 250 to 300mm in thickness, manually using wheel barrows. Pour sequence was such that next layer of concrete is placed over the layer beneath within final setting time of concrete to avoid formation of cold joints. Concrete was placed carefully to avoid formation of cold joints. Concrete was placed carefully to avoid displacement of reinforcement, openings, cut-outs and inserts, if any. Final setting time was established with lab trials. Curing of the pier is done by the high pressure curing pump installed on the ground.

Compaction of Concrete
Each layer of Fresh Concrete was compacted by immersion vibrators to the minimum practicable consolidated volume. 60/40 mm dia vibrator needles was mostly used except in the areas of congested reinforcement, in which case 60mm dia needles was engaged. The vibrators were withdrawn slowly out of the concrete. Over vibration was avoided.



Picture : (Left) – Working Platform (Right) – Slipform Assembly of different Components

Concrete Finish
Once the slip form is lifted the finishing work for the exposed concrete surface and necessary repairs are done by the masons available on the masons platform. It is about 1.5m below the working platform.

OPERATION OF SLIPFORM COMPONENTS

Working Platform

The function of working deck is to facilitate:

- To vibrate concrete placed inside the shutter.
- To carry out adjustments and operation of slip form.
- To fix inserts, block-outs and trying of reinforcements.
- To clean the shuttering plates.

screw is installed on the yoke assembly legs. The one thread of wall thickness screw gives an inside movement of 2mm to the slip form. The plates of the slip form is side shifting

.

DISMANTLING OF SLIPFORM

Dismantling of slip form requires planning a dismantling sequence minutely and implementation of plan under an expert eye.

Picture : (Left) - Slipform Jacks (Right) - Yoke beam assembly and jack rods

Slipform jacks

Slipform jack transfers the load of slip form assembly to the jack rod. Generally 26 numbers of 6T jacks were used.

Jack Rods

Jack rods are to support the slipform assembly. The jack rods are spaced at equal intervals. The jack rod transfers the load of slip form assembly to ground/ wall. The jack rods are housed inside a tapered sleeve tube.

The jack rod were extracted later and filled with cement slurry.

Firstly, with the help of hydraulic power pack the slip form jack transfer the load of slip form assembly to the jack rod . The jack rod are spaced at equal interval in the straight portion and more nos are installed at the circular portion of the pier. Jack rod transfer the load of slip form assembly to ground.

Water level pipe is installed to check the undulation while lifting, if it happens it is rectified with the help of adjusting bolt installed on the slip form jack by which the upward movement of each jack can be restricted or increased.

The pier was tapered with base as 2.5m and top as 1.5m to carry out this tapering a wall thickness

For dismantling cranes was used to maximum possible extent.

CONTINGENCY PLAN

Sufficient jack spares were maintained at site. Slip from operators and key persons were be provided with raincoat, in case of slip form operation in rain. At the time of any planned or unplanned stoppages the level of concrete was maintained and the surface was prepared for cold joint by leaving shear keys in the wall. When resuming the concrete, surface was cleaned with water and 25mm thick mortar at 1:2 ratios was placed over the old surface.

Precautions

- Coordination between workmen while placing the formwork sheets, yoke legs, yoke beam.
- Connecting bolts and alignment of Waller pipes while fixing the assembly.
- Formwork should be adequately braced, anchored or otherwise secured properly along with yoke beam and yoke leg while applying lifting mechanism.
- Placement of yoke legs shall be ensured along with beams while lifting the platforms.
- The shuttering should be able to carry the loads coming on it during vibration of

concrete, sliding or erection.

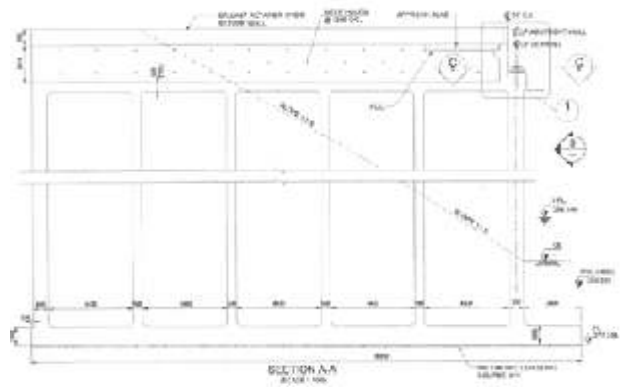
- Inspect that laps and joints in the shuttering should be vertical, inclined joints or overlaps may cause a drag component in horizontal direction which will cause torsional effects on slip form assembly.
- Wallers, beam must be suitably fixed to take the lateral pressure of the fresh concrete laid inside the form panels.
- Yokes, Slipform hydraulic jacks must place and fixed as per the approved design scheme.
- Proper housekeeping to avoid trip & fall during steel, shifting of hand tools, power tools.
- Support shall be given to prevent fall of yoke legs and yoke beam during erection.
- Checking the starter casting for level and correct diameter.

Erection of working platform

- Anchorage of working platform with the yoke beam and yoke leg shall be ensured.
- Climbing brackets platform should be free from obstruction while moving the whole platform.
- Gaps should be avoided in the working platform (landing mats shall be aligned properly)
- Loose material shall be cleared from the working platform.
- Hand Rail, Middle rail, Toe Guard must be provided.
- Suitable ladders must be used. Ladders are made of metal (not bamboo or wood) are checked for serviceability prior to each use.
- Ladders should be placed on levelled ground and extended one meter above the landing platform.
- The work platform must be inspected & safe enough for complete operation of slip form equipment and bringing up all type of materials, equipment, concrete, staff and workers etc.
- Work platform must be maintained in a levelled good condition.
- Work platform must be free from unnecessary materials.
- Work platform must not be overloaded beyond its load capacity.
- All the sides of the work platform must be properly fixed with fall protection arrangement with Railing post. His railing post must be 900 mm above the work platform with middle rail at 450mm and 100mm Guard rail at edge of the work platform.

Specific Cases

Br 678



1	Project	-	WDFC CTP1&2
2	Location	-	Package-7, Major Bridge – 678 Abutment A1
3	Total height of the Abutment	-	18.026 (PCC top to Abutment Cap bottom)
4	Height for Lift by slipform method	-	17.326m
5	Start Date	-	23rd March 2017
6	Completion Date	-	8th April 2017
7	Total days for concreting	-	16 days
8	Conventional Method Time estimate	-	4.5 months
9	Slipform Method total time	-	2 months
10	Saving in time	-	2.5 months

Set up and start of work

Concrete plugging during night

07.09.17

08.09.17

10.09.17

14.09.17

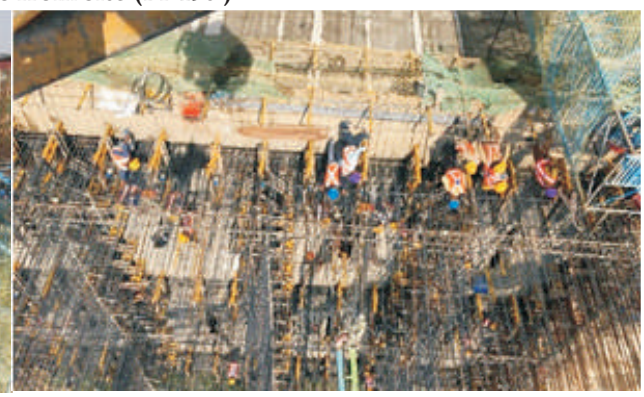
Br 676

Description	Detail
Location	WDFC CTP 1&2 Project, IMB 676 (Jawai Dam)
Structure Member	Pier P8
Total height	18.026m
Total Concrete Qty	615.6 cum
Start Date	12th August 2017
End Date	23rd August 2017
Concreting Duration	11 Days

Reference

1. *Details collected from site.*
2. *Quality assurance programme for slipform construction.*

Other pictures from site (Br 490)



Major Provisions

Conditions of Contract for Plant and Design Build for Electrical and Mechanical Plant and for Building and Engineering Works Designed by the Contractor (Yellow Book of FIDIC 1999 Edition)

Ajay Kumar
ED/EDFC/DFCCIL

ABSTRACT

FIDIC Yellow Book 1999 Edition has been adopted as GCC for the Design Build Lump – Sum Contracts of DFCCIL. GCC cover obligation on the part of Employer, Engineer and Contractor. This document list out major provision regarding obligation of the Contractor as included in the FIDIC Yellow Book. The purpose of this document is to make field officials aware about the obligation of the contractor, so that they can properly monitor the same. This will also help in Contract Management by supervisors in the field. This list is not exhaustive but useful for DFCCIL officials operating the Design Build Contracts. For specific reference and taking action as per the contract, it is advisable that the relevant Para of FIDIC Yellow Book 1999 Edition should be referred.

1.8 Care and Supply of Documents	The Contractor shall keep, on the Site, a copy of the Contract, publications Variations and other communications given under the Contract.
1.10 Employer's Use of Contractor's Documents	The Contractor shall be deemed (by signing the Contract) to give to the Employer a non-terminable transferable non-exclusive royalty-free licence to copy, use and communicate the Contractor's Documents, including making and using modifications of them.
1.12 Confidential Details	The Contractor shall disclose all such confidential and other information as the Engineer may reasonably require in order to verify the Contractor's compliance with the Contract.
1.13 Compliance with Laws	The Contractor shall, in performing the Contract, comply with applicable Laws.

4.1 Contractor's General Obligations	The Contractor shall design, execute and complete the Works in accordance with the Contract, and shall remedy any defects in the Works. When completed, the Works shall be fit for the purposes for which the Works are intended as defined in the Contract.
4.2 Performance Security	The Contractor shall obtain (at his cost) a Performance Security for proper performance, in the amount and currencies stated in the Appendix to Tender.
4.3 Contractor's Representative	The Contractor shall appoint the Contractor's Representative and shall give him all authority necessary to act on the Contractor's behalf under the Contract.
4.4 Subcontractors	The Contractor shall be responsible for the acts or defaults of any Subcontractor, his agents or employees, as if they were the acts or defaults of the Contractor.
4.6 Co-operation	The Contractor shall, as specified in the Contract or as instructed by the Engineer, allow appropriate opportunities for carrying out work to: (a) the Employer's Personnel, (b) any other contractors employed by the Employer, and (c) the personnel of any legally constituted public authorities,
4.7 Setting Out	The Contractor shall set out the Works in relation to original points, lines and levels of reference specified in the Contract or notified by the Engineer. The Contractor shall be responsible for the correct positioning of all parts of the Works, and shall rectify any error in the positions, levels, dimensions or alignment of the Works.
4.8 Safety Procedures	The Contractor shall: (a) comply with all applicable safety regulations, (b) take care for the safety of all persons entitled to be on the Site, (c) use reasonable efforts to keep the Site and Works clear of unnecessary obstruction so as to avoid danger to these persons, (d) provide fencing, lighting, guarding and watching of the Works until completion and taking over under Clause 10 (e) provide any Temporary Works (including roadways, footways, guards and fences) which may be necessary, because of the execution of the Works, for the use and protection of the public and of owners and occupiers of adjacent land.
4.9 Quality Assurance	The Contractor shall institute a quality assurance system to demonstrate compliance with the requirements of the Contract.
4.10 Site Data	The Contractor shall be responsible for interpreting all such data. The Contractor shall be deemed to have inspected and examined the Site, its surroundings, the above data and other available information, and to have been satisfied before submitting the Tender as to all relevant matters, including (without limitation):

4.11 Sufficiency of the Accepted Contract Amount	Unless otherwise stated in the Contract, the Accepted Contract Amount covers all the Contractor's obligations under the Contract (including those under Provisional Sums, if any) and all things necessary for the proper design, execution and completion of the Works and the remedying of any defects.
4.13 Rights of Way and Facilities	The Contractor shall bear all costs and charges for special and/or temporary rights-of-way which he may require, including those for access to the Site. The Contractor shall also obtain, at his risk and cost, any additional facilities outside the Site which he may require for the purposes of the Works.
4.14 Avoidance of Interference	The Contractor shall not interfere unnecessarily or improperly with: (a) the convenience of the public, or (b) the access to and use and occupation of all roads and footpaths, irrespective of whether they are public or in the possession of the Employer or of others.
	The Contractor shall indemnify and hold the Employer harmless against and from all damages, losses and expenses (including legal fees and expenses) resulting from any such unnecessary or improper interference.
4.15 Access Route	The Contractor shall be deemed to have been satisfied as to the suitability and availability of access routes to the Site. The Contractor shall use reasonable efforts to prevent any road or bridge from being damaged by the Contractor's traffic or by the Contractor's Personnel. These efforts shall include the proper use of appropriate vehicles and routes.
4.16 Transport of Goods	The Contractor shall give the Engineer not less than 21 days' notice of the date on which any Plant or a major item of other Goods will be delivered to the Site;
4.17 Contractor's Equipment	The Contractor shall be responsible for all Contractor's Equipment. When brought on to the Site, Contractor's Equipment shall be deemed to be exclusively intended for the execution of the Works. The Contractor shall not remove from the Site any major items of Contractor's Equipment without the consent of the Engineer.
4.18 Protection of the Environment	The Contractor shall take all reasonable steps to protect the environment (both on and off the Site) and to limit damage and nuisance to people and property resulting from pollution, noise and other results of his operations.
4.19 Electricity, Water and Gas	The Contractor shall be responsible for the provision of all power, water and other services he may require.
4.21 Progress Reports	Monthly progress reports shall be prepared by the Contractor and submitted to the Engineer.

4.22 Security	(a) the Contractor shall be responsible for keeping unauthorised persons off the Site, and (b) authorised persons shall be limited to the Contractor's Personnel and the Employer's Personnel; and to any other personnel notified to the Contractor, by the Employer or the Engineer, as authorised personnel of the Employer's other contractors on the Site.
4.23 Contractor's Operation On Site	The Contractor shall confine his operations to the Site, and to any additional areas which may be obtained by the Contractor and agreed by the Engineer as working areas.
4.24 Fossils	All fossils, coins, articles of value or antiquity, and structures and other remains or items of geological or archaeological interest found on the Site shall be placed under the care and authority of the Employer. The Contractor shall take reasonable precautions to prevent Contractor's Personnel or other persons from removing or damaging any of these findings.
5.1 General Design Obligations	The Contractor shall carry out, and be responsible for, the design of the Works. Design shall be prepared by qualified designers who are engineers or other professionals who comply with the criteria (if any) stated in the Employer's Requirements.
5.2 Contractor's Documents	The Contractor's Documents shall comprise the technical documents specified in the Employer's Requirements, documents required to satisfy all regulatory approvals, and the documents described in Sub-Clause 5.6 [As-Built Documents] and Sub-Clause 5.7 [Operation and Maintenance Manuals].
5.3 Contractor's Undertaking	The Contractor undertakes that the design, the Contractor's Documents, the execution and the completed Works will be in accordance with: (a)the Laws in the Country, and (b)the documents forming the Contract, as altered or modified by Variations.
5.4 Technical Standards and Regulations	The design, the Contractor's Documents, the execution and the completed Works shall comply with the Country's technical standards, building, construction and environmental Laws, Laws applicable to the product being produced from the Works, and other standards specified in the Employer's Requirements, applicable to the Works, or defined by the applicable Laws.
5.5 Training	The Contractor shall carry out the training of Employer's Personnel in the operation and maintenance of the Works to the extent specified in the Employer's Requirements.
5.6 As-Built Documents	The Contractor shall prepare, and keep up-to-date, a complete set of "as-built" records of the execution of the Works, showing the exact as-built locations, sizes and details of the work as executed.

5.7 Operation and Manuals Maintenance	Prior to commencement of the Tests on Completion, the Contractor shall supply to the Engineer provisional operation and maintenance manuals in sufficient detail for the Employer to operate, maintain, dismantle, reassemble, adjust and repair the Plant.
5.8 Design Error	If errors, omissions, ambiguities, inconsistencies, inadequacies or other defects are found in the Contractor's Documents, they and the Works shall be corrected at the Contractor's cost, notwithstanding any consent or approval under this Clause.
6.1 Engagement of Staff and Labour	The Contractor shall make arrangements for the engagement of all staff and labour, local or otherwise, and for their payment, housing, feeding and transport.
6.2 Rates of Wages and Conditions of Labour	The Contractor shall pay rates of wages, and observe conditions of labour, which are not lower than those established for the trade or industry where the work is carried out.
6.3 Persons in the Service of Employer	The Contractor shall not recruit, or attempt to recruit, staff and labour from amongst the Employer's Personnel.
6.4 Labour Laws	The Contractor shall comply with all the relevant labour Laws applicable to the Contractor's Personnel, including Laws relating to their employment, health, safety, welfare, immigration and emigration, and shall allow them all their legal rights. The Contractor shall require his employees to obey all applicable Laws, including those concerning safety at work.
6.6 Facilities for Staff and Labour	The Contractor shall provide and maintain all necessary accommodation and welfare facilities for the Contractor's Personnel.
6.7 Health and Safety	The Contractor shall at all times take all reasonable precautions to maintain the health and safety of the Contractor's Personnel. In collaboration with local health authorities, the Contractor shall ensure that medical staff, first aid facilities, sick bay and ambulance service are available at all times at the Site . The Contractor shall appoint an accident prevention officer at the Site, responsible for maintaining safety and protection against accidents.
6.8 Contractor's Superintendence	Throughout the design and execution of the Works, and as long thereafter as is necessary to fulfil the Contractor's obligations, the Contractor shall provide all necessary superintendence to plan, arrange, direct, manage, inspect and test the work.
6.9 Contractor's Personnel 6.10 Records of Contractor's Personal and Equipment	The Contractor's Personnel shall be appropriately qualified, skilled and experienced in their respective trades or occupations. The Contractor shall submit, to the Engineer, details showing the number of each class of Contractor's Personnel and of each type of Contractor's Equipment on the Site.

6.11 Disorderly Conduct	The Contractor shall at all times take all reasonable precautions to prevent any unlawful, riotous or disorderly conduct by or amongst the Contractor's Personnel, and to preserve peace and protection of persons and property on and near the Site.
7.3 Inspection	The Contractor shall give notice to the Engineer whenever any work is ready and before it is covered up, put out of sight, or packaged for storage or transport.
7.4 Testing	The Contractor shall provide all apparatus, assistance, documents and other information, electricity, equipment, fuel, consumables, instruments, labour, materials, and suitably qualified and experienced staff, as are necessary to carry out the specified tests efficiently.
7.5 Rejection	If, as a result of an examination, inspection, measurement or testing, any Plant, Materials, design or workmanship is found to be defective or otherwise not in accordance with the Contract, the Engineer may reject the Plant, Materials, design or workmanship by giving notice to the Contractor, with reasons. The Contractor shall then promptly make good the defect and ensure that the rejected item complies with the Contract.
7.7 Ownership of Plant and Materials	Each item of Plant and Materials shall, to the extent consistent with the Laws of the Country, become the property of the Employer at whichever is the earlier of the following times, free from liens and other encumbrances: (a)when it is delivered to the Site; (b)when the Contractor is entitled to payment of the value of the Plant and Materials under Sub-Clause 8.10
7.8 Royalties	The Contractor shall pay all royalties, rents and other payments for: a)natural Materials obtained from outside the Site, and b)the disposal of material from demolitions and excavations and of other surplus material (whether natural or man-made).
8.1 Commencement of Work	The Contractor shall commence the design and execution of the Works as soon as is reasonably practicable after the Commencement Date, and shall then proceed with the Works with due expedition and without delay.
8.2 Time for Completion	The Contractor shall complete the whole of the Works, and each Section (if any), within the Time for Completion for the Works or Section including achieving the passing of the Tests on Completion.
8.3 Programme	The Contractor shall submit a detailed time programme to the Engineer within 28 days after receiving the notice under Sub-Clause 8.1 [Commencement of Works]. The Contractor shall also submit a revised programme whenever the previous programme is inconsistent with actual progress or with the Contractor's obligations.
8.4 Extension of Time for Completion	If the Contractor considers himself to be entitled to an extension of the Time for Completion, the Contractor shall give notice to the Engineer in accordance with Sub-Clause 20.1 [Contractor's Claims].

8.8 Suspension of Work	During such suspension, the Contractor shall protect, store and secure such part or the Works against any deterioration, loss or damage.
9.1 Contractor's Obligations	The Contractor shall carry out the Tests on Completion in accordance with this Clause and Sub-Clause 7.4 [Testing], after providing the documents in accordance with Sub-Clause 5.6 [As-Built Documents] and Sub-Clause 5.7 [Operation and Maintenance Manuals]. The Contractor shall give to the Engineer not less than 21 days' notice of the date after which the Contractor will be ready to carry out each of the Tests on Completion.
13.2 Value Engineering	The Contractor may, at any time, submit to the Engineer a written proposal which (in the Contractor's opinion) will, if adopted, (i) accelerate completion, (ii) reduce the cost to the Employer of executing, maintaining or operating the Works, (iii) improve the efficiency or value to the Employer of the completed Works, or (iv) otherwise be of benefit to the Employer.
14.3 Application for Interim Payment Certificates	The Contractor shall submit a Statement in six copies to the Engineer after the end of the period of payment stated in the Contract (if not stated, after the end of each month), in a form approved by the Engineer, showing in detail the amounts to which the Contractor considers himself to be entitled, together with supporting documents which shall include the relevant report on progress in accordance with Sub-Clause 4.21 [Progress Reports].
14.10 Statement at Completion	Within 84 days after receiving the Taking-Over Certificate for the Works, the Contractor shall submit to the Engineer six copies of a Statement at completion.
14.11 Application for Final Payment Certificate	Within 56 days after receiving the Performance Certificate, the Contractor shall submit, to the Engineer, six copies of a draft final statement with supporting documents showing in detail in a form approved by the Engineer.
14.12 Discharge	When submitting the Final Statement, the Contractor shall submit a written discharge which confirms that the total of the Final Statement represents full and final settlement of all moneys due to the Contractor under or in connection with the Contract. This discharge may state that it becomes effective when the Contractor has received the Performance Security and the out-standing balance of this total in which event the discharge will be effective on such date.
17.1 Indemnities	The Contractor shall indemnify and hold harmless the Employer, the Employer's Personnel, and their respective agents, against and from all claims, damages, losses and expenses (including legal fees and expenses) in respect of: (a) bodily injury, sickness, disease or death, of any person whatsoever arising out of or in the course of or by reason of the design, execution and completion of the Works and the remedying of any defects, unless attributable to any negligence, wilful act or breach of the Contract by the

	Employer, the Employer's Personnel, or any of their respective agents, and (b) damage to or loss of any property, real or personal (other than the Works), to the extent that such damage or loss:
17.2 Contractor's Care of the Works	The Contractor shall take full responsibility for the care of the Works and Goods from the Commencement Date until the Taking-Over Certificate is issued (or is deemed to be issued under Sub-Clause 10.1 [Taking Over of the Works and Sections]) for the Works. If any loss or damage happens to the Works, Goods or Contractor's Documents during the period when the Contractor is responsible for their care, from any cause not listed in Sub-Clause 17.3 [Employer's Risks], the Contractor shall rectify the loss or damage at the Contractor's risk and cost, so that the Works, Goods and Contractor's Documents conform with the Contract.
18.1 General Requirements Insurances	Wherever the Contractor is the insuring Party, each insurance shall be for effected with insurers and in terms approved by the Employer. These terms shall be consistent with any terms agreed by both Parties before the date of the Letter of Acceptance. This agreement of terms shall take precedence over the provisions of this Clause.
18.4 Insurance for Contractor's Personnel	The Contractor shall effect and maintain insurance against liability for claims, damages, losses and expenses (including legal fees and expenses) arising from injury, sickness, disease or death of any person employed by the Contractor or any other of the Contractor's Personnel. The insurance shall be maintained in full force and effect during the whole time that these personnel are assisting in the execution of the Works. For a Subcontractor's employees, the insurance may be effected by the Subcontractor, but the Contractor shall be responsible for compliance with this Clause.

DESIGN CONSIDERATION OF RAILWAY BRIDGES

Ashok Kumar Goel
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ABSTRACT:
Historically, Indian Railway has been adopting standard Design and Drawings for bridges issued by RDSO or carrying out designs departmentally. The Design consultants do not have much exposure to Railway Bridges. DFCC project one of the biggest Railway project is being executed with "Contractors Design and Lump sum price bids". In this mode of contract, it is the natural tendency of the contractor to cut cost by adopting designs which may not be fully meeting the concerns of the Railways. This paper attempts to bring out some of the aspects in design of bridges, which the Consultants, tend to omit or misinterpret in their design presentation. These are some points, as observed by the author, during review of the designs in DFCC project.

1. Railway Vs Road bridges

Design of bridge whether for Road traffic or Railway traffic largely has same criteria except for applicability of codes and the loadings, however, there are certain differences in the approach for planning and design of Railway bridges. There are no written rules or guide lines in Railways except for Standards, codes and Manuals for type of bridge to be adopted on the Indian Railway, however the practices developed on Indian Railway over long time and instructions from time to time, guide the Bridge Engineer, some of the considerations are as following,

- Spans greater than 24.4m are preferred to be of steel. This is because pre-casting and launching spans longer than 24.4m is found to be not practical. The site quality controls for in situ casting of PSC girder bridge has been found wanting in many cases.
- Large spans greater than 45m (150 ft.) are open web steel trusses, this is also the International practice generally. Recently however, China has constructed several bridges for Railways using continuous spans with PSC, maximum span in PSC exceeding 400 ft.
- All the superstructure designs are standardized by RDSO, applicable over entire IR. Any non-standard design is discouraged. This is probably in view of little expertise of designing available in Zonal Railways and also for interchangeability of span for Emergency replacement without loss of time. Further only simply supported spans are provided.

- Inspection and Maintainability of the structure is given very high priority in selecting the type of structure to be adopted. Hollow section and other shapes avoided if they cannot be physically inspected.
- Replacement or repair of the bridge under train running conditions in case of any damage/disability of the bridge due to any mishap or unusual occurrence, with least disturbance to traffic. Substructure should be able to be repaired by retrofitting and grouting/strengthening measures. In case of damage of the bridge and/or approaches, laying a diversion is considered to be last option due to long length of diversion, requiring many times acquisition of land etc.
- The bridge deck needs to be stiff, to restrict the deflection of the bridge under live load. The train loads are much higher than road loadings, besides train lengths being sometimes in KMs i.e. even larger than bridge lengths the geometry of the track/deck is to be considered over multiple spans of the bridge of vibrating loads of moving train.
- Hydrology of the bridge has to be given due importance, as any minor scour of the foundations or reduction of the anchor depth of foundation or overtopping of the HFL requires regulation of traffic and is not acceptable to Railway.
- The river guidance system and protection of approaches are given importance as any damage to approaches can result in stoppage of traffic on the bridge and minor damage not noticed, can gradually open up and may result in catastrophe consequences.

2. From design considerations.

2.1 There are 2 main requirements for Railway Bridges,

a) Provision of adequate support to the railway loads and infrastructure throughout the life of the structure.

- This requirement can be expressed in terms of requirements for the following,

i. Strength and fatigue endurance
ii. Limiting the bridge deformations
iii. Durability
iv. Maintainability and ease of inspection to ensure continued performance of the bridge for its designed life.

b) Provision of adequate clearances between the structure and traffic both on and beneath the bridge.

- The second requirement pertains to the Standard Schedule of Dimensions and provisions of IRS-Codes issued by RDSO/Railway board.

2.2 The special features of DFCC bridges are,

i. Ballasted track on the bridges
ii. Continuous welded track on the bridges
iii. Electrified OHE 22KVA requiring special measures for isolation
iv. Service ducts along with foot path

3 Strength considerations

i) Indian Railway Standards like Bridge rules, Concrete Bridge code, Steel Bridge code etc. give various loads and combination of loads to be considered and the permissible limits of strength which are to be followed. The codes concerning concrete structures are based on Limit State Design but the code for designing steel structures are based on Working stress principles. Limit state design is more rational and SBC needs to be updated to Limit state design and is under process in RDSO.

ii) There are some provisions in the IRS codes which tend to be misunderstood some times, some are indicated below,

- Design of slabs (CBC) does not require provision of minimum shear reinforcement as in the case of beams. Mainly, the reason appears to be slender depth of slab in which accommodating shear stirrups can be impractical. For effecting economy in design, contractors do resort to less depth and provide shear reinforcement where ever required on analysis. This should be avoided and the depth of slabs should be adopted so that no shear reinforcement is required to be provided for better constructability.
- The bracket/ cantilever coming out of a wall or column is to be designed as corbel (Cl 17.2.3.1 of CBC) if the ratio of distance of point of application of load to the depth of the member, is equal or less than 0.6. However, research/ testing has shown that the cantilever works as a corbel even up to the ratio of 1.5. ACI however, stipulates a ratio of 1.0 up to

which the bracket/cantilever should be designed as corbel. Generally it is a good practice to design all pier caps as corbel and if required the depth of the pier cap may be increased suitably to bring within the ratio of 1.0.

- Precast segmental construction even for minor bridges, if permitted must be with safe guards of keys between segments for longitudinal/ transverse and vertical alignment under vibrating loads and the joints should be sealed properly to prevent any ingress of moisture through them and make leak proof.
- The passive pressure due to the soil in front of Retaining wall/return wall etc. can be considered in terms of (IRS-Substructure and Foundations code Cl.5.7.1.5) for only that part of soil which will not be scoured under worst design condition during the life of the structure. Many International codes, however do not consider prudent to take help from this soil contributing to passive pressure. Further, the active/passive pressure is generated by only that part of soil which is present in continuum or limited to the contribution from the failure wedge plane.
- Many times design of retaining/return wall involves provision of a key at the base of the wall to resist sliding force due to lateral pressure. Many International codes like CALTRAN consider the point of rotation of the wall at the lowest point of the key, this increases the overturning moment and reduce the corresponding safety factor. There are no clear stipulations in IRS/IRC code in this regard, It is preferable to take a safe approach as per International practice.
- CALTRAN as well as IRC codes stipulate considering only half the passive pressure mobilized for soil below the scour level but IRS (Substructure and Foundation Code) permits only 1/3rd of the theoretically calculated value because of sensitive nature of Railway bridges compared to road structures.
- Calculating the scour depth of bridges is another critical area for design of bridges (IRS-Substructure and Foundation Code). For sandy soils the silt factor is defined quite specifically and there is not much chance of misunderstanding, still in cases where one thin layer of the bed material if having gravel or coarse sand (generally at the bed level or just below the bed level) can change the weighted average of grain size and hence the "silt factor" value. Cl.4.6.3 of IRS-Substructure and Foundation Code is clear that a representative value of silt factor in the scour region is to be obtained. Any outlier values of layers of either very coarse or very fine layers which do not represent the general type of soil in the scour zone should be ignored, to find "Silt Factor".
- The Lacey's Formula used for the scour depth is mainly for natural channels flowing in alluvial beds. As per IRS-Substructure and Foundation Code Cl.4.6.7 if bed material is clayey, scour depth is to be taken from actual observations. Since the design scour depth has to be considered under maximum flood discharge (50 year return period), this shall be possible if there is a gauging site in the vicinity of the proposed bridge location, with historical data, which may not be feasible in most cases. IRS-78 Cl. 703.2.2.2 (Appendix-1) however provides a formula for bed material finer than 0.04mm (Coarse silt) as under,

i) In case of soil having Φ<15° and c (cohesion of soil) > 0.2 kg/cm2
'Ksf calculated as follows:\
Ksf= F(1 +Root(c)) where c in kg/cm2
Where, F = 1.50 for Φ> 10° and < 15°
= 1.75 for Φ>5° and < 10°
= 2.00 for Φ< 5°

ii) Soils having Φ>15° will be treated as sandy soil even if c is more than2N/mm2 and silt factor will be as per provisions of Clause 703.2.2.2 i.e. for sandy soils. Further, silt factor for soils with mean diameter it, dm is 0,04mm or more has to be considered as for sandy soil irrespective of the value of "c" and "Φ".

iii) This formula can be followed for fine soils in the absence of observed data from any gauge site.

4 Fatigue Assessment of Bridges:

4.1 Steel Structures: IRS Steel Bridge Code provides detail treatment for consideration of fatigue design in steel bridges. This is at par with provisions in Euro Code- EN-1993-1-9 (2003) and BS-5400-10-1980. BS-5400 part 10 is a comprehensive code which is based on the concept

of cumulative fatigue damage. The code concerns with the fatigue design methodology for highway and railway bridges. Fatigue life assessment is based on the S-N curve approach using Palmgren-Miner's damage summation model wherein the number of cycles to failure is dependent only on stress range and not on maximum stress values. The methodology for determination of stress range has been described for welded and non-welded details and a simplified method has been given for determining the limiting value of the maximum range of stress for the specified design life for two different types of standard loadings. The code specifies different factor k1,k2, k3, k4 & k5 for design parameters such as design life, multiple cycle of stress loading, type of standard loading, annual GMT and multiple lane loading respectively. The code gives specific methodology and tables to calculate the factors for different design parameters.

On the Indian Railway, the site welds are not allowed and either rivets or HSFG bolts are to be used for connecting the fabricated elements, through holes in the parent material. Thus the details are a hybrid of welds in shop and rivets/bolts for field connections. However, fatigue detail of the member given in the 2 tables only cover the welded or non-welded members, but not for hybrid members as used on Railway bridges. The provision in the IRS- Steel Bridge code, Clause 3.6.4 (Appendix-19) provides for concept of Modifying Stress Factor due to any geometric discontinuity in the material like notches, holes etc. Clause 7.1.2 (C) however states "Stress concentration, except when specifically stated as a requirement for a detail or a joint" can be ignored. The reference to Fig.-2 in the IRS code relates to welded fillet joint only but the stress concentration due hole is as per Fig. 1 (Geometric stress concentration) which is not covered under any clause except Cl.7.1.2(C) referred above, but it is not clear in the code what should be referred for situations where this modifying factor is to be accounted for in case of concentration of stress at hole location as shown in Figure-1 of SBC. IRS-SBC Cl.8.3.3 the modification factor may be adopted from standard references or from finite element calculations.

The standard solution like from Ernst Gustav Kirsch's linear elastic solution suggests that the Stress Modification factor in case of an infinite plate with a hole will vary between 2-3 times the nominal stress as shown in Fig.(B) below,

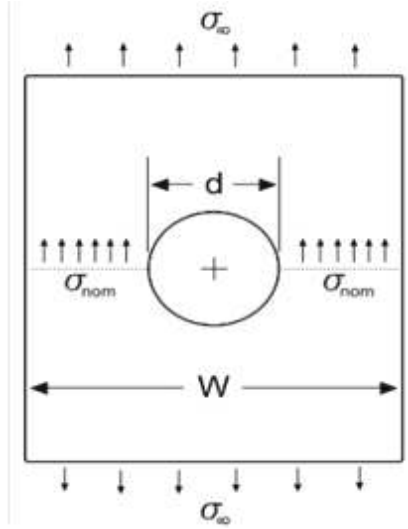

Fig.- (A) A hole of diameter "d" in a plate of width W

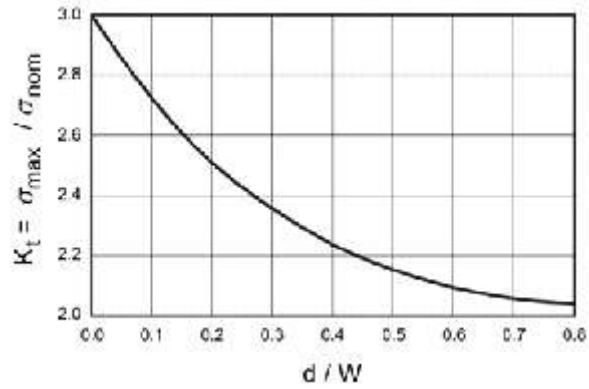

Fig. (B) Stress modification factor, Kt around a hole.

If the value of Kt is considered at lower range of 2.0, the modified stress level in the material at the joint with a hole will be 2 times the nominal stress i.e. without hole. This will require strengthening of the steel members around the holes significantly. BS-5400, Part-10 as also EN-1993-Part1-9 both stipulate modifying the stress duly considering the modification factor around holes.

In view of the ambiguity tilting towards not considering the stress concentration factor in Cl. 7.1.2 and 7.2 of Appendix 19 of SBC, this factor is not being considered by the design Engineer in DFCC. This should require clarifications from RDSO/Railway Board.

4.2 Concrete Structures: The stress range even while the stress is fluctuating in concrete structures is quite small compared to steel bridges. IRS code (Concrete Bridge Code) as also other International codes considers the effect of fatigue loading to RCC/PSC structure only for the reinforcement bars which have been welded, vide Cl7.1.4.5.There are however no guidelines for "Good/Poor geometry or details of structures in regard to Fatigue fluctuating loading. Even if the stress levels in concrete may be much less compared to steel structures, the fluctuating stresses even in concrete can damage the structure if any geometric detail is not satisfactory for fluctuating stresses.
This is left to the expertise of the Design Engineer and avoid details which entail a change in the cross-section of an element or parts of an element are sometimes not avoidable in bridges. The simplest example can be found in Open foundations footing for a column or wall, cantilever extension of PSC girders for creating space for accommodating stressing jacks, deck slabs over pre tensioned PSC girders, Box culverts connecting wall with base slab as well as top slab. Some recommended details are given below,.

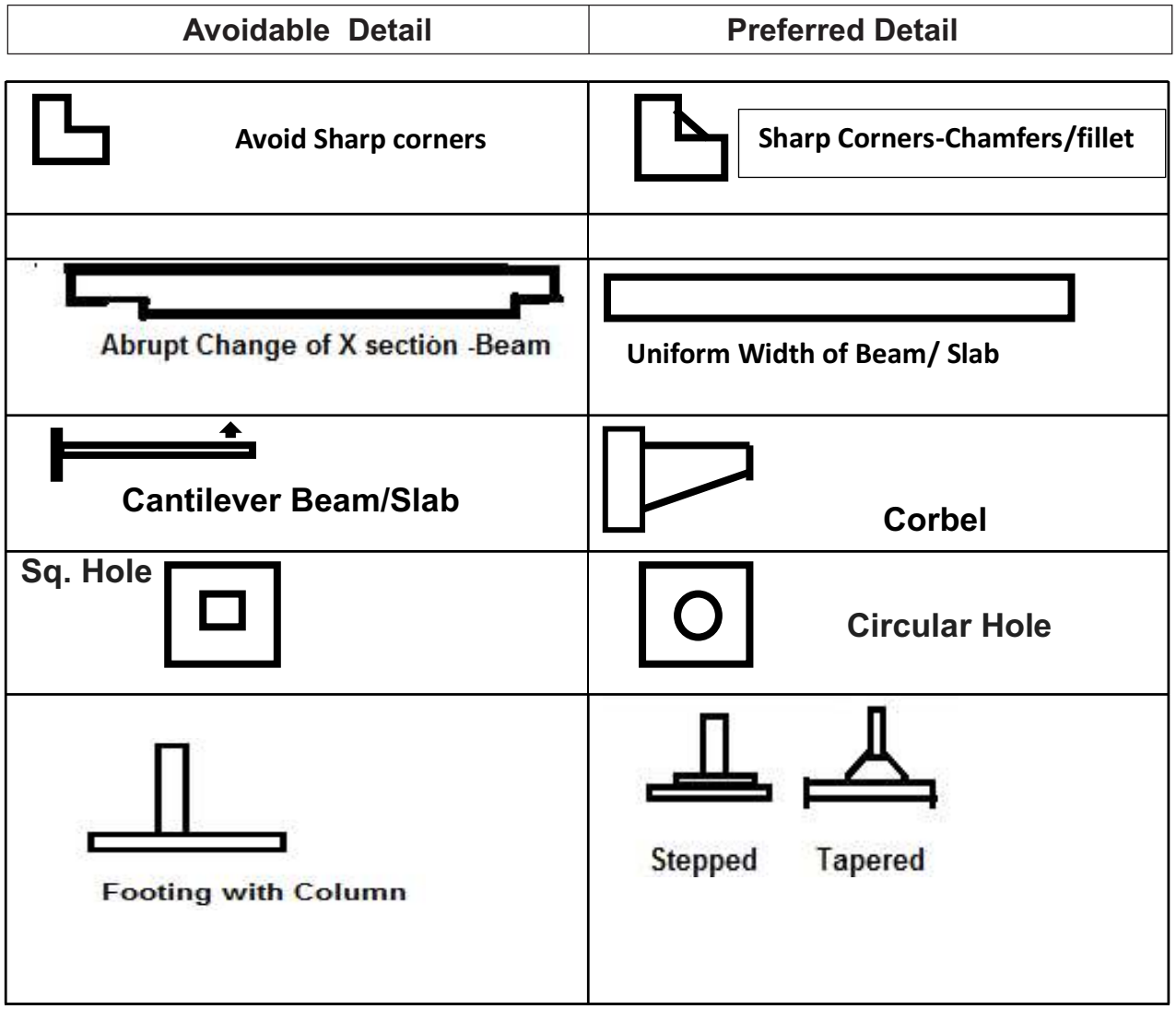

Fig. (C) Fatigue details in Concrete structures

5. Bridge deformations:

The Concrete bridge decks expand and contract by the a) change in temperature b) Creep of concrete structures c) Shrinkage of Concrete with time. While these are not new things for bridge Engineer and articulations have been provided to take into account these deformations, but assume a different dimension in case of Railway bridges where Continuous Welded Track (CWR) is to be continued over the Bridges and merely providing articulations like expansion contraction joints, movable bearings etc. cannot match the requirement of CWR.

The deformations which may be permitted on the bridges on Indian Railway, as per existing codes and specifications are as under,

- Vertical deflection of foundations due to live load= 25mm (Substructure and Foundation code-IRS)
- Vertical deflection of superstructure due to live load=1 in 600 (Steel Bridge Code-IRS)
- It is to be noted that IRS codes do not recognize the need to limit the deformations of RCC/PSC ballasted deck bridges even from the point of stability of the ballast and the track structure. Further, it is pointed out that Vertical displacement of Foundation under live load (25mm) and of superstructure for steel bridge as provided in the IRS codes do not match with the International Standards of UIC or BS/EN codes.

5.1 Euro code (EN-1990- Annexure A2)however, recognize that the deformations in the bridge can de-stabilize the track structure and create unsafe/ uncomfortable conditions for train running and prescribe as under,

i). Excessive bridge deformations can endanger traffic by creating unacceptable changes in vertical and horizontal track geometry, excessive rail stresses and vibrations in bridge structures. Excessive vibrations can lead to ballast instability and unacceptable reduction in wheel rail contact forces. Excessive deformations can also affect the loads imposed on the track/ bridge system, and create conditions which cause passenger discomfort.

ii). Deformation and vibration limits are either explicit or implicit in the bridge stiffness criteria given in A2.4.4.1(2) EN-1991-Part 2.

- IRS- Bridge Rules however, permit laying of CWR track as per provisions of UIC-774-3 (R), the limits on deformations of bridge and track after interaction are given as below,
  - ✓ Maximum displacement between rail and deck or embankment under braking and tractive force is to be limited to 4mm.
  - ✓ Maximum absolute displacement of the deck is +5mm.
  - ✓ End Rotation under vertical load, the displacement of the upper edge of deck end must be limited to $\delta(\theta H)$= 8mm
- In case of LWR track on ballasted deck where expansion joints are provided actual gap due to temperature, should normally be limited to 10-15mm and the span should be decided correspondingly,(UIC-774-3 (R)
  - ✓ In such case of expansion joint having been provided, the maximum permissible absolute displacement of the deck should be maximum 30mm.

5.2 The UIC code or IRS codes do not however, recognize the contribution of "twist" on the deck and vertical uplift at the end of deck (Kick-up, in case of the bearing is sufficiently inside the edge of deck) to destabilize the track under train loading,. This will affect in skew bridges and also due to uneven placement of track on the deck transversely. EN-1990-Appendix 2 provides as under,

The maximum twist t [mm/3m] of a track gauge s [m] of 1,435 m measured over a length of 3m should not exceed the values given in Table below,

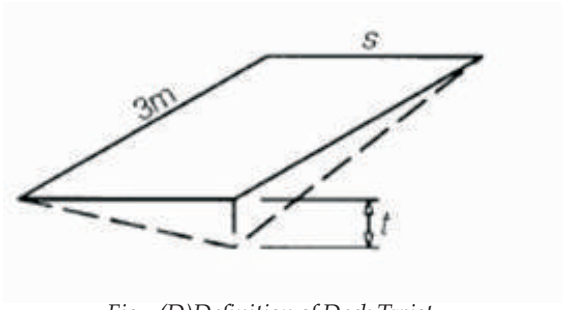

Fig.- (D)Definition of Deck Twist

Limiting values of deck twist	Maximum twist, t
Speed range V (km/h)	(mm/3m)
V ≤ 120	t ≤ t1
120 < V ≤ 200	t ≤ t2
V > 200 t ≤ t3	

This can be modified suitably if used for B.G. track. The total track twist due to any twist which may be present in the track when the bridge is not subject to rail traffic actions (for example in a transition curve), plus the track twist due to the total deformation of the bridge resulting from rail traffic actions, shall not exceed tT.
NOTE: The value for tT may be defined by concerned Railway authority but recommended value is 7.5mm/3m.

5.3 Uplift at end of deck: The vertical displacement of the upper surface of a deck relative to the adjacent construction (abutment or another deck) dV [mm] due to variable actions shall not exceed the following values:
– 3 mm for a Maximum Line Speed at the Site of up to 160 km/h,
– 2 mm for a Maximum Line Speed at the Site over 160 km/h.

5.4 Lateral deformations: The total lateral deformations of the deck under centrifugal force, racking force, wind load, lateral temperature gradient should be limited as per limits provided in UIC-776 3 (R). This is mainly to ensure acceptable track geometery and passenger comfort. The limits are expressed in terms of maximum permitted change in track radius and maximum change in angle at the end of deck of the bridge. However, for short to medium span bridges this is never a significant issue and is generally ignored.

5.5 **Vertical acceleration of deck of bridge:** For high speed railways with speeds of 200 Km/Hr or more, it is important to assess the dynamic behaviour of the bridge as to avoid resonance with the vibrations produced by the moving train loads. This needs special expertise in vehicle and structure dynamics and is not discussed here.

6 Settlement of foundations:

Settlements are mainly caused by permanent loads and backfill. Variable or time dependent settlements vary monotonically (in the same direction) with time and need be taken into account from the time they give rise to effects in the structure (i.e. after the structure, or a part of it, becomes statically indeterminate. On the Indian Railways as also on DFCC only simply supported bridges are being designed and constructed. While settlement of foundations under live load are expected to be in the elastic region, i.e. soon after the passage of train the bridge comes back to its original position. Assuming that first pier settles by 25mm the limiting value and the nearby pier shows no settlement, the longitudinal gradient, of the bridge superstructure as also the track of the loaded span will be very small of the order of 1 in 1000 (For 25m span of bridge), which is not likely to be damaging to the safety or comfort to the Railway users.

6.1 Effects of uneven settlements should be taken into account if they are considered significant compared to the effects from direct actions. However, in case of simply supported bridges they rarely are significant and are taken care while maintaining track to ensure safety and comfort to the traffic.

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7. Durability:

Owing to the need of taking traffic blocks, or access to bridge through land of third parties, it is generally difficult to take up maintenance of the bridges and even proper inspection of the Railway bridge . Particularly for minor bridges cost of access, inspection and maintenance can be high compared to the cost of the bridge itself.
From the maintenance Engineers point of view an ideal bridge has minimum no. of parts of bridge to be inspected, which are accessible easily, without places where water dirt can gather. Important components which will require taking traffic block for inspection, such as deck and floor members, is not considered justified. The frequency of detailed examination of even major bridges is much higher than track renewal and also can not be matched. Important elements of bridge like components and connections that can only be inspected by removing the track and ballast needs to be avoided.

7.1 RCC/PSC structures: Prior to advent of high grade cements and twisted (Tor) reinforcement bars, it was generally considered that good quality of concrete in regard to proper vibration, no honeycombing, and adequate curing gives a very durable structure and the bridges built in early 1960's and prior are giving service even after 50-60 years. These however are RCC structures and minor bridges.

In regard to PSC structures used in Major bridge, the experience in IR has not been encouraging. The codal life of concrete bridges is per IRS-CBC (Cl 15.1.3) are as under,

Type of Structure	Design Life
Bridges in sea	50 yrs
Bridges in coastal areas	80 yrs
Bridges in rest of India	100 yrs

However, the Pre-stressed concrete bridges technology was introduced in IR in nineteen sixties and many of those bridges have been replaced due to cracks etc. on Eastern and North Eastern Railways. Thus many of the PSC/RCC bridges do not live even for codal life as indicated above.

This however, is not true for the structures built with high grade cement and HYSD/Tor bars reinforcement. In order that RCC/PSC bridges and viaducts may be durable, will it be sufficient to have a proper design for strength, to limit crack widths under service load conditions through conventional methods of design, to specify large cover to re-bars and to maintain good workmanship while building bridges, viaducts and other structures ? I would feel that the answer would be in the negative. The reasons may be as under,

i) The high heat of hydration from HG cement is not being dissipated gradually which is causing shrinkage cracks and micro-cracking in concrete. The quality of concrete, formwork, low water cement ratio, through the addition of admixtures, achieving greater compaction and lengthening the period of moist curing has not been achieved.

ii) The HYSD/CTD bars corrode much faster compared to mild steel round bars even in normal environment and the corrosion might set in the bars even prior to interning the bars in concrete, which has not been removed.

While the quality of concrete is being satisfactorily maintained especially when manufactured at central weigh batching plant and concrete transported through transit mixers, the moist curing is being avoided by contractors due to short availability of water in more than 50% of the country and curing compound is being only used. The long term effect on concrete cured by curing chemicals are not fully established. Even in 28days, the crushing strength of cube is about 10% less than in wet curing. In some experiments however, it has been found that the permeability of concrete in case of curing compound are more than wet curing. Another aspect is the method and quality of workmanship in applying the compound. The compound should be applied at a uniform rate. The usual values for coverage range from 0.20 to 0.25 m2/lit. Curing compound can be applied in two applications at right angles to each other by hand or power sprayer usually at about 0.5 to 0.7 MPa pressure. For maximum beneficial effect on open concrete surfaces, compound must be applied after finishing and as soon as the free water on the surface has disappeared and no water is visible, but not so late that the liquid curing compound will be absorbed by the concrete. When forms are removed, the exposed concrete surface should be wetted with water immediately and kept moist until the curing compound is applied. Just prior to application, the concrete should be allowed to reach to a uniformly damp appearance with no free water on the surface and then application of the compound should begin at once.

The importance of removal of rust from the re-bars prior to use must be ensured. In certain aggressive environments, IRS-CBC (Cl 7.1.5) protective coating may be provided on the reinforcement. Another, recommendation about delaying corrosion of re-bar and delay the carbonation of concrete, concrete surface is also given protective coating.

7.2 Steel bridges: The lobby for RCC/PSC bridges always consider that steel bridges require difficult and costly maintenance for protection against corrosion apart from Initial higher cost of construction. While, on initial cost basis steel bridges do cost about twice the cost of RCC/PSC structures. AS per experience of IR, there are large no. of steel bridges constructed more than 100 years back even in the sea and still serving

Railway, the without any problem. In modern times, various coating systems based on Epoxy, vinyls, poly-urethane etc. are available which have long life as much as 15 years, against 4-5 years of oil based paints.

Then we have technology of metallizing which can be used in more corrosive environments. Indian Railways have standardized the method of galvanizing and metallizing which can be referred to for use However, there are certain type of super-structure like semi through bridges which have very complex connections at the level of deck level and difficult to access for inspection. Such details may be avoided. Railway Engineers and staff are well adept in maintaining steel bridges and equally ignorant of maintaining Concrete bridges.

There is an opinion among some of the Railway men and Engineers that on consideration of Life Cycle Cost the steel structures may even work out cheaper, though no scientific study is available.

8.0 Inspection and Maintenance: Many of the points covered in para 7 above are applicable under this item as well. To have a strong and durable structure it is necessary to have an integrated approach which combines design for strength, inspection, and maintenance. The durability of structure is largely decided at the stage of planning and design. All facilities should be planned and designed for maintenance and inspection of bridges. Some of these are,

- Availability Bridge inspection unit for inspection of underside of bridge superstructure as also the sub-structure.
- Access in closed sections and overhead members for an Engineer to reach and physically examine the elements of bridge.
- Advanced equipment for investigation of corrosion in RCC/PSC structures
- Availability of non-destructive testing of materials like Pulse velocity tester, Schmidt hammer etc.
- In PSC girder bridges the deck below the wear course should be inspected at least once in 5 years.
- Ladders in the approach of bridges to reach the ground level and also for inspection of bearings.
- Platform for inspection and replacement of bearings.
- Any element susceptible to corrosion like expansion joints, bearings, Hand railings, foundation bolts for any structure like OHE mast etc. should be provided with convenience of dismantling the unserviceable element and replacing with a new one.

Radical Approach to Rehabilitation & Resettlement (R&R) of Project Affected People (PAPS) in Maharashtra

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ABSTRACT:
250 Ha of private land and 178 Ha of Govt. land is being acquired in 102 villages of Raigad, Thane & Palghar district of Maharashtra state for laying DFC tracks. All the three districts have various type of title holders of housing units like owners, not title holders, squatters etc. The disparity in entitlement for R&R of PAPs in the Act of 2008 and 2013 led to lot of resentment. Not only did the compensation of land is substantially more in the new act but also the entitlement of housing units and other benefits are substantial. By adopting a pragmatic approach, the unit developed a package within the available Acts to have parity for all the PAPs for R&R. The paper basically deals with these methods.

1 INTRODUCTION

Total length of Dedicated Freight Corridor in Maharashtra State is about 180 km. For this, 250 Ha of private land and 178 Ha of Govt. land is being ac-quired in 102 villages of Raigad, Thane & Palghar district. All the three districts have various type of title holders of housing units like owners, not title holders, squatters etc. Land acquisition for DFC is being mostly done under a Special Act viz. Railway Amendment Act – 2008.The compensation for the land and structure was made as per RAA 2008.

Govt. of India enacted a new Central Act viz. "The Right to Fair Compensation & Transparency in Land Acquisition, Rehabilitation & Resettlement Act – 2013" (RFCTLARR – 2013). Not only did the compensation of land is substantially more in the new act but also the entitlement of housing units and other benefits are substantial.

Since most of the land acquisition and disburse-ment of compensation was over, no revision of land awards was proposed. However, to rectify the anomaly in the R&R provisions in the relevant Entitle-ment Matrix, a package was formulated and developed so as to overcome the resentment of the PAPs due to disparity in the two Acts.

2 COMPARISON OF OLD & NEW ACTS

2.1 The Disparity

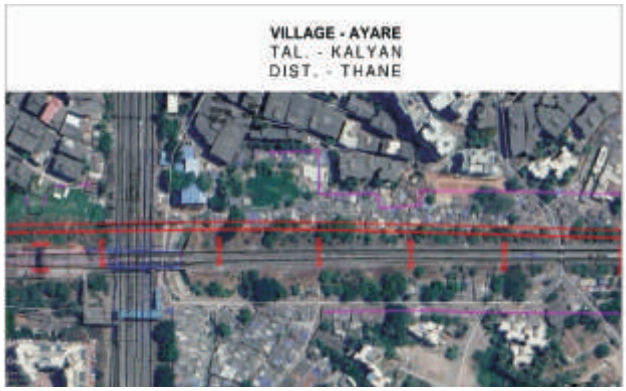
The comparison of the new act RFCTLARR – 2013 and old act RAA – 2008/NRRP – 2007 for entitlement is as below:

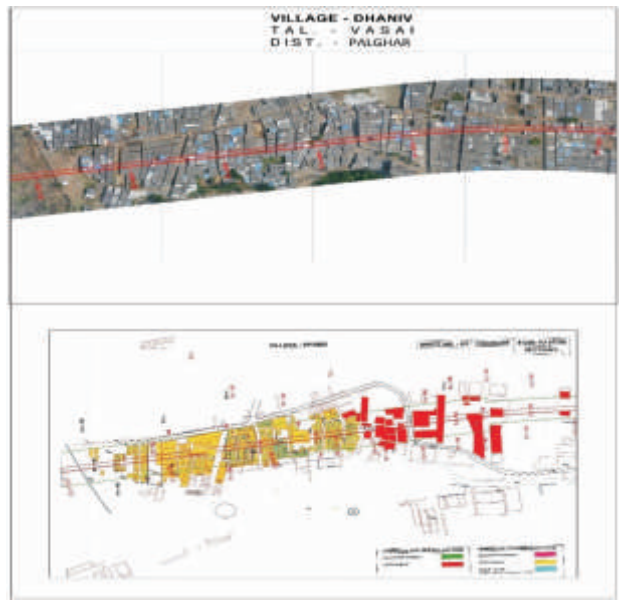
S N	Item	As per RFCTLARR -2013	As per RAA-2008/ NRRP-2007
		R&R	
1	Provision of Housing Unit	All affected families to be relocated with	--
		Constructed house as per Indira Aawas Yojana Specification in rural areas.	
		Constructed house as per State Govt. Policy in urban area.	
2	Alternate benefit in lieu of housing unit	If not opted for constructed house	Only BPL families to be provided with additional financial benefit towards housing unit.
		Equivalent cost of Rs. 1,65,000/- in lieu of constructed house in rural area.	Equivalent to latest construction cost of Indira Aawas Yojana Scheme in rural areas.
		One-time financial assistance not less than Rs. 5,50,00/- in urban area.	Cost of house construction under JNURM in urban areas.
3	Annuity or Employment /Rehabilitation assistance for loss of livelihood:	Choice of Annuity or Employment any one of the below (iii)	Rehabilitation assistance for loss of livelihood: -
		Provision for employment at a rate not lower than the min. wages to at least one member of affected family in the project or arrange for job in other project; OR	Rehabilitation grant equivalent to 750 days min. agri. Wages to those families losing livelihood (Rs. 1,08,750/-).
		One time payment of Rs. 5 lakhs per affected family; OR	Training assistance of Rs. 4000/- for income generation per household.
		Rs. 2000/- per month per family for 20 years.	Temporary employment in project construction work to affected person with particular attention to BPL PAPs by the project contractor during construction to the extent possible.

As can be seen from the above comparison the benefits are substantially higher under the new act. Due to this there was a general resentment among the PAPs whose land has been acquired under the old act. Though most of the acquisition was done under the old act but no physical possession of acquired land was taken in areas where there were structures. When the contracts came in place and the process of physical possession and handing over of land was initiated, the areas where structures were there posed stiff resistance. To overcome this resistance and to convert the involuntary shifting of PAPs to voluntary various methods were thought and deliberated.

3. APPROACH FOR R&R POLICY

The shifting of PAPs from railway land in Mumbai area prior to the Act of 2013, for all Rly projects, was dealt by MMRDA through a special policy formulated in 1997 (Amendment 2000). No policy was available for resettlement of squatters on Rly land outside the limits of MCGM. Till the new act came into existence, they were not provided residential accommodation or any other benefits. This has led to delay in completion of various important projects. This anomaly has now however been taken care of by the new act. For the DFC project, the disparity in benefits for PAPs in two acts had the potential to derail the project timeline. Based on the experiences of other projects, fundamental approach has been adopted which is not of confrontation but resolving the issue in an amicable way within the frame work of new act RFCTLARR – 2013. A comprehensive proposal was prepared and sent to Railway Board. Railway Board approved the R&R policy of DFCCIL as a special case in Mumbai Area for the WDFC project in Maharashtra vide letter no. 2009/infra/3/1/10 part –II dated 26.12.2017.





4. DETAILS OF PAPs

The number of displaced PAPs is approximately 3215 in Maharashtra. Same has been arrived after identification of no. of displaced PAPs through the JMS of private land and Govt. land and further through the assessment by the nominated NGO. The district wise bifurcation of no. of PAPs is as under:

SN	District	PAPs			Total	Resettlement process
		Resi. Owner	Occupier	Squatters		
1	Raigad	0	50	244	294	R&R
2	Thane	110	329	417	856	through
3	Palghar	92	1521	452	2065	GR
				Total	**3215**	

Out of the total stretch of about 180 km in Maharashtra state these PAPs are affecting about 12 km of the stretch. The no. and the stretch are substantially higher. However, since all the other stretches were already offered to the package

contractors for executing the work some breather was available to find an amicable solution for R&R of the PAPs. Use of force or any other coercion method would have not worked in highly dense habitated areas.

To minimize the disparity and to provide adequate R&R benefits to displaced families, proposal was prepared by DFCCIL considering the already available policy of R&R of MMRDA, CIDCO and other Government bodies.

5. PROPOSAL FOR ISSUE OF GOVERNMENT RESOLUTION (GR)

5.1 After approval from Board, the draft policy of R&R for DFCCIL PAPs was formulated by the Mumbai (South) unit and submitted to Govt. of Maharashtra for their consideration and if found in order, then to issue the necessary Govt. Resolution. The unit developed this proposal to save time and to assist the state government in appreciating the problem within the limited time.

5.2 Several rounds of discussion were held. By the end of May 2018, GoM issued two GRs. One dealt with the entitlement and the procedure to be adopted and other nomination of DRO who will carry out the R&R work.

5.3 GR issued on 22.05.2018 for Resettlement and Rehabilitation (R&R) of eligible Project Affected people due to DCCIL project covered all types of PAPs:

1. Eligible displaced PAPs included in the Structures Compensation Award.
2. Displaced Squatters on Public land & PAPS not covered under one above.
3. Rehabilitation of affected Common Property Resources.

The GR issue on 22.05.2018 covers all type of PAPs including squatters on Railway Land. The DROs for Raigad, Thane & Palghar Dist. have been appointed exclusively for DFC R&R work on 19.05.2018. The process of implementation is now in place and the actual shifting of PAPs from two most critical areas has been planned and is not far away. Once the process starts it will take a year to shift all the PAPs.

6. PROCEDURE FOR IMPLEMENTATION

The salient features of the R&R GR are as under:

I. Nomination of district rehabilitation officer – Divisional Commissioner shall nominate the district wise DROs for complete implementation of R&R of DFC project affected structures and CPRs. The same have been done for all the three districts and the work of identification of beneficiary PAPs is in advanced stage in Thane district.

II. Process of R&R implementation of PAPs by DROs

a. The competent authority shall submit the copies of village wise structures Compensation Award declared by them to the nominated DROs.

b. Nominated DROs shall prepare list of structures and sub structures based on JMS and valuation by PWD etc.

c. Based on the above-mentioned structures / sub structures list, other records and survey con-ducted by NGO appointed by DFCCIL, DROs shall prepared the list of eligible displaced PAPs duly verifying the necessary documents to established eligibility for R&R.

d. Further, the nominated DRO shall initiate the procedure for allotment of housing units to the confirmed eligible structure owners. They will inform the concerned PAPs by publishing the notices in daily newspapers and also on village notice boards for the alternate housing unit and other payable cash assistance as approved vide GR dated 22.05.2018

e. The PAPs in reference to notice can appeal to DRO for any of their grievances within one month from the date of notice. The DRO shall give such person an opportunity of being heard and after hearing if he feels necessary by order either allow or disallow the objection within next two months.

f. In case of structures / sub structures having no objection towards its ownership final list of structures owners shall be prepared mentioning the entitled housing unit and other payable cash compensation duly approved by Divisional Commissioner.

g. The allotment of housing units at designated lo-cation to the concerned structure owner shall be done by nominated DRO, through prescribed / extant lottery system. The final award / order mentioning PAP wise allotment of housing unit and other payable cash

compensation shall be prepared by nominated DRO.

h. The PAPs who do not to agree with order can appeal to Dy. Commissioner Rehabilitation within one month from the issue of award.

The Rehabilitation & Resettlement (R&R) has been done for the first time in the DFC project for PAPs of Maharashtra.

7. HOUSING UNITS

I. Formulation of policy, issue of GRs and nomination of DROs was only the tip of the iceberg. The main issue was of the availability of housing units for resettlement of the PAPs.Usually for all the projects in MCGM (Municipal Corporation of Greater Mumbai) limits the houses are constructed by MMRDA (Mumbai Metropolitan Region Development Authority) in nominated areas of the city. Hence the unit approached MMRDA Chief for arranging housing units for DFCCIL project as well. However, during the initial discussions, itself it was made clear that this won't be possible since the avail-able houses are not even meeting the require-ments of PAPs for MCGM projects especially Metro. Therefore, the unit deliberated on various alternatives like constructing new houses, purchasing ready-made houses, engaging MHADA for keeping some provision in their projects etc. However, none of this was found viable. The unit then came to know of under construction houses in Kalyan area by KDMC (Kalyan Dombivli Municipal Corporation) un-der a scheme called BSUP (Basic Services for Urban Poor). A total of 7000 houses are pro-posed to be constructed under this scheme. Some were ready, some were under construction and some were yet to start. KDMC initially was reluctant to spare these houses for DFCCIL but after series of meetings, they finally agreed for the same. The proposal was sent by them to GoM for communicating approval for utilising these houses. Though GoM communicated theirin-principle approval but since the houses were constructed under a scheme of Central Govt, proposal was sent to Secretary/ HUD for consent. In September 2018, through the GR the houses were allotted for use of DFCCIL and further through the amendment the conditions which could not be implemented were also dropped, based on the request of the unit.

II. The condition was to link the R&R with Pradhan Mantri Aawas Yojana (PMAY). But DFC does not agree for housing unit under PMAY scheme since it had several conditions which are to be fulfilled for the allotment of housing units. These conditions would have not been accepted by PAPs. The primary condition for the allotment under PMAY is that they have no house anywhere in India. It cannot be ensured because the PAP will not disclose the same. The Government of Maharashtra was kind enough to understand the view of the unit and issued the amendment to the GR on 26.10.2018.With this amendment to the GR of 25.09.2018,nowthe housing units constructed / under construction in KDMC area under BSUP scheme shall be allotted to PAPs of DFC project. The process of transfer of these houses has already been initiated and KDMC will shortly be advising the per unit cost to be borne by DFC for transfer of these houses for use of the project. KDMC is ready to spare approximately 3000 housing units for PAPs of DFC projects under BSUP scheme. Out of 3000 housing units, 1000 housing units are ready for possession and the PAPs of Thane district are proposed to be shifted to these initially. Remaining 2000 housing units are under construction and likely to be completed within six months in a phased manner. The R&R of other districts will be dealt as son as the units are ready.

The PAPs who are not willing to accept these housing units, the possibility of which is remote, will be paid cash assistance and other benefits. These provisions have already been taken care through the GR.

9. AKNOWLEDGMENTS

The authors on behalf of the Mumbai South Unit are thankful to the various agencies like Railway Board, Govt. of Maharashtra, KDMC, and others who understood the importance of the project and have given activeco-operation for acceptance of the R&R Policy for the first time in DFCCIL Project for the State of Maharashtra.

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Policy framework for development of Project on Private-Public-Partnership (PPP)

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ABSTRACT:
Creation of infrastructure such as Roads, Highways, Water and Sanitation (W&S), Ports, Power, Airways, Urban transport is a prerequisite for rapid economic development of any country. Normally creation of such Infrastructure is prime responsibility of the State or Government. However over the time with increasing social obligations and growing aspirations from industry, Govt. is finding difficulty in mobilise matching resources for creation of infrastructure needed for attaining required level of growth. Further large investment in Infrastructure needs to be supported by technological innovation, skilled workforce and excellent project management. This realization has brought together the public and the private sector in a mutually beneficial relationship in the form of Public Private Partnerships (PPPs) an alternate mode of Funding and to execute infrastructure projects duly sharing of risks.
This article deals mainly with the basic concepts, frame work and procedure involved in developing Project on PPP basis. DFCCIL is executing Dankuni- Sonnagar (540 km) Project of Eastern DFC on PPP basis, the experience of which can be used in developing future Freight Corridors and other Projects like Private Freight Terminals (PFT) on PPP mode which may come to DFCCIL.

1. Introduction:

1.1 Creation of durable and high quality infrastructure such as Highways, Ports, Power,Airways, Urban transport is a prerequisite for rapid economic development of any country.In India, from the beginning of First five year plan, creating Infrastructure was the prime responsibility of the Government. However, with increasing social obligations and growing aspirations from industry and people, it has been realised that Govt. alone can't mobilise resources for creation of infrastructure, country may require. Large investment in Infrastructure needs to be supported by technological innovation, skilled workforce and excellent project management. For governments alone to bring together all these elements is not

always possible. The strain is especially great for developing country whose economies are undergoing rapid development and unbanisation. This realization has brought together the public and the private sector in a mutually beneficial relationship in the form of Public Private Partnerships (PPPs) to execute infrastructure projects.

1.2 **Public Private Partnerships (PPP)** implies the coming together of two dominant but divergent sectors of the economy, each with different prescriptions and objectives, for the overall development of the community and country. Public Private Partnerships have emerged as one of the latest and successful instruments of public finance, and are increasingly being adopted by both developed and developing countries as a way of increasing access to infrastructure services for their citizens and economies at a reduced cost.

1.2.1 The basic intent of PPP is to encourage the private sector to dedicate its capacity to raise capital and the ability to complete projects on time and to budget for the welfare of the community, without having to compromise the profit motive.

1.2.2 At the same time, the public sector would retain its responsibility to provide goods and services to the public at large at affordable rates. This arrangement, indeed, calls for a judicious approach to decision making and underscores the need for a framework that enables the private sector partner to make reasonable returns on investments without diluting the standards and quality of services provided.

1.2.3 The key to the success of PPP projects is a balanced and fair sharing of risks and benefits between the partners, and transparency and accountability in all transactions relating to the award and management of the contract.

1.3 **The objectives of a PPP in infrastructure are to:**

- increase the availability of infrastructure services, and
- do so with greater efficiency (lower cost for the level of services provided) than could be achieved using the traditional public sector approach.

1.4 **PPPs make this possible because:**

- PPPs allow access to the substantial financial resources of the private sector,
- PPPs enable the public sector to benefit from private sector technical expertise, experience and efficiency, and
- PPPs enable the public sector to transfer project-related risks to the private sector.

A PPP brings the public and private sectors together as partners in a contractual agreement, for a pre-defined period matched to the life of the infrastructure assets used to provide the services. The private partners (investors, contractors and operators) provide specified infrastructure services and, in return, the public sector either pays for those services or grants the private partner the right to generate revenue from the project. For example, the private partner may be allowed to charge user fees or receive revenue from other aspects of the project.

The best PPPs will have the public and private partners working together to build and sustain a long-term relationship that is of benefit to all.

1.5 **Definition of PPPs in India:** The Department of Economic Affairs (DEA) defines as:

PPP means an arrangement between a government or statutory entity or government owned entity on one side and a private sector entity on the other, for the provision of public assets and/ or related services for public benefit, through investments being made by and/or management undertaken by the private sector entity for a specified time period, where there is a substantial risk sharing with the private sector and the private sector receives performance linked payments that conform (or are benchmarked) to specified, pre-determined and measurable performance standards.

2. Characteristics of PPPs

2.1 A PPP typically has the following characteristics:

- **the private sector** is responsible for carrying out or operating the project and takes on a substantial portion of the associated project risks,
- during the operational life of the project, the

public sector's role is to monitor the performance of the private partner and enforce the terms of the contract,

- the private sector's costs may be recovered in whole or in part from charges related to the use of the services provided by the project, and may be recovered through payments from the public sector
- public sector payments are based on performance standards set out in the contract
- often the private sector will contribute the majority of the project's capital costs, although this is not always the case
- PPP is focused on outputs, and
- The outputs of the PPP are infrastructure services, not infrastructure assets.

3. Risk – a key focus of PPP design

Allocating risk to achieve added efficiency is what makes PPP a potentially powerful way of reducing project-related costs and achieving improved value for money for the public sector. The level of risk can be changed by allocating responsibility for individual risks to those who are best able to manage them.

3.1 The parties involved in a project can affect the amount of risk by:

- the level of influence they have over events, and
- the level of information they have about the present and the future.

3.2 The public and private sectors are different in the types of influence and information that they have. This means they can control risks in different ways from each other and they are better at controlling some risks and not as good at controlling others.

3.3 One of the goals of a well-designed PPP is to pick out the strengths and combine them together. The result should be that a partnership of public and private parties is stronger and more efficient than either party by itself.

4. When should PPP be used?

4.1 The use of PPP for infrastructure projects should only be considered when:

- **The public sector environment is suited to supporting PPPs:**

A PPP is a complex arrangement that requires support from the Public sector during development and operation. The likelihood of PPP success will be increased when the public sector supporting environment is strong.

- **The project is suitable to being carried out as a PPP:**

  Certain characteristics make a project well suited to being a PPP, while others imply that the PPP approach will be difficult or inappropriate.

- **The potential barriers to successful project implementation have been identified and can be overcome:**

  Many of the common obstacles to successful PPP implementation can be identified in advance. If these are insurmountable then the project should not proceed as a PPP. If they can be overcome, then this needs to be factored into the PPP development and thoroughly planned for.

- **Given that these conditions are satisfied, the project must be commercially viable for the private sector and offer value for money (VFM) for the public sector:**

  The choice of PPP should allow the project to be undertaken at lower cost on a lifetime basis, while delivering the same or better quality services than could be achieved through implementation by the public sector or private sector on their own. It must also be commercially viable in order to be attractive to private investors.

These important conditions should be checked early for every project. This will improve the quality and likely success of projects entering the PPP development pipeline. Where these tests are not met, it may be better to carry out the project through the traditional public sector route.

5. PPPs in Indian Railways:

Indian Railways have successfully implemented certain port/ mine connectivity projects since 2002 involving its Customers and Users. Cabinet Committee on Infrastructure has approved a policy on "Participative models for Rail Connectivity and Capacity augmentation projects" as communicated by Ministry of Railways vide letter No.2011/Infra/12/32 Dt.10.12.2012 to strengthen,

modernise and expand the IR network for its existing shelf of projects and also for new Projects. The policy provides following models for implementation of various types of rail-connectivity and capacity augmentation projects in Indian Railways:

i. Non-Government Private Line model,

ii. Joint Venture (JV) model,

iii. Build, Operate and Transfer (BOT) model,

iv. Capacity augmentation with funding provided by customers model, and

v. Capacity augmentation through annuity model

Three of these models (Private line, JV and Customer Funded) involve participation of strategic investors/customers and two other (BOT and Annuity models) are pure PPP models. The salient features of Build, Operate and Transfer (BOT) model and Capacity augmentation through annuity model are briefed below

5.1 **Build, Operate and Transfer (BOT) model:**

The salient features of BOT model are

5.1.1 **Applicability:**

For the projects where it is not possible to identify any stakeholder, a BOT type model is suitable. The project under this model will be generally long rail corridors carrying traffic generated from various streams like sandwiched sanctioned new lines, gauge conversion projects or dedicated freight corridors.

5.1.2 **Project Development:**

Project development, preparation of DPR, establishing financial viability & bankability will be done by Railway by engaging credible consultants and the project will be sanctioned as a railway project following the applicable procedure of appraisal/approval of PPP project.

5.1.3 **Design, Build, Finance, Maintain and Transfer (DBFMT) Concession**

- The project will be funded by the concessionaire. The concessionaire will design and build the project within the design & performance parameters specified by MoR. The statutory/mandatory design approvals, wherever required, will have to be taken from CRS or the concerned Zonal Railway. However, it will be responsibility of the cocnessioning Authority/IR/Zonal Railway to get these approvals within a specific time frame.
- Land acquisition for the project will be done by the Railways at their cost. Land will be owned by the Zonal Railways. It will be given to concessionaire on license on a token license fee of Re 1 per annum.

5.1.4 **Selection of Concessionaire:** The Concessionaire shall be selected through competitive bidding process. Premium or Grant (through Viability Gap) will be bidding parameters.

5.1.5 **Concession Period:** Under this model, the normal concession period is 25 years. This shall include construction period. In case the user fee on the expiry of 20 year is falling short / exceeding the projected revenue by 4%, the Concession period will be increased /decreased by six months for every 2% shortfall/enhancement. However, the concession period shall not be less than 20 years and will not be more than 30 years.

5.1.6 **Concessionaire to be Railway Administration:**

Under the framework agreement, Government recognizes that the line built by the Concessionaire will be a Railway Administration under the Railway Act, 1989. This facilitates construction and maintenance by the Concessionaire.

5.1.7 **Revenue share/ Use Fee:**

A new concept of projected revenue has been introduced in this model instead of projected traffic to provide reasonable certainty and comfort to the Concessionaire to manage its finances effectively throughout the concession period. User fee to be paid by IR will be calculated on the basis of following principles

i. To provide comfort to investor from any uncertain variation in freight rates the base tariff, i.e. the tariff applicable during the RFQ year is escalated annually at a rate linked with WPI.

ii. Inter Railway Financial Adjustment formulae shall be used for appointment of freight realized by IR on the projection section.

iii. MoR shall pay 50% of apportionment of

freight revenue as user fee.

iv. MoR would guarantee 80% of the projected revenue during any year.

v. In case actual user fee in a particular year is in excess of 120% or 150% of the projected revenue, 50% or 75% of the excess revenue respectively will be paid to MoR by the Concessionaire.

5.1.8 Construction

Project Construction will be done by Concessionaire through its own agency under mandatory certification and supervision from Railways/ Independent Engineer (IE).

5.1.9 Maintenance

The concessionaire shall be responsible for maintenance of the project line to make it rail-worthy at all times including replacement/renewal of assets as per IR standards and specifications. Supervision and certification shall be done by IR on payment of specified charges.

5.1.10 **Golden Share:**

The concessionaire shall allot one equity share in favour of MoR (Golden Share). The purpose of this clause is not to interfere into the day to day functioning of the concessionaire but to facilitate better communication between the concessionaire and MoR.

5.1.11 **Conditions Precedent:**

The rights and obligations under the agreement are subject to fulfillment of conditions precedent specified in the agreement. MoR has to procure the right of way, approvals and permits etc to implement the project. The Concessionaire needs to provide Performance Security and should execute escrow agreement, substitution agreement, financing agreement as Conditions Precedent. Delay in fulfillment of such conditions requires payment of damages to the tune of 0.1% of the Performance Security by MoR and 0.2% of the Performance Security by Concessionaire subject to maximum of 20%.

5.1.12 **Financial Close:**

The Concessionaire has to achieve financial close within 180 days from the date of the agreement. Extension can be granted subject to payment of damages to Ministry of Railways at the rate specified in the agreement.

4.1.13 **Utility shifting:**

The cost of utility shifting would be borne by MoR. The reason is that MoR will have better control on the costs of utility shifting through various government agencies than the Concessionaire.

5.1.14 **Construction, Monitoring and Supervision of Rail System:**

The Concessionaire has to undertake construction of rail system within the Specifications and Standards of MoR in a time bound manner. The Concessionaire is expected to complete the construction within a period of four years. For monitoring of construction, MoR shall appoint an Independent Engineer (IE). The cost of IE will be jointly shared. The purpose of appointment of IE and cost sharing is to ensure neutrality of IE.

5.1.15 **Technical Parameters:**

The Rail System will be built as per standards and specifications specified by Ministry of Railways.

5.1.16 **Maintenance and Capacity Augmentation of the Rail System:**

The maintenance of the Rail System shall be undertaken by the Concessionaire or can be entrusted to Zonal Railways on payment of costs. Maintenance requirements as enshrined in the agreement will need to be observed. Damages are paid to MoR in case concessionaire fails to rectify the defect within the period specified in the agreement.

5.1.17 **Operation:**

Indian Railways will provide seamless operation.

5.1.18 **Safety:**

The responsibility for safety on the Rail System will be that of Concessionaire. The concessionaire has to ensure adequate facilities for rescue operation on the Rail System. Zonal Railway shall arrange relief and evacuation at the cost of concessionaire if requested in writing by the concessionaire.

5.1.19 **Concession Fee:**

Ministry of Railways will provide land at a

nominal fees of rupee one per annum.

5.1.20 **Escrow Account:** The Concessionaire company has to open an escrow account. This account will receive all inflows of funds and withdrawals will have to be strictly as per the provisions of the agreement. MoR has to ensure that at the transfer date at least 5% of the total user fee for the preceding year should be available in the escrow account for meeting any liabilities after termination.

5.1.21 **Compensation for Breach of Agreement:**

In case Concessionaire is responsible for any material default or breach of agreement, it shall pay to MoR all direct costs suffered by MoR. MoR has to pay all direct costs in case of its material default. Ministry of Railways in case of concessionaire default during the operation period shall pay to the concessionaire an amount equal to 90% of the debt due less insurance cover and 70% of the amount representing Additional Termination Payment. In case termination is on account of MoR's default, Concessionaire will be paid an amount equal to full debt due plus 150% of the Adjusted Equity and 115% of the amount representing Additional Termination Payment.

5.1.22 **Approval:**

The project development and preparation of DPR to establish financial viability and bankability will be done by Ministry of Railways. Once the financial viability is established with or without Viability Gap Funding (VGF), RFQ can be launched either through Railway Board or by Zonal Railway or through Railway PSU. PPP-AC route will need to be adopted for appraisal of such projects before final sanction of appropriate authority.

5.2 **Capacity augmentation through annuity model**

The salient features of BOT model are

5.2.1 **Applicability:**

- For projects where user charges cannot sustain the required private investment, an alternative to the user charge based BOT model is required, to execute various important projects of doubling, 3rd line, fourth line etc.
- The Annuity model is also applicable to execute such projects where it may not be possible to find funding from any specific user.
- Under this model, the construction risks are allocated to the concessionaire and other risks such as traffic risk and all direct & indirect political risks are assigned to the Authority.

5.2.2 **Project Development:**

Indian Railways will be responsible for project formulation, DPR, Survey, Scale Plans etc. The Feasibility Report would be prepared by a consulting firm to provide and indicative assessment to the prospective bidders. Indian Railway shall also be responsible for finalization of Engineering standards and specifications. The bidders will carry out their own due diligence.

5.2.3 **Selection of Concessionaire:**

The Concessionaire will be selected through open transparent bidding system and Lowest Annuity demanded for pre-determined period will be selection criteria.

5.2.4 **Land and utility shifting:**

Land acquisition and utility shifting will be done by MoR or its entity.

5.2.5 **Concession Period:**

Concession period will be fixed in the range of 15-20 years based on the Feasibility Report (FR).

5.2.6 **Nature of Concession:**

The Concessionaire will be responsible for financing and construction. Supervision and Certification of construction will be done by MoR/IE.

5.2.7 **Operation:**

Train Operations and Maintenance will be done by MoR.MoR will manage stations, signals, level crossing gates etc.

5.2.8 **Revenue:**

Payment to Concessionaire will be through Annuity which is determined through competitive bidding for pre-determined period.

5.2.9 **CRS sanction:**

IR shall, based on the requisite papers submitted by the Concessionaire, apply for and obtain CRS sanction.

5.2.10 **Non-interlocking (NI):**

Non-interlocking (NI) activities preceding operationalization of the double/multiple line will be undertaken within a stipulated period after Construction Completion Certificate in respect of the civil works is furnished by the Concessionaire. NI will be done by the Concessionaire under the supervision of IR.

6. Overview of the framework:

Niti Aayog (erstwhile Planning Commission) has formulated guidelines for development of any project on PPP basis. The various steps are involved are:-

- **Development of standard document:** Like Request for Qualification (RFQ), Request for Proposal (RFP), Concession Agreement (CA)
- **Approval of Regulatory Bodies:**
  For approval of project to be taken up on PPP and For approval of Viability Gap Fund (VGF) needed for project to be taken up on PPP
- **Selection of bidder :** Through open bidding following RFQ and RFP process
- **Financial Close:**
- **Appointment of Independent Engineer(IE):** For supervision and monitoring of construction and maintenance of project.
- **Execution and maintenance of Project:** Execution of works as per the laid down standard and specification and Key Performance Indicator(KPI)

6.1 Development of standard document:

6.1.1 Need for a standardised framework:

With a view to enabling a smooth transition from public sector projects to PPPs and for adoption of best practices, Government of India has recognized the critical role of standardizing documents and processes to be adopted for structuring and award of Public Private Partnership (PPP) concessions. Standardised documents enable project authorities to save on the time and costs involved in structuring complex PPP projects. In addition, they afford protection to individual entities and officials against making errors and answering for them. Such standard documents typically lay down the norms, principles and parameters to be followed for PPP projects and enable project authorities to adopt them with considerable ease for meeting the specific requirements of individual projects.

6.1.2 Need for Consultants:

The process of structuring PPPs is complex and the requisite expertise does not normally exist within the government. Nor do the Project Authorities have the time and staff resources that go into fine tuning the documentation for PPPs. Employing experienced consultants enables the project authorities to enhance the possibilities of a successful project, helps in avoiding costly mistakes, promotes capacity building within the government sector and builds investor confidence in the entire process.

6.1.3 Separate technical, financial and legal consultants:

The Central Ministries, State governments or Statutory entities owning such projects (the "Project Authorities") would normally need expert financial, legal and technical advice for formulating project documents necessary for award and implementation of PPP projects in an efficient, transparent and fair manner. Project Authorities sometimes seek the comfort of a single consultancy firm to handle all aspects of project preparation and award. While it may appear to be a convenient approach especially for Project Authorities lacking in experience, this can lead to sub-optimal outcomes and large contingent liabilities or claims arising out of the project document and contract. It is an international best practice to engage technical, legal and financial consultants separately as the firms rendering such services are independent of each other and must also provide their advice independently. Where necessary, the Project Authorities Consultants required for structuring a successful PPP project Separate technical, legal and financial consultants

Standardised documents save on time and costs; avoid costly mistakes Feasibility Report is necessary for defining a bankable project may also entrust the financial adviser with the role of transaction adviser for coordinating the bid process.

6.2 Keeping in view of above requirement, the various stages are:

6.2.1 **Selection of different Consultants:**

There are three Consultants namely Technical Consultant, Legal Consultant and Financial Consultant cum Transaction Advisor essentially required to be appointed by Authority. The model RFP documents for Selection of these Consultants have been formulated by Planning Commission and further modified by MoR.

6.2.2 **Role of technical consultants:**

Technical consultants are normally required for preparing Feasibility Reports(FR), setting performance targets and determining investment needs. They are expected to be well conversant with the physical aspects of the infrastructure sector under consideration. They can provide a range of skills and services including general and architectural design, costing and quantity surveying, planning and traffic studies, technical feasibility studies and reviews, life-cycle costing and analysis, and project monitoring and management. In short, they are instrumental in defining the project. They may also develop Manual of Standard and Specification(MSM). The Technical Consultants mainly comprises of "Team Leader" to lead, co-ordinate and supervise the multi-disciplinary team for preparation of the Feasibility Report with support of other Experts in Bridge, Track, Estimate, Electrical, Signal & Telecommunication, Environment, Traffic etc depending the type of Project.

6.2.3 **Role of Financial Consultant & Transaction Advisor:**

The role of financial consultants is critical since the success of a PPP project depends on its Financial Viability. The financial consultants are, therefore, expected to appraise the project, develop a Revenue model and structure the project on a least cost basis. The financial consultants should also compile and analyse the financial data relating to all costs and revenues, and help in identification and allocation of project risks. An important aspect of good financial advice would be a clear assessment of the financial impact of a project on the government and the users. The important Reports prepared by them are Revenue Model and Appraisal Report. Based on Revenue modelling, the quantum of Viability Gap Funding (VGF) is worked out to ensure specified Rate of return to Concessionaire. Various Financial data so worked out is used for processing PPPAC "in – principal" approval, PPPAC "Final approval, VGF "in – principal" approval and VGF Final principal approval.

6.2.4 **Role of Legal Consultant:**

Based on international best practices, a number of Model Concession Agreements (MCAs) have been evolved for different sectors The process of pre-qualification and selection of bidders has also been standardised through adoption of model documents for a two-stage selection comprising the Request for Qualification (RFQ) and Request for Proposals (RFP). These documents can be adapted with considerable ease for meeting the specific requirements of individual projects. The rights and obligations of all stakeholders including the government, users and the concessionaire flow primarily out of the respective PPP contracts. The role of legal consultants in drafting the bid documents, therefore, assumes critical significance. Where new contracts are to be drafted, the legal consultants would have an extensive role. In cases where standard documents are to be applied, such as the Model RFQ, RFP and MCA, the role of legal consultants could be largely confined to adapting these documents to project-specific requirements. They would also be expected to provide legal counsel in the course of bid process and award, including execution of the agreement and its coming into effect. Legal advice may also be necessary on matters ranging from regulatory review to execution and enforcement of project contracts.

6.3 **Approval of Regulatory Bodies:**

There are mainly two approvals needed for taking up project on PPP involving two stages in each case i.e.

- For approval of project to be taken up on PPP: Public Private Partnership Appraisal Committee (PPPAC) - " in principle" approval and "final approval"
- For approval of Viability Gap Fund (VGF) needed for project to be taken up on PPP:

Appraisal by Empowered Institutions (EI)/ Empowered Committee (EC) - " in principle" approval and "final" approval.

6.3.1 **For approval of PPPAC for project to be taken up on PPP:**

While stepping up public investments in infrastructure, the Government of India has been actively engaged in finding the appropriate policy framework, which gives the private sector adequate confidence to invest in infrastructure projects and simultaneously preserves adequate checks and balances through transparency, competition and regulation. Recognising these requirements, Finance Ministry has issued "Guidelines for Formulation, Appraisal and Approval of Public Private Partnership Projects, 2013"with objective to fast track the appraisal and approval of PPP projects of all sectors. The salient points are

- **Applicability :**

  These guidelines will apply to all PPP projects sponsored by Central Government Ministries or Central Public Sector Undertakings (CPSUs), statutory authorities or other entities under their administrative control.

  The procedure specified herein will apply to all PPP projects with capital costs exceeding Rs. 100 crore

- **Committee Constitution:**

  Appraisal Committee (PPPAC) has been set up comprising of the following:

(a) Secretary, Department of Economic Affairs (in the Chair)

(b) Secretary, Planning Commission

(c) Secretary, Department of Expenditure

(d) Secretary, Department of Legal Affairs and

(e) Secretary of the Department sponsoring a project

The Committee may co-opt experts as necessary

- **'In Principle' Approval of PPPAC:**

  Required before calling of RFQ for selection of Concessionaire,

  While seeking 'in principle' clearance of PPPAC, the Administrative Ministry shall submit its proposal (in six copies, both in hard and soft form) to the PPPAC

  Secretariat in the format specified Memorandum for PPP Appraisal Committee for 'In Principle' Approval,

  The pre-feasibility/feasibility report and a term-sheet containing the salient features of the proposed project to be submitted,

  In cases where the PPP project is based on a duly approved Model Concession Agreement (MCA), 'in principle' clearance by the PPPAC would not be necessary.

  PPPAC will either recommend the proposal for approval of the competent authority (with or without modifications) or request the Administrative Ministry to make necessary changes for further consideration of PPPAC.

  Once cleared by the PPPAC, the project would be put up to the competent authority for final approval. The competent authority for each project will be the same as applicable for projects approval by PIB.

  Following the 'in principle' clearance of PPPAC, the Administrative Ministry may invite expressions of interest in the form of Request for Qualification (RFQ) to be followed by shortlisting of pre-qualified bidders.

- **'Final Approval of PPPAC:**

  Required before calling of RFP/ Financial Bid for selection of Concessionaire,

  the Administrative Ministry shall submit its proposal (in six copies, both in hard and soft form) to the PPPAC Secretariat in the format specified Memorandum for PPP Appraisal Committee for Final Approval

6.3.2 **For approval of Viability Gap Fund (VGF) for project on PPP:**

- " The Scheme and Guidelines for Financial Support to PPPs in Infrastructure, 2013" issued by Ministry of Finance provides financial support in the form of grants, one time or deferred, to infrastructure projects undertaken through PPPs with a view to make them commercially viable.
- The Government of India provides total Viability Gap Funding up to twenty (20) per cent of the total project cost; normally in the form of a capital grant at the stage of project construction.
- The Government or statutory entity that owns the project may, if it so decides, provide additional grants out of its budget up to

further twenty (20) percent of the total project cost.

- The Scheme requires the project authorities to seek 'in-principle' approval of the Empowered Institution/Empowered Committee prior to seeking bids, and obtain the final approval after the selection of the bidder.
- **The Composition of the Empowered Institution is as follows:**

i. Additional Secretary (Economic Affairs)
ii. Additional Secretary (Expenditure)
iii. Representative of Planning Commission (now NITI Aayog) not below the rank of Joint Secretary
iv. Joint Secretary in the line Ministry dealing with the subject
(v) Joint Secretary (FT), DEA -- Member Secretary

Viability Gap Funding(VGF) up to Rs. 100 crore (Rupees one hundred crore) for each project may be sanctioned by the Empowered Institution (EI). Empowered Institution will also consider other proposals and place them before the Empowered Committee.

- The composition of Empowered Committee is as follows:

i. Secretary (Economic Affairs)
ii. Secretary (Planning Commission)(now CEO NITI Aayog)
iii. Secretary (Expenditure)
iv. Secretary of the line Ministry dealing with the subject

The Empowered Committee (EC) is responsible for Sanctioning Viability Gap Funding up to Rs. 200 crore (Rs. Two hundred crore) for each project and amounts exceeding Rs. 200 crore may be sanctioned by the Empowered Committee(EI) with the approval of Finance Minister;

- **Procedure:**

The proposal for seeking clearance of the Empowered Institution shall be sent to the PPP Cell of the Department of Economic Affairs in the format specified "Memorandum for Empowered Institution" along with Certificate Relating to User Charge/Tariff, Certificate relating to Concession Period for the Project and Certificate relating to Total Project Cost. The proposal should include copies of all project agreements (such as Concession Agreement, state support agreement, Substitution Agreement, Escrow Agreement, O&M agreement and shareholders' agreement, as applicable) and the Project Report.

- **Eligibility:**

a. The PPP projects may be posed by the Central Ministries, State Government or Statutory Authorities (like Municipal Authorities and Councils), which own the underlying assets;
b. The PPP projects should be implemented, i.e. developed, financed, constructed, maintained and operated for the Projects term by a Private Sector Company to be selected through a transparent and open competitive bidding process;
c. The criterion for bidding should be the amount of Viability Gap Funding
d. The project should provide a service against payment of pre-determined tariff or user charge;
e. This Scheme will apply only if the contract/concession is awarded in favour of a private sector company in which 51 percent or more of the subscribed and paid up equity is owned and controlled by a private entity.
f. The approval is given prior to invitation of bids and actual disbursement takes place once the private entity has expended his portion of the equity; and
g. The final VGF is determined through the bidding.

- **Eligible Sectors:** The sectors eligible for Viability Gap Funding under Scheme are:

a. Roads and bridges, railways, seaports, airports, inland waterways;
b. Power;
c. Urban transport, water supply, sewerage, solid waste management and other physical infrastructure in urban areas;
d. Infrastructure projects in Special Economic Zones and internal infrastructure in National Investment and Manufacturing Zones;
e. International convention centers and other tourism infrastructure projects;
f. Capital investment in the creation of modern storage capacity including cold chains and

post- harvest storage;

g. Education, health and skill development, without annuity provision;**

h. Oil/Gas/Liquefied Natural Gas (LNG) storage facility (includes city gas distribution network);

i. Oil and Gas pipelines (includes city gas distribution network);

j. Irrigation (dams, channels, embankments, etc);

k. Telecommunication (Fixed Network) (includes optic fibre/ wire/ cable networks which provide broadband /internet);

l. Telecommunication towers;

m. Terminal markets;

n. Common infrastructure in agriculture markets; and

o. Soil testing laboratories.

- **In- Principal Approval:**

  Financial bids shall be invited for award of the project within four months of the approval of the Empowered Institution.

- **Final Approval :**

  Within three months from the date of award, or such extended period as may be permitted, the Lead Financial Institution shall present its appraisal of the project (in six copies, both in hard and soft form) for consideration and Final approval of the Empowered Institution.

  The appraisal shall be accompanied by an updated application in the format specified along with the project report and project agreements.

  The Lead Financial Institution shall verify the contents of the application and convey its recommendation to the Empowered Institution

  Prior to final approval by the Empowered Institution, the Ministry, State Government or statutory authority, as the case may be, proposing the project, shall certify that the bidding process conforms to the provisions of this Scheme and that all the conditions specified in the Scheme have been complied with.

7.0 Selection of bidder:

The bidding process for PPP projects is typically divided into two stages. In the first stage, eligible and prospective bidders are shortlisted through Request for Qualification (RFQ) or Expression of Interest (EoI). The objective is to short-list eligible bidders for stage two of the process. In the second and final stage referred to as the Request for Proposal (RFP) or invitation of financial bids, the bidders engage in a comprehensive scrutiny of the project before submitting their financial offers. .

7.1 Request for Qualification (RFQ):

7.1.1 The RFQ process should aim at short-listing and pre-qualifying applicants who will be asked to submit financial bids in the RFP stage.

7.1.2 The objective is to identify eligible bidders who have the requisite Technical and Financial capacity for undertaking the project. Model document specific the various criteria for adoption of eligible project under different categories of projects, Net worth, and maintenance experience.

7.1.3 The Applicant firm for pre-qualification under RFQ may be a single entity or a group of entities (the "Consortium"), coming together to implement the Project.

7.1.4 The information sought for the purposes of pre-qualification generally be restricted to technical and financial capabilities that are relevant to the project. Such information should be precise and quantified so that the process of short-listing is fair and transparent, and does not expose the government to disputes or controversies.

7.1.5 The credentials of eligible Applicants shall be measured in terms of their Experience Score. The sum total of the Experience Scores for all Eligible Projects shall be the 'Aggregate Experience Score' of a particular Applicant. In case of a Consortium, the Aggregate Experience Score of each of its Members, who have an equity share of at least 26% in such Consortium, shall be summed up for arriving at the combined Aggregate Experience Score of the Consortium.

7.1.6 The Applicants shall then be ranked on the basis of their respective Aggregate Experience Scores and short-listed for submission of Bids(RFP).

7.1.7 The Authority expects to shortlist upto 6 (six) pre-qualified Applicants for participation in the Bid Stage. The Authority, however, reserves the right to increase the number of short-listed pre-qualified Applicants by adding additional Applicant.

7.1.8 The Authority may, in its discretion, maintain a reserve list of pre-qualified Applicants who may be invited to substitute the short-listed Applicants in the event of their withdrawal from the Bidding Process or upon their failure to conform to the conditions specified herein.

7.2 Request for Proposal (RFP):

7.2.1. After pre-qualification and shortlisting of eligible firms through Request for Qualification (RFQ), financial offers from pre-qualified and short-listing of eligible bidders are called through the Request for Proposals (RFP).

7.2.2 During RFP stage the bidder is required to quote only the value for a single bidding parameter for either Grant (to be paid as VGF) or Premium (up- front payment to Authority)

7.2.3 The detailed terms of the project is specified in the Concession Agreement that should form an integral part of the Bidding Documents to be provided to the bidders along with the RFP document.

7.3 **Financial Close:**

After appointment of Concessionaire, Financial Close is to be done in 180 days.

7.4 **Appointment of Independent Engineer (IE):**

For supervision and monitoring of construction and maintenance of project, like PMC Independent Engineer (IE) is appointed in mutual understanding with Authority and Concessionaire. To ensure neutrality, the cost is equally borne by Authority and Concessionaire.

7.5 **Execution and maintenance of Project:**

Execution of works as per the laid down standard and specification and Key Performance Indicator (KPI)

8. PPP Projects in Indian Railways:

Presently two Projects identified as pilot Projects under Annuity Model on Indian Railways being developed by Zonal Railways under guidance of Infra Directorate of Ministry of Railways. The current status of these Projects are as detailed below:

1. 3rd Line between Bhadrak- Byree(67km) part of Bhadrak- Nergundi section of East Cost Railway: RFQ finalised and four bidders shortlisted i.e. M/s IRCON, M/s Oriental Structural Engineers Pvt Ltd, M/s EsselIndifra Project, M/s IL&FS . RFP opened and under finalisation.
2. 3rd Line between LidhauraKhurd-Golapatti(95 km) part of Bina- Katani section of West Central Railway: RFQ under finalisation

9. PPP in Dedicated Freight Corridor Corporation of India Limited. (DFCCIL)

9.1 As a part of Eastern Dedicated Freight Corridor (EDFC), the Dankuni- Sonnagar section (538 Km)is approved by Ministry of Railways ("MoR") to develop through Public Private Partnership ("PPP") basis on Design, Build, Finance, Maintain and Transfer ("DBFMT") model based on Policy guidelines issued by MoR on Participative Models for Rail Connectivity and Capacity Augmentation Projects (2012). Subsequently, Ministry of Railways ("MoR") directed to take up this project in two stages, i.e. Dankuni-Gomoh (282.22 Kms) as Phase-I and Gomoh-Sonnagar (256.58 Kms) as Phase-II.

9.2 Salient features of Dankuni-Gomoh section (282.22 Km), Phase-I are :

S. No	Description	Details
1.	Route Length	**282.22 Kms**
2.	Double/Single Line	Double Line
3.	Construction Period	**4 years**
4.	Concession Period (incl. const. period)	DBFMT Model – 25 years
5.	Construction Cost (including IDC and Financing fee)	**Rs. 7527.22 crores**

The salient features of the proposed Project Development Structure i.e. DBFMT are:

SALIENT FEATURES	DBFMT MODEL
Right of Way (at the time of signing of agreement)	Right of Way for **at least 90% of** the total area required and necessary for the Rail System.
Concession Period	25 years (includes 4 years of Constructions)
Construction	By Concessionaire through its own agency under mandatory certification and supervision from Railways/DFCCIL/Independent Engineer.
Financing\VGF	Responsibility of Concessionaire/ **VGF Grant 12.52%** or **Rs 825.31 Cr** to achieve 14% return
Operation	By DFCCIL.
Fixed Infrastructure Maintenance	The Concessionaire shall be responsible for maintenance of the project
Revenue	1. The Authority shall pay to the Concessionaire a sum equal to 50% of the revenue apportionment from freight operations on the Rail System, determined in accordance with Inter Railway Financial Adjustment Rules, as the User Fee for using the Rail System. 2. During the Concession Period the base tariff shall be escalated at the rate of 3% (three percent) annually. 3. The projected revenue for the 1st year after COD shall be determined and for each subsequent year, the projected revenue shall be deemed to be 6% higher than for the immediately preceding year. 4. 80% of the projected revenue during any year will be guaranteed. 5. In case traffic is in excess of 120% & 150% of the projected revenue, provision of additional revenue share with Concessioning Authority. **6.** Provision for review and change in concession period based on projected revenue at the end of 20th year of concession.

9.2.1 **PPP documentation Position:**

Following documents Dankuni-Gomoh section (282.22 Km), Phase-Ihave been firmed up at DFCCIL and send relevant documents to Railway Board

1. Manual of Specifications and Standards,
2. Traffic Study,
3. Feasibility Report,
4. Revenue Model,
5. PPPAC for in-principle approval,
6. Customization of RFQ and RFP documents,
7. Model Concession Agreement,
8. Memorandum for in-principle approval for VGF
9. EIA and SIA study

9.3 **Gomoh- Sonanagar section (240.74 Km), Phase-II:**

9.3.1 **PPP documentation Position:**

Following documents Dankuni-Gomoh section (282.22 Km), Phase-Ihave been firmed up at DFCCIL and send relevant documents to Railway Board

1. Manual of Specifications and Standards,
2. Traffic Study,
3. Feasibility Report,

9.3.2 **Financial Consultant & Transaction Advisor for Phase-II** have been appointed in Nov 2018 and work on updation of cost is in progress. Based on updated Project cost and Financial Modelling, RFQ, RFP and CA documents will be ready by Dec 2018.

9.4 **The current status of Land Acquisition for both phases is**

Section	Total land requirement	Land under Possession	% Land under Possession	Remarks
Dankuni - Gomoh Ph-I	904.41 Ha	833.35 Ha	92.14	Achieved min of 90%
Gomoh - Sonnagar Ph -II	1119.047 Ha	803.87 Ha	71.84	

9.5 As directed by Board now, Tendering Process of floating of RFQ/RFP will be done for both phases simultaneously.

10. Looking forward:

10.1 DFCCIL has successfully completed Ateli- Phulra(WDFC)on 15.08.18 and Badan- Khurja (EDFC) on 30.11.18 as targetted. All other sections have also been targeted. It is expected that future freight corridors may be taken up on PPP basis by DFCCIL. The experience gained in developing Dankuni-Sonnagar section (538 Km) on PPP basis can be fruitfully applied for such future Freight Corridors.

Reference :

1. *Ministry of Railways' Letter No. 2011/Infra/12/32 dt 10.12.2012 on "Participative Model for Rail – Connectivity and Capacity Augmentation project"*
2. *"Overview of Framework for Participative Model for Rail – Connectivity and Domestic & Foreign Direct Investment, 2014", issued by PPP Cell Infrastructure Directorate, Ministry of railways*
3. *Model document Request for Qualification (RFQ) for Annuity/ BOT Model issued by Ministry of Railways vide letter No. 2015/Infra/12/24 dt. 10.5.18*
4. *Model document Request for Proposal (RFP) for Annuity/ BOT Model issued by Ministry of Railways vide letter No. 2015/Infra/12/24 dt. 10.5.18*
5. *Model document Concession Agreement (CA) for Annuity/ BOT Model issued by Ministry of Railways vide letter No. 2015/Infra/12/24 dt. 10.5.18*
6. *Model document Request for Proposal (RFP) for selection of Technical Consultant issued by Planning Commission.*
7. *Model document Request for Proposal (RFP) for selection of Financial Consultant & Transaction Advisor issued by Planning Commission.*
8. *Model document Request for Proposal (RFP) for selection of Legal Advisor issued by Planning Commission.*
9. *"Guidelines for Formulation, Appraisal and Approval of Public Private Partnership Projects, 2013"issued by Finance Ministry.*
10. *" The Scheme and Guidelines for Financial Support to PPPs in Infrastructure,2013"issued by Ministry of Finance*
11. *" Concession Agreement " between Ministry of Railways & DFCC Feb 2014.*

"MAINSTREAMING THE ENVIRONMENTAL AND SOCIAL SUSTAINABILITY TOOLS & INDICATORS IN DEVELOPMENT OF A NEW FREIGHT RAILWAY CORRIDOR – THE IMPROVED PRAGMATIC APPROACH"

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ABSTRACT:

This paper has focused on those selective environmental and social tools and indicators, which resulted in integration of sustainability concepts in development of a new freight railway corridor, with specific reference to the Western Dedicated Freight Corridor (WDFC). The concise information provided is based on experience gained during integration of environmental and social parameters during different phases of the project, right from the concept stage till construction stage.

The key success strength in the project lies in addressing potential environmental and social impacts on "Continual Improvement Model" and recognizing various factors, risks, challenges and constraints and taking appropriate and timely actions for enhancing sustainability performance of different activities and deliverables associated with the project. These factors were based on – a) "Compliant Level" to comply with laws & regulations; b) "Reactive Level" to reduce negative impacts of the project; c) "Proactive Level" i.e. the area where the project contributes to; and d) "Purpose Level" i.e. where the sustainability considerations are included in the justification of the project.

The key inputs and results of sustainability performance in WDFC are focused on – Environmental Performance; Social Performance; Policy Initiatives & Tools; Human Rights Performance; and Integration of International Standards. Active participation of all stakeholders and community facilitated the consideration of sustainability aspects and provided a framework on how the different variables of sustainability relevant to the project activities are considered in the management and monitoring of environmental and social variables.

DFC project is also following a low carbon path adopting various technological options which can help DFC project to operate in a more energy efficient fashion and at the same time explore options to offset its own GHG emissions by investing in low carbon assets such as solar power, wind power and afforestation.

1.0 INTRODUCTION

The main aim of mainstreaming environmental and social sustainability initiatives in development of a large-sized new freight railway infrastructure project is to avoid, reduce or mitigate any negative impacts, while maximising potential benefits. This paper has focussed on the use of sustainability tools and indicators for assessing, evaluating, and monitoring the impacts of environmental and social issues and making timely decisions for achieving sustainability during project design and execution of the Western Dedicated Freight Corridor (WDFC).

The Dedicated Freight Corridor (DFC) is one of the largest transport infrastructure projects implemented in India, conceived to meet the needs of India's rapid economic growth while inducing further regional economic development. The DFC project signifies a major transition in the freight transport sector by increasing the relative share of rail as an energy efficient, environment friendly and less carbon-intensive mode of transport.

Although railway schemes are not normally subjected to Environmental Impact Assessment (EIA) in India, the involvement of JICA in the Western Dedicated Freight Corridor (WDFC) has itself ensured that the project is subjected to scrutiny regarding its potential environmental and social impacts throughout its development, in compliance with the safeguard policies of the funding agencies. These policies are aimed at avoiding where possible and mitigating where necessary the potential negative environmental and social impacts. Safeguards generally include policies on environmental assessment, involuntary resettlement, indigenous people, gender, wildlife and natural habitats, cultural historical resources, and other important aspects.

2.0 METHODOLOGICAL APPROACHES

2.1 ENVIRONMENTAL FACTORS FOR IMPROVED SUSTAINABILITY PERFORMANCE

The integration of sustainability factors for addressing potential environmental and social impacts in the WDFC project strategized on "Continual Improvement Model" during different phases of the project and resulted in enhanced performance.

This was done by identifying possible gaps; appropriately incorporating additional provisions on account of further developments or recommendations in the project; made use of improved understanding and knowledge based on the results of engineering and technical design; and addressed various issues as well as potential environmental and social impacts by specifying more concrete and practical actions.

The detailed review of the mitigation, management, and monitoring measures identified during ESIA study stage revealed that there were broadly five factors which needed to be considered for integrating additional / revised mitigation, management and monitoring measures so as to enhance environmental and social performance in the project.

These factors were based on "Compliant Level" to comply with laws & regulations; "Reactive Level" to reduce negative impacts of the project; "Proactive Level" i.e. the area where the project contributes to; and "Purpose Level" i.e. where the sustainability considerations are included in the justification of the project.

These five factors were:

[A] Existing or newly recognized Environmental Clearance (EC) / Forest Clearance (FC) Process;

[B] Implications of Enforced Environmental Laws and Regulations and Court Orders;

[C] Site-specific measures for identified Critical Environmentally Sensitive Areas (ESAs);

[D] Elaboration or Extension of measures based on improved practices & more technical & practical approach; and

[E] Results of Reviewed Engineering Design.

After integrating all pertinent additional/revised measures on the basis of above listed factors, the continuous updated mitigation, management and monitoring measures assisted all involved parties (design consultant, contractor, project management consultant, or client) to apply environmental and social measures in each phase of the project (pre-construction/design, construction, operation) in an effective and efficient manner.

2.2 ENVIRONMENTAL AND SOCIAL TOOLS AND INDICATORS

Various potential environmental and social impacts were identified in the WDFC project through series of surveys, field investigations, hiring of subject experts & expert agencies, and use of international

techniques & impacts assessment methodology relevant to the Railway projects. In order to offset any significant impacts, technically and practically feasible Mitigation, Management, and Monitoring Measures were designed and integrated in the design and contractual documents during construction stages, such as:

- Site-specific Safety, Health & Environment (SHE) Policy & Plans including issue-wise supplementary plans before start of work at the Contractor's level;
- Regular meetings with all stakeholders to monitor implementation of environmental and social management in the project; etc.;
- Effective Monitoring & Supervision Control of Contractor's Activities; etc.

The key tools and indicators employed in the project, mainly during construction phase, encompassing sustainability approaches are summarized in Figure-1.

The comprehensive study at the ESIA (as a sustainability tool) and engineering design level consisted of pollution control, natural environment, social impact, public consultation and information dissemination, impact identification and assessment, preparation of mitigation measures, and preparation of Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP).

Mitigation measures were identified for all environmental impacts due to different project activities and its components to curtail adverse impacts including a detailed monitoring plan for safeguarding the environment with a time frame for the monitoring activities. Example of some of these initiatives are summarised below in Box#1:

BOX # 1

[Examples of Initiatives to Mitigate Environmental Impacts]

Potential Impacts	Initiatives on Mitigation Measures
Air Quality	
< Construction Phase >	
Deterioration of air quality due to particulate matter such as dust, especially during dry condition, and gaseous emissions from construction equipment and vehicular traffic	• Storage of construction materials in covered go downs or enclosed spaces. • Coverage of truck carrying soil, sand and stone to avoid spilling. • Adequate dust suppression measures such as regular water sprinkling on unpaved haul roads and vulnerable areas of the construction sites. • Use of low emission construction equipment, vehicles and generator set
Noise and Vibration Levels	
< Construction phase >	
Noise and vibration due to movement of vehicles, and operation of light and heavy construction machineries	• Use of low noise construction equipment. • Construction activities carried out near residential area preferably in daytime. • Provision of protective gears such as ear plugs etc. to construction personnel exposed to high noise levels
Water Quality	
< Construction phase >	
• Wastewater from construction activities with suspended impurities. • Wastewater disposal from the workers camp and sludge generated from construction site.	• Provision of silt fencing near water bodies. • Control of quality of construction wastewater emanating from the construction site through suitable drainage system with sediment traps. • Provision of proper sanitation facilities at the construction site to prevent health related problems due to water contamination
Flora	
< Construction stage >	
• Loss of flora due to felling of trees along the ROW. • Deposition of fugitive dust on pubescent leaves of nearby vegetation	• Appropriate compensatory plantation with about 2 times of the number of trees felled. • Compensation for forest land and trees to be felled in forest area and private land. • Mixed plantation consisting of flowering shrubs and evergreen ornamental trees • Strip plantation in available open spaces on both sides of the railway track. • Provision of cooking fuel to construction workers to avoid cutting/felling of trees for fuel wood

2.3 ENVIRONMENTAL AND SOCIAL RISKS, CHALLENGES AND CONSTRAINTS

The project took adequate steps to overcome two major risks:

- Land acquisition risk: By constructing major part of alignment covering around 3300 km across multiple states in the country along the existing railway tracks of Indian Railways (IR). For the balance requirement, MoR (under powers vested in it through The Railways Amendment Act, 2008) acquired land and gave it on long-term lease to DFCCIL.
- Environmental risk: The loan covenants with bilateral/multilateral agencies required detailed environmental and social impact assessment along with preparation of appropriate rehabilitation and resettlement matrix. The project has timely obtained all relevant clearances and approvals.

The major challenges and constraints are embedded in issues linked to infrastructure development – Direct Impacts and Indirect Impacts

Direct impacts

The nature of infrastructure projects differs widely. Direct impacts depend on type of activity (e.g. railway), applied technology, geographic circumstances (e.g. seismic, flood, weather related risks), type of ecosystem (e.g. wetland or dryland), population density (in relation to impacts by noise, dust, pollution, accident risks, etc.), traffic density (disturbance; wildlife-vehicle collision risk) and more.

In general, linear infrastructure projects usethe concept of 'effect zone', i.e. a zone of a certain width parallel to the entire project, used to quantify potential negative ecological, environmental and social impacts. From a biodiversity perspective important potential direct impacts are habitat loss, fragmentation, disturbance, altered drainage patterns, and erosion/sedimentation. Infrastructure can act as a barrier in wildlife migration corridors.

Indirect impacts

Infrastructure facilitates further developments, with intended (e.g. planned human settlement) or unintended consequences (e.g. illegal settlement, hunting or logging in formerly inaccessible areas, spread of communicable diseases such as HIV AIDS). These impacts are usually more severe and affecting a wider area than the direct infrastructure impacts. Especially linear railway projects can lead to over exploitation of resources, land speculation, human wildlife conflicts, loss of culture, local knowledge and livelihood of indigenous groups.

3.0 KEY INPUTS AND RESULTS FOR SUSTAINABILITY PERFORMANCE

3.1 INTEGRATION OF INTERNATIONAL STANDARDS, GUIDELINES & ISO CERTIFICATIONS

WDFC project integrated implementation of "International Standards, Guidelines & ISO Certifications" in all Contract Packages during construction phase. Every Contractor was contractually obliged to ensure that their works were undertaken in accordance with the applicable international guidelines, standards and specifications on "Safety, Health and Environment" and the Contractors were accredited under the following schemes before commencement of physical works –

ISO 14001-2015: Environmental Management Systems

OHSAS 18001-2007: Occupational Health and Safety Management Systems

Once the certification was obtained at the project level covering all activities specific to a particular contract package, the project was subjected to regular internal / external / surveillance audits and inspection of various activities on the construction sites in accordance with the audit guidance, procedure and management system as per ISO 14001 and OHSAS 18001 on aspects related to safety, labour protection, occupational health & welfare, and environmental management.

These certifications created systematic management system of monitoring, measurement & review of environmental and social performance in the WDFC Project as required by internal and external audits procedure.

3.2 POLICY SUSTAINABILITY INITIATIVES & TOOLS

The project took various proactive initiatives to address environmental and social impacts of different activities through integration of high level of compliance with the national and international environmental laws & regulations at every stage of the WDFC project. Environmental approach was reflected from the initiatives taken with selection of

DFC alignments such that land acquisition, forest land diversion and impact to environment was minimum.

Through careful planning, the WDFC project overcome following intricate issues related to compliance with legislations and statutory requirements:

(1) Complex web of legal requirements in Indian context;

(2) Lengthy processes of permissions and approvals;

(3) Risk of non-compliances leading to unexpected court orders;

(4) Untimely actions leading to time delays in project executions;

(5) Project cost overrun;

(6) Risk of non-compliances affecting reputation of employer and funding agencies.

Though Railway and Bridge construction projects are exempted legally from the national environmental clearance process, yet as a responsible corporate and recognizing ESIA as a "Sustainable Development Tool", a Detailed & Comprehensive Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) studies with data generation in all critical seasons were conducted for WDFC to meet the JICA safeguard policies. The comprehensive set of various laws and regulations applicable to the project are summarized in Box#2 and Box#3.

Box#2: Applicable Acts and Regulations (pre-construction phase)

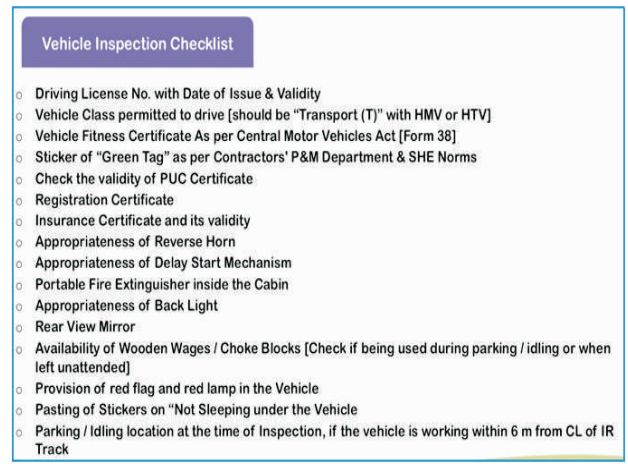
Box#3: Applicable Acts and Regulations (construction phase)

Box#2:

Box#3:

In order to judge the extensiveness of particular laws and regulation as applied to the various activities of the project, the example is presented in Box#4 on the level of monitoring and control parameters for Central Motor Vehicles Act, 1988 and Rules, 1989 applied to the project activities considering the fact that the project deployed large number of construction vehicles and machinery.

EXAMPLE OF VEHICLE INSPECTION CHECKLIST



Key Success Factors:

- Systematic and pragmatic approach to address wide range of environmental and social issues;
- Transparency engagement of different stakeholders to promote participation
- Proper coordination between engineers (design, civil, alignment, etc.) and environmental and social professionals
- Using innovative approaches and maintaining dynamism in the process

3.3 ENVIRONMENTAL SUSTAINABILITY PERFORMANCE

The environmental dimension of sustainability concerns and project's impacts on living and non-living natural systems including ecosystems, land, air and water were addressed through relevant Environmental indicators to cover performance related to inputs (e.g. material, energy, water) and outputs (e.g. emissions, effluents, waste).

Four different components were taken into account for integrating environmental sustainability performance of WDFC activities during pre-construction and construction phases. These were: Water Conservation, Construction Materials and Waste Management, Control of Emissions and Wildlife & Natural Conservation.

3.3.1 **Water Conservation** - Construction of DFC Corridor is a linear project and does not depend on the local water sources for a longer period of time. Abstraction of water is restricted to construction requirement and domestic use of construction workers. Various initiatives implemented at construction sites resulted in prevention or reduction of any wastage of water and included –

- Training & awareness among workers, engineers, etc. on behavior issues regarding usage of water;
- During monsoon, the rain water from rooftop of site huts are collected in tanks and later reused in Dust suppression, landscaping/gardening;
- Developing borrow and quarry areas into pond to recharge local ground water sources; etc.
- Keeping record of water consumption at all work sites;
- Display Posters, Slogans and messages for promoting conservation and prevent wastage of water;
- Recharging through water harvesting methods along the project corridor and adopting rainwater harvesting scheme at level crossings, road under bridges (RUBs) and building areas (station, residential);
- Use of efficient fixtures in toilets and washrooms at sites to reduce the wastage;
- Regular maintenance and repairing of water supply network and waste water carrying pipeline to ensure that there is no leakage or obstruction to flow; etc.

3.3.2 **Construction Materials and Waste Management:** Major construction materials used in the project include concrete, borrow material (earth), quarry material (aggregate, ballast, blanketing), rail supply, sleeper supply, HSD, and others. Key initiatives implemented to conserve resource use and prevent land pollution included –

- Maximum use of locally available materials to reduce transportation impacts;
- Use of fly ash and fly ash-based products in certain structures;
- Every contractor was contractually obliged to prepare, implement, and monitor "Solid Waste, Hazardous Waste, C&D Waste & e-Waste Management" throughout the construction period;
- Recycling & Reuse of waste within the work sites itself;
- Training & awareness among all workers and staff on work sites for reduction in waste generation; etc.

3.3.3 **Control of Emissions (Air, Noise, Vibration):** DFC project is intended to follow a low carbon path adopting various technological options which can help the project to operate in a more energy efficiency manner and at the same time explore options to offset its own GHG emissions by investing in low carbon assets such as solar power, wind power and afforestation.

Key success factors in control of emissions during implementation phase included –

- Regular environmental monitoring for air, water, noise (environmental & occupational), vibration, soil, etc.;
- Regular meetings among all stakeholders to monitor implementation of environmental management;
- Dust control & its effective management on all sites with a variety of measures, such as limiting vehicle speed; covering all trucks/dumpers carrying fine grained loose materials with secured tarpaulins; daily water sprinkling on roads; etc.;
- Noise & Vibration reduction & abatement measures were in-built in project design, locomotive technology, track design, and construction methodology.

3.3.4 **Wildlife & Natural Conservation: Key success factors covered –**

- Annual financial contribution to encourage research for improving measures for Wildlife Conservation in Protected Areas (PA);
- Construction of wildlife passes at strategic locations inside PA;
- Installation of wildlife fencing along corridor for stretch of alignment passing through PA;
- Implementation of pre-afforestation (1:10 ratio) in eco-sensitive areas to increase tree and vegetation cover;
- Mangrove plantation to arrest soil erosion and reduce salinity due to sea ingress;

The project recognized the indigenous rights of Scheduled Tribes and other categories of forest dwellers dependent upon it for their sustenance and livelihood and successfully involved and engaged these local people after obtaining resolution from the village.

3.4 SOCIAL SUSTAINABILITY PERFORMANCE

Some of the major components which resulted in enhanced social sustainability performance in WDFC project included -

3.4.1 **Stake Holders Meetings (SHM) / Public Consultations Meetings (PCM)**

WDFC project undertook public consultation meetings between 2007 and 2012 and set good example of an elaborate consultation mechanism to involve community, project affected persons (PAPs) suggestions in the final freight corridor design.

First Stage SHM/PCM was conducted at state level all along the whole WDFC project area. Second and third Stage PCMs were held at 22 districts level. In addition, village-level meetings were held between the Second and Third Stage SHMs. At the end of social study, a central level stakeholder/public consultation meeting was held to disseminate the results of ESIA and SEA to the stakeholders and public.

Wherever the community raised issues, a team including environmental and social specialists and the Railway design engineers visited the sites to work out alternative designs. The final designs were again discussed with the PAPs, at each of the locations to demonstrate how the community concerns were integrated with the design, reason out how conflicting community concerns have been resolved, and wherever not incorporated, and the associated solutions. The costs of preparing appropriate designs, and mitigating local impacts were offset due to the smooth implementation of the project.

3.4.2 **Base line and Census of WDFC Project for preparation of RRP**

To establish the severity of adverse impact on people, census and socio-economic surveys are the beginning point. The basis for the preparation of the resettlement plan for the project was the identification and quantification of affected persons, the extent and nature of the impacts on them, and their existing socio-economic condition. It indicated the categories of impact to develop entitlements for compensation and assistance packages. Moreover, it formed the baseline to measure effectiveness of resettlement activities. The several socio-economic survey were conducted between 2007 and 2012 for preparation and finalization of RRP.

- Identification of the number of potentially affected structures as PAFs in the parallel sections and the detour sections by the field survey; and conducted the socio-economic questionnaire at 10% of identified PAFs in the field by using the on-site sampling method, process and analyzed the obtained data in 2007;
- Detailed project affected structure survey as well as project affected families to be resettled for land acquisition process in 2008.
- 100% Baseline and Census survey was conducted during 2010 to 2012 covering all along the DFC Corridor.

The project involved high quality of census survey, additional baseline and census survey was conducted wherever alignment design was modified. Identification of squatters and encroaches eligible for assistance was most challenging in this project. R&R policies specify the date of census/surveys as the cut-off for all project affected persons including squatters and encroachers. This was conducted to prevent fraudulent claims by opportunistic encroachers occupying the ROW at a date subsequent to the census.

In this project, Baseline and Census Survey, 30,912 families with 164080 persons were interviewed. This projected wide publicity of the Project throughout the study area.

3.4.3 **Review and Upgradation of RRP Policy for Public Acceptance**

Most resettlement preparation and planning conclude in an implementable Rehabilitation and Resettlement plan (RRP). Background studies cover census and socioeconomic surveys of the people in the impact area, land tenure and its use, and of income restoration programmes. In addition, consultations with stakeholders at various levels were carried out. Analyses and outputs from studies and consultations form the basis for minimizing adverse impacts, finalization of R&R policy, framework for ongoing consultation, site selection for relocation, institutional arrangements, implementation schedule, monitoring arrangements with indicators and budget, which becomes a part of RRP. The following three important concerns that considered course of preparing and upgradation of socially sustainable a realistic RRP.

- Recognizing the adverse impacts of the project and addressing the involuntary displacement and other related adverse social impacts, MOR and DFCCIL had formulated the Resettlement and Rehabilitation Policy including entitlements keeping in view the national laws and international guidelines: The Railways (Amendment) Act, 2008 (RAA 2008), the National Rehabilitation and Resettlement Policy, 2007 (NRRP 2007), and Japan Bank for International Cooperation (Ex-JBIC) Guidelines for Confirmation of Environmental and Social Considerations, April 2002, social acceptability of the Project.
- Further, as per "THE RIGHT TO FAIR COMPENSATION AND TRANSPARENCY IN LAND ACQUISITION, REHABILITATION AND RESETTLEMENT ACT, 2013" under sec 108, DFCCIL prepared the "Entitlement Matrix 2015" for providing adequate R&R benefits affected PAPs.
- DFCCIL conducted the additional Non-titleholder field verification survey in Maharashtra. Appox, 1693 houses were required at different locations in Maharashtra to be provided to the PAPs (TH&NTHs) for R&R compensations under LARR-2013 Act, as per their eligibility based on cut-off date. The issue of R&R was taken care by MOR /DFCCIL/Government of Maharashtra for sustainability of the Project.

3.4.4 **Wide range of Information Disclosure for this Project**

DFCCIL's information disclosure mechanisms of "Environment and Social Impact Assessment Report" & RRP reports of displaying documents in State Administrative level like popular station or offices, including village level panchayat and websites of DCCIL served a great purpose. The dissemination of project documents in the different public forum had been very effective. The PAPs knew their entitlements from their interaction with the NGOs,/ public officer and the wider community found it easily access in different locations. Public sent their grievances and demands to the Project proponent for rectifications of the entitlement matrix for affected persons.

The R & R policies were also translated in the local languages in all the projects and disclosed and distributed among the project-affected persons. To that end, the disclosure of the EIA and SIA & RRP document has been successful and created transparency among the affected PAPs. Project moved successfully in a sustainable manner.

3.4.5 **Grievance Redress Mechanism as a social sustainable tool**

Grievance Committees at the field and Headquarter levels to hear and redress grievances made by PAPs and any other local residents having a stake in the DFC project implementation process was established as per RRP. In addition to the committees, arbitrator for compensation matter as per RAA 2008 and LARR 2013 Act and ombudsman for R&R matter have been appointed to hear and resolve grievances not addressed by the Grievance Committees to the satisfaction of the concerned project affected person/family upon receipt of request from him/her.

The grievances related with land acquisition which have been raised from the PAPs such as requirement of construction of under bridge on the DFC alignment or sharing of land use with other projects are tackled by Deputy General Manager/Public Grievances in DFCCIL. Ombudsman is also on board to look out this matter.

3.5 **ENERGY AND CLIMATE SUSTAINABILITY PERFORMANCE**

The project integrated various options in its design and project implementation to improve energy performance –

- Energy Optimization and Saving in Electric Locomotive Operations for Different Train Mix Type
- Enhanced Utilization of Renewable Energy on both Short-term and Long-term Basis
- Energy Efficient New Technological Options in Traction and Non-Traction
- Energy Conservation Measures for Non-traction Applications
- Energy Efficiency and Conservation Measures in Corporate Office Building

Reduction in specific energy consumption was accomplished through various measures at different construction sites, such as –

- Use of solar PV for street and site security lighting;
- Low-sulphur HSD to run DG sets in emergency situations only on account of power failure;
- Permitting only energy efficient equipment and machineries on construction sites together with their regular "Maintenance Regime";
- Introduction of contractual clauses on "Energy Conservation"; etc.

DFC project is also following a low carbon path adopting various technological options which can help DFC project to operate in a more energy efficient fashion and at the same time explore options to offset its own GHG emissions by investing in low carbon assets such as solar power, wind power and afforestation.

3.6 HUMAN RIGHTS SUSTAINABILITY PERFORMANCE

WDFC project adopted two major policies – "DFCCIL's Work Place Policy on Labour Protection", and "DFCCIL's Work Place Policy on HIV/AIDS Prevention & Control for Workers Engaged by Contractors", to serve as some of the key instruments in assessing and monitoring of human rights performance and impacts.

The project laid enough stress to safeguard and respect human rights and labor standards in its day-to-day operations as well as during implementation of wide range of works contract through a battery of contractors, consultants, suppliers, and service providers. It had continuously strived to integrate relevant national and international laws and practices that relate to human rights and labor standards into DFCCIL's policies, code of conduct, contractual requirements and procedures in order to mainstream the principles in every stakeholder's activities, operations, and deliverables.

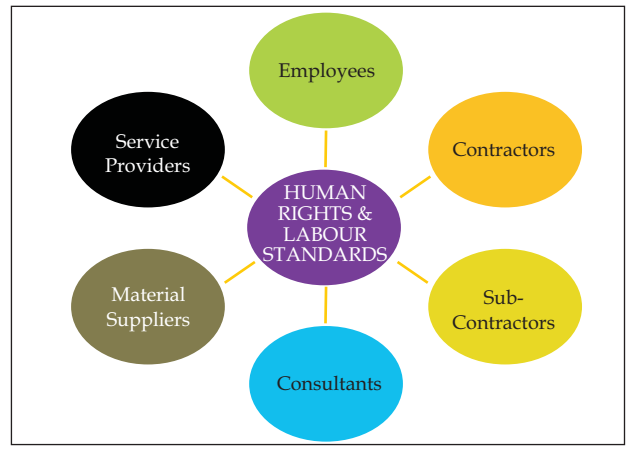
The basic principle emphasized that all employees including the employees of contractors, subcontractors or consultants must live with social and economic dignity and freedom, regardless of nationality, gender, race, economic status or religion. It is committed to the principles of – No child or forced labour in its operations; Discrimination free workplace; Gender Equity; and Supportive work environment.

Major section of workforce comprising of unskilled, semi-skilled, skilled, and highly skilled categories, on various construction sites of DFC alignment were regularly trained and educated on wide variety of human rights aspects, such as HIV/AIDS prevention & control, minimum wages rights, occupational health and personal hygiene, safety management, and other labour related policies and procedures.

In addition to these, technical trainings were also facilitated for professional up gradation of staff and officers of DFCCIL on Organizational & Team Leadership; Brand Communication & Perception Management; Land Acquisition and Resettlement & Rehabilitation Program; Right to Information (RTI) Act, and other critical aspects.

Key Success Factors –

- Strict Monitoring & Supervision of Field Activities;
- A Joint Coordination Committee among all Stakeholders;
- System of Penalties and Incentives;
- Experience sharing among different Projects & Contracts through Interface Meetings;



- Control Systems of Compliance & Enforcement;
- Training & Awareness to all Workers;
- Mix of Self-regulatory & Audit Mechanism; etc.

4.0 SUMMARIZING THE LESSONS LEARNED AND WAY FORWARD

Some learnings extracted from the key performance results due to integration of environmental and social dimensions in a large-sized railway infrastructure development project in different phases of the project life cycle, but with specific reference to construction phase:

- Environmental and social sustainability aspects should ensure the integration of sustainability in project design and execution;
- The management of environmental and social initiatives should benefit the project's objectives and deliverables over the entire project lifecycle, starting from initiation and planning to post-construction review;
- The dynamic approach should be considered in refining environmental and social interventions for better results and enhanced performance; and
- The active involvement of project stakeholders in ensuring integration of environmental and social agenda in the project should be coherent, supportive, and assist in agile decision-making and implementation.
- Innovative and newer approach is instrumental in driving contractors and other project stakeholders towards attaining defined goals and targets for long term environmental benefits and responsibility.

5.0 CONCLUDING REMARKS

This paper reported the learning experience on the integration of environmental and social considerations of sustainability in the project during different phases of development of the Western DFC.

The assessment, evaluation, deliverables, and results of the project reflected to the holistic analysis of the sustainability of the project, regarding the application of tools and indicators in integration of environmental and social factors. This formed an essential step in the environmental performance of the project.

Assessing the ground realities and key factors strengthened the integration of improved understanding and learning in environmental and social sustainability aspects in all major phases of the project life cycle.

Revisiting the identified mitigation, management and monitoring measures all along the project life cycle in relation to the various activities associated with development of a new freight railway corridor is a key for strategic approach on sustainability issues.

Leveraging Procurement for Delivering Sustainable Infrastructure

Sanjay Kumar
GM/LA/DFCCIL

1. Infrastructure as a driver of economy

The role of infrastructure in facilitating primary, secondary and tertiary economic activities in a country has been well documented. It is also an admitted fact that the level of economic development in a country can be directly linked to the development of infrastructures such as port, highway, railways, airport, real estate, internet-highway etc. It is indispensable for development and poverty elimination, as it enhances access to basic services, education and work opportunities, and plays a vital role in boosting human capital and quality of life. The Federal-Aid Highway Act of 1956 in the USA mandated the construction of a 41,000-mile network of interstate highways spanning the length and breadth of the country. Many consider it an engine that brought unprecedented prosperity and positioned the United States to remain the world's pre-eminent power into the 21st century. About 50 years later in 2001, India launched the Golden Quadrilateral Highway Project that revolutionised transportation sector in India and contributed to India's economic growth. The same is true for many other countries.

The critical role of infrastructure has been reiterated by the global community when the United Nations Summit in September 2015 adopted the Sustainable Development Goals (SDGs). These are universal goals that call for action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. SDG 9 encourages the development of quality, reliable, sustainable and resilient infrastructure to support economic development and human well-being, with a focus on affordable and equitable access for all. Further, Infrastructure is not only one of the SDGs but has direct impacts on the achievement of other SDGs such as Clean Water & Sanitation (SDG 6), Affordable and Clean Energy (SDG 7), Decent Work and Economic Growth (SDG 8) and Sustainable Cities & Communities (SDG 11). Further, it has indirect impacts on other SDGs too. Therefore meeting SDG 9 would be critical for meeting all SDGs by 2030 so that no one is left behind. This would naturally mean a huge investment in infrastructure both in the industrialised and non-industrialised world. As per UNCTAD, developing countries alone would need investment to the tune of $ 1.6-2.5 trillion annually between 2015-2030.

2. Why Sustainable Infrastructure?

Infrastructure is the fixed, long-lived structures typically having a lifespan between 20-100 years. The International Federation of Consulting

Engineers (FIDIC) in its report titled 'State of the World: FIDIC Infrastructure Report' has flagged many challenges such as economic crises, urbanisation, non-renewable resource depletion, water scarcity, climate change, waste management and increasingly complex disasters, which threaten the resilience of critical infrastructure and service. The world has fresh memories of what happened to critical infrastructure such as railways, metro, highway, airport, water supply etc. during the recent flood in Kerala, India in August 2018. All infrastructure crumbled when the people needed them the most. This raises the question what kind of infrastructure does the world need?

Of course, the world needs more infrastructure, particularly in developing countries. But investing in conventional infrastructure would put these countries in a great danger of locking in the capital, technology, and patterns of economic activity that will last for decades and become progressively unsustainable. Further, it would not help us achieve the economic, social and environmental objectives embodied by the Paris Agreement and the Sustainable Development Goals (SGDs). Therefore, the need of the hour is not just any infrastructure but infrastructure that is sustainable, low-carbon and climate resilient. Arranging fund for infrastructure development in developing countries is going to be a big challenge but the bigger challenge would be to make these infrastructures sustainable and climate resilient in view of climate change and diminishing natural resources.

Building a new infrastructure comes at significant environmental risks such as deforestation, loss of habitat, water pollution, GHG emission, soil erosion, displacement of people etc. The existing stock of infrastructure and its use accounts for more than 60 percent of the world's greenhouse gas (GHG) emissions. Buildings and construction together account for 36% of global final energy use. The fact that majority of the infrastructure in developing countries that would be required to meet the societal need and well being of the people by 2050 is yet to be built, imagine the resources that would be required to construct those infrastructures. This brings us to the question how do we design, plan and build infrastructure that consumes fewer resources, less energy, less water, produce less waste and at the same time supports the conservation and sustainable use of natural resources, and contributes to enhanced livelihoods and social well-beingduring construction and use phase? Investment in sustainable infrastructure would augment and improve the efficiency of energy, mobility, and logistics and thereby boost the productivity and competitiveness of all sectors, spur economic growth and unlock waves of innovation and creativity.

Closing the infrastructure gap in these countries would naturally need spending more on roads, power plants, and water Sewage systems etc. but more importantly it would mean spending differently and transforming the way infrastructure is planned, developed and operated. Infrastructure that is built now will determine our climate future. It is estimated that globally, 35–60% of the future carbon budget will be taken up by infrastructure (The New Climate Economy, 2016). The impacts of climate change are growing concerns, reducing the predictability of future infrastructure needs as well as increasing the vulnerability of assets. Therefore, delivering sustainable infrastructure is complex given climate change, environmental concerns, and social challenges. But at the same time, the scale of new investment that must be made offers a unique opportunity for developing countries, including India, to accelerate the transitions towards low-carbon, climate resilient and sustainable economy.

3. Procurement as a strategic tool

The belief that conducting environmental and social impact assessments for infrastructure projects would lead to the sustainable outcome has not yielded any significant results. It has merely become a part of the licensing and construction permit requirements for undertaking infrastructure projects. Therefore, the focus shall move away from conducting environmental and social impact assessments to integrating sustainability concerns across the entire project lifecycle. Notably, addressing some sustainability aspects upstream could be much more cost effective than trying to address sustainability when projects are designed or in operation .That is the reason the procurement phase of the infrastructure cycle presents perhaps the most critical opportunity to deploy sustainable infrastructure . The rationale for leveraging procurement phase as a tool is based on a couple of important learnings. Firstly, in developing and emerging economies, about 60–65% of the cost of infrastructure projects is financed by public

resources, while in advanced economies this figure is around 40% . Secondly, it is the stage at which governments, the originators of the project, go to a market and issue public tenders in an effort to seek out bidders that offer the best for value for money (VfM). Thirdly, procurement acts as a gatekeeper and choices exercised at this stage of procurement on the kind of products and services that would go into the construction of infrastructure has a significant bearing on overall impact on environment and well being of people. By demanding greener products, works and services, the government can minimize (if not eliminate) negative impacts of infrastructure during its construction, operation and use on the environment and society.

However, the conventional method of achieving Value for Money (VfM) in public procurement by awarding a contract to the lowest price bidder has been criticised in recent time and found unsuited to deliver sustainability goals. VfMis typically defined as "what a government judges to be an optimal combination of quantity, quality, features and cost, expected over the whole of the project's lifetime" . The infrastructure sector is highly competitive and contractors win bids by lowering their costs. Thus the winning tenderer may not have the incentive to provide an infrastructure that uses fewer resources, consume less energy and water, generate less waste etc. Besides, it may well be the one which pays the lowest wages, does not provide adequate health and safety benefits to labourers, employs shortcut procedure to bypass environmental regulations and provide/use technology that is inherently unsustainable.

The traditional method to achieve VfM has some glaring shortcomings, which are coming in the way of delivering larger objectives of the government. Firstly, it does not consider even all economic costs over the entire life cycle of the project when arriving at the lowest price. For example, capital equipment that is used in infrastructure projects during construction and use, the cost of operations, maintenance and disposal of the equipment over its life cycle may far outweigh the initial procurement cost over the life cycle of the equipment. Hence value for money becomes an important consideration – which can be addressed in public procurement by way of appropriate Description, Specification, Contract conditions like inclusion of cost of supply of initial essential spares and total present value of Annual Maintenance Contracts (AMC) for specified number of years within the estimated cost and also the evaluation criteria of procurement contract. Secondly, it does not capture the negative externalities caused during execution, operation, use and dismantling of the infrastructure on environment and society. Therefore, the VfM as a concept has to be broadened to include social and environmental externalities or factors such as employment creation, support for vulnerable groups, or local content etc. to better utilise tax payers' money and achieve wider sustainability objectives of the government. The concern on this issue has been brewing globally and now the consensus has emerged on broadening VfM conceptamong stakeholders with question remaining how we integrate sustainability concerns in procurement decision.

The World Bank in its latest review of the procurement system in 2016 has introduced VfM as a core principle in all procurements financed by them. This essentially means a shift in focus from the lowest evaluated compliant bid to bids that provide the best overall value for money, taking into account quality, cost, and social and environmental risks as needed. The Bank,in fact, found VfM concept so transformational for delivery of developmental outcome that they released a separate guideline on "Achieving VfM in Investment Projects Financed by the World Bank by the World Bank"in July 2016. In this guideline, the Bank defines VfM as the effective, efficient, and economic use of resources, which requires the evaluation of relevant costs and benefits, along with an assessment of risks, and of non-price attributes and/or life cycle costs, as appropriate. Price alone may not necessarily represent VfM. The General Financial Rule 2017 also states that purchases should be made in a transparent, competitive and fair manner, to secure the best value for money. It further definesVfM in the Manual for Procurement of Goods 2017 as "VfM means the effective, efficient, and economic use of resources, which may involve the evaluation of relevant costs and benefits, along with an assessment of risks, non-price attributes (e.g. in goods and/or services that contain recyclable content, are recyclable, minimise waste and greenhouse gas emissions, conserve energy and water and minimize habitat destruction and

environmental degradation, are nontoxic etc.) and/or life cycle costs, as appropriate". This is in line with the Most Economically Advantageous Tender (MEAT) method of assessment, introduced by the European Parliament in January 2014, that is used as the selection procedure for publicly-procured contracts, allowing the contracting party to award the contract based on aspects of the tender submission other than just price.

The procurement process that takes into account social, environmental and public health concerns in procurement decision apart from economic parameters like quality, price, delivery period etc. is called sustainable procurement. As per UN Environment, Sustainable public procurement (SPP) is a "process whereby public organizations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life-cycle basis in terms of generating benefits not only to the organization, but also to society and the economy, whilst significantly reducing negative impacts on the environment". Depending on region and country, SPP is also known as green purchasing, environmentally preferable purchasing, or socially responsible procurement, green government procurement etc. It is now widely recognized as a strategic lever to drive innovation and improve the sustainability performance of both public and private sector organizations across the globe. As per UN Report 2017, 41 countries have reported having SPP commitments and provisions in either a sustainable or 'green' procurement policy or in other organizational policies, e.g. general procurement regulations or environmental policies. This policy could equally be used for procuring sustainable infrastructure.

However, delivering sustainable infrastructure is not that easy considering the complexity of the infrastructure projects. Infrastructure when viewed from the perspective of different disciplines—engineering, finance, economics, development, climate, social, and environmental—looks very different; some of these differences are so pronounced that they often create disagreement if not diverging approaches . Many times, the decision would boil down to making a trade-off among competing priorities. Therefore, developing a common framework to operationalize infrastructure sustainability, the definition and principles should be translated into practical and measurable criteria depending on the national context of a country. It would further clarify end goals and give a valuable basis for analysis to identify key actions, including roles and responsibilities, at different stages across the whole project life cycle. Many governments and organisations have successfully addressed numerous challenges like legal framework, availability of greener products in market, training &capacity building of stakeholders, methodology to integrate sustainability criteria into a standard tender document, verification of sustainability claims made by contractors etc. coming in the way of delivering sustainable infrastructure employing procurement as a tool.

4. Case Study: London Olympic 2012

Olympic Delivery Authority (ODA) was given the mandate for construction of main venues and infrastructure for the London 2012 Olympic and Paralympic Games. The London bid team created an aspirational vision called "Towards a One Planet Olympics" to deliver a sustainable legacy. It addressed environment with objectives on GHG emission, water and waste; social issues like noise, communities, transport and mobility; and economic factors like employment and business. The mission of the ODA was to deliver venues, facilities and infrastructure and transport on time and in a way that maximises the delivery of a sustainable legacy within the available budget. The ODA's Procurement Policy stated that "the ODA would seek to use its purchasing power to support sustainable development in London and the UK and ……., and would aim to ensure that sustainability is integrated into business cases, procurement plans and related contracts". The construction of the Olympic Park and Athletes village was largely publicly funded and cost approx. £9.3bn.

ODA estimated requirement of 500,000 cubic-meter of ready-mixed concrete and an equivalent aggregate requirement of 1 million tonnes and identified them as the area of major spend. Also, concrete has a high environmental impact and therefore improving the sustainability of the concrete was a key focus for the ODA. The procurement was done on a "Two Envelop" system with 60% and 40% weight for quality and price respectively. Further, in total 20% of the weighting of the technical assessment in the tender evaluation

was applied to meeting sustainability requirements. Bidders were encouraged to identify opportunities to deliver innovative solutions. The tenderers were specifically asked to ensure that they either met or exceeded the following targets:

- Ensure that as a minimum, construction materials (by value) comprise at least 20 % recycled content;
- Ensure that 25 % of aggregate used will be recycled;
- Transport 50 % of materials (by weight) to site by sustainable means i.e. water or rail; and
- Use energy-efficient, low emissions vehicles on-site

With these sustainability criteria, a framework contract for ready-mixed concrete was awarded to M/s Aggregate Industries UK Ltd, a member of the Holcim Group. The contractor used materials such as China Clay Waste – Cornish Granite, Glass Sand, Ground Granulated Blast Furnace Slag (GGBS), Pulverised Fuel Ash (PFA) etc. to replace primary aggregate/cement to meet the sustainability criteria. Some of the recycled alternative used were recycled crushed concrete, spent rail ballast, glass sand and road planings. Over 90% of the total aggregate volume was delivered to the Olympic Park by rail. The strategy resulted in the use of approximately 170,000 tonnes (almost 22 %) of recycled and secondary aggregate, a saving of approximately 30,000 tonnes (24 %) of embodied carbon and elimination of over 70,000 road vehicle movements .

A number of new, more sustainable products and processes were developed by the supply chain and implemented on the Park. Two of the most important lessons from the Learning Legacy are that many environmental sustainability benefits go hand in hand with cost savings and that with the right approach to projects of this scale it is possible to drive innovation in areas such as design and materials specification .Thanks to this commitment, the London Games raised the bar and set new standards for sustainability in many areas by saving 400,000 tonnes CO2 equivalent, achieving 'zero waste' to landfill target, using 100% sustainability sourced timber etc. and most of all inspiring sustainable living in many Londoners. It was one of the projects that demonstrated that embedding sustainability criteria in purchasing decision early on in the project cycle could be the smartest way to drive a market for adopting innovative solutions and deliver sustainable infrastructure.This was also one of the first projects in which sustainable procurement as a policy to deliver sustainability outcome in infrastructure was tested on the ground. The success story of ODA in delivering sustainable project has been documented in "The Legacy: Sustainable Procurement for Construction Projects" by the Department for Environment, Food & Rural Affairs, Government of United Kingdom .

5. Conclusion

The investment in infrastructure is widely recognised as a critical factor for achieving Sustainable Development Goals by 2030. However, it is clear that the need of the hour is not just infrastructure but low carbon, climate resistant and sustainable infrastructure. Many organisations have already used procurement as a tool to deliver sustainable infrastructure. London Olympics' ODA is one the success stories. It clearly demonstrated that it is possible to deliver sustainable outcome within the given budget provided sustainability is built into the process since the very inception of the project. The example also highlights the importance of leadership in embedding sustainability into the supply chain. Understanding the impacts of purchasing products, works and services on the environment and society besides economic impacts on the organisation and taking responsibility for these impacts are fundamental for ensuring shift towards sustainable infrastructure.

Bhiwandi pipeline bridge - Soldier pile box construction for protection of Railway Bank

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ABSTRACT:
The author through this paper intend to highlight the challenges faced and how by meticulous planning, design and construction techniques of temporary work could surmount the difficult site conditions and ensure smooth construction of foundations for the major Bhiwandi pipeline bridge parallel to the existing Mumbai sub-urban tracks. The protection work involved the construction of soldier pile box supported with walers and struts at different levels up to the soft rock level. The design of this soldier pile box was done considering the Railway loads. The continuous monitoring of the settlement of both the soldier pile box and the Railway structures was ensured. The arrangements adopted ensured minimal disruptions to Railway traffic and avoided imposition of crippling speed restrictions during the construction work. Thus, by meticulous planning, design and additional safety measures for the temporary protection work, the treacherous stretch of Mumbai sub-urban could be tackled for the construction of foundations of the Bhiwandi bridges.

1 INTRODUCTION

The stretch under Mumbai(S) unit is around 102 km in the state of Maharashtra and runs parallel and close to the densely worked suburban tracks of Mumbai. In this stretch, a few Open Web Steel Girder (OWG) bridges (spans varying from 150 feet to 400 feet) have been planned running across rivers, running lines and pipelines. The substructures of these bridges had to be planned in such a way that there is least disturbance to the running traffic, the surrounding buildings and the nearby utilities. The necessary temporary works like sheet piling or soldier piling etc have been adopted as per the requirement of the site. The main aim was to adopt the methodology which creates least disturbance to the running lines not only during the execution of the temporary work but also during the execution of the foundation works. This paper deals specifically with the adoption of soldier pile protection method for deep excavation near running lines for Bhiwandi pipeline bridge.

2 GENERAL DESCRIPTION

2.1 Bridges

There are five major and important bridges in Maharashtra section which fall parallel to the densely worked sub-urban tracks of Mumbai. These are as follows: -

Table 1. Description of Bridges

Bridge Name/ Number	Span Arrangement (Overall) (m)
Kopar flyover RFO-06	1 ×79.98 + 1 × 28
Ulhas Br. 122	6 × 79.98
Bhiwandi Br. 126	1 × 64.15 + 1 × 48.5
Kamwadi Br. 135	3 × 48.5
Kalamboli Flyover	1 × 108 + 1 × 85, 1 × 103 + 1 × 75

2.2 Background

These bridges form part of the proposed new WDFC track running parallel to the Jawaharlal Nehru port-Panvel-Kopar-Juichandra-Vaitarna section of Central Railway. The availability of land in this stretch is very less. Hence the proposed tracks have been kept close to the existing tracks. The foundations of these structures require excavations of Railway banks for depths varying from 8m to 12m at a distance of around 8 to 9m from the nearest Railway track centre. Any excavation so close to the Railway track is to be done with properly designed temporary structure. Suitable system which shall ensure safety not only to the existing Railway bank, abutments, OHE mast etc but also nearby structures was required.

3 CHALLENGES FACED

The various challenges faced and the factors taken into account for the design of the appropriate system for temporary protection of Railway bankat Bhiwandi bridge are as follows:-

a) The method should be sturdy enough to bear the lateral earth pressure combined with the superimposed dead and Railway live loads without causing any tilt.

b) The execution of the system should be fast.

c) The system should have the requirement for minimum traffic block or speed restrictions during its execution

d) The system should have no requirement for speed restriction during execution of excavation and construction of foundation works for bridges.

e) The rock existed at a shallow depth below ground level.

4 SOLDIER PILE BOX ARRANGMENT

4.1 Layout of the soldier pile box

Taking into considerations the various challenges outlined in para 3 above, the method of protection for the Railway bank was selected as the steel (I-section) soldier piles with provision of strut and waler arrangement at pre designed levels all around to form a box like structure. The gap between the steel soldier piles was filled with wooden battens (called laggings). These were further strengthened by steel cross angles. The arrangement of the soldier pile box is as shown in Figure 1.

Figure 1: Soldier pile box arrangement

4.2 Construction of soldier pile box

The step by step procedure for the construction of soldier pile box arrangement is as follows:-

a) Hard fencing sheets shall be provided at a distance of 3.5m from the nearest Railway track and of height around 1.2m above formation level of railway track for safety.

b) Before commencing the piling activity, the ground shall be levelled adequately for allowing safe movement of crane with proper compaction.

c) Carry out survey and mark piling points for sol-dier piles with iron pegs to set out the position of the soldier pile wall.

d) Two level guide frame along with anchor beam shall be placed on the levelled surface at the re-quired position (Figure 2).

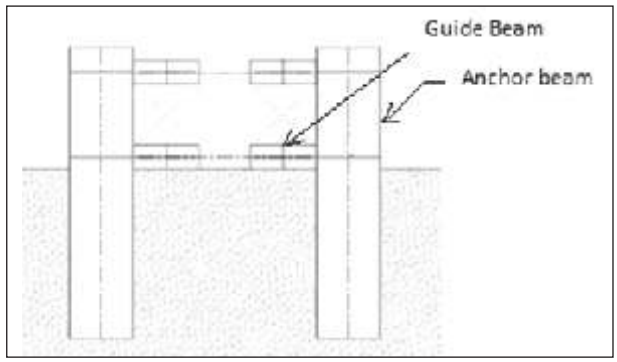

Figure 2: Two level guide frame with anchor beam

Figure 3: Driving of soldier pile with vibro hammer

e) Now drive structural steel section using vibro-hammer, till it reaches the required level in rock in accordance with the approved drawings, leav-ing about 1m length of the structural section protruding from the ground (Figure-3).

f) Structural steel sections are to be provided at a spacing of0.5m c/c, as per additional safety margin,on the side parallel to track and at 1.0m c/c on the other three sides, as per the design (Figure 4a).

g) Above steps shall be repeated till the entire length of the soldier pile wall construction is completed.

h) After entire length of the soldier pile wall is constructed excavation shall be done in layer of 0.5m and after every 0.5m excavation suitable design lagging (wooden) shall be placed. This will be ensured by manual excavation for the width of 1.5m from the inner face of soldier pile.

i) Excavation between the soldier piles shall be done to a minimum of 125mm so that laggings shall be easily placed (Figure 4b).

j) Level 1 strut and waler shall be placed in accordance with the approved drawings (supported on steel brackets and welded to the soldier piles) as shown in Figure 5.

k) Excavation shall continue till 0.5m below level 2 strut and waler, as shown in Figure 6, and lag-gings shall be placed.

l) Level 2 strut and waler shall be placed in accordance with the approved drawings as shown in Figure 7.

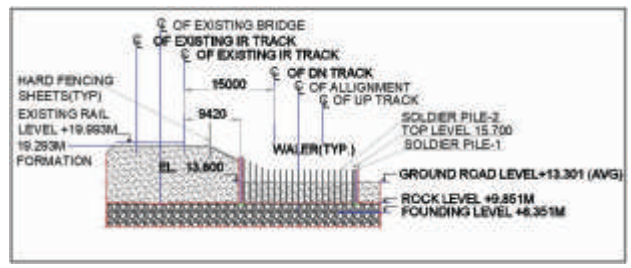

Figure 4a: Driven structural steel I-sections

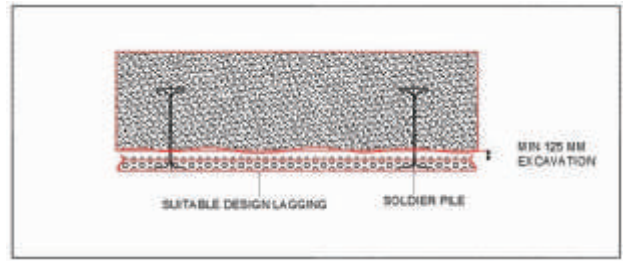

Figure 4b: Structural steel section with laggings

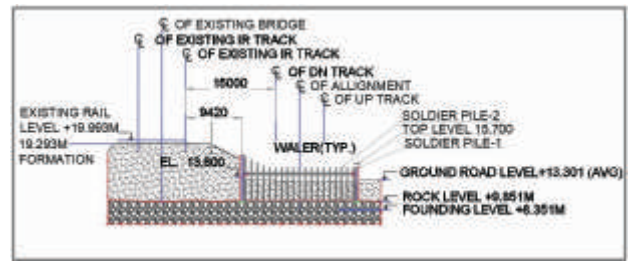

Figure 5: Placement of level 1 strut and waler

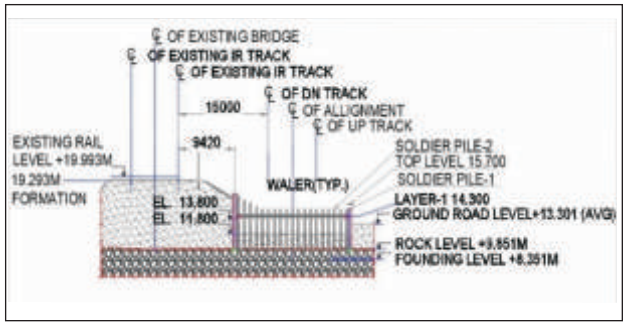

Figure 6: Excavation till level 2 strut and waler

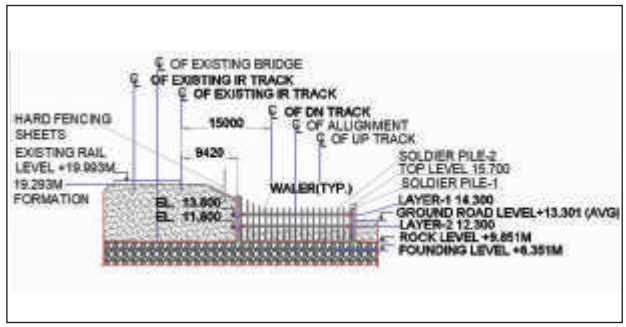

Figure 7: Placement of level 2 strut and waler

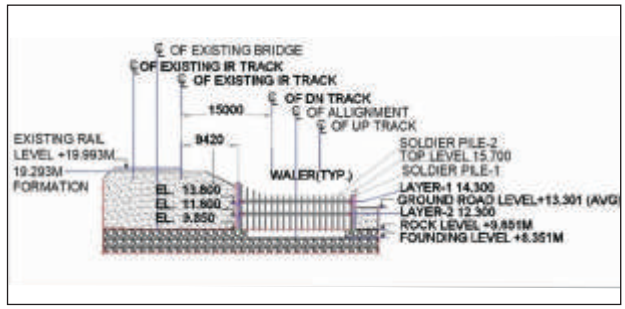

Figure 8: Excavation up to the bottom of foundation

m) Excavation shall continue till founding level along with forming a berm below bedrock level as shown in Figure 8 and laggings shall be placed till bedrock level.

n) Steel angle cross bracings may be provided across the soldier piles, as an additional safety measure for supporting the wooden laggings.

The soldier pile box thus formed is shown in Figure1.

The soldier pile box is thus placed on the top of the rock, with little embedment. After the complete construction of the soldier pile box up to the soft rock level, the excavations for the foundation was done through the rock up to the required depth by rock breakers and excavators, keeping an offset of around 1m from the inside face of the soldier piles. This offset is required for the stability of soldier piles, as small or no offset may cause the soldier piles to subside and fail. Thus the size of the box should be kept around 2m more than the required excavation size in case the foundation is to be taken inside the rock.

5 REMOVAL OF SOLDIER PILE BOX

The casting of the foundation and abutment is done after the excavation is completed. The concrete surface in contact with the earth is painted with bitumen and then the backfilling is done with the suitable material. As the backfilling reaches the level 2 strut and waler, the same is removed. This process continues till the ground level is reached, after which the soldier piles are driven out by means of vibro hammer.

6 SAFETY MEASURES DURING EXCAVATION

In order to ensure safety of the Railway banks, bridge abutments and other structures like OHE masts, adjoining buildings etc, following measures were taken-

a) Targets were fixed on each of these structures (Figure 9a,9b& 9c) as well on the soldier piles on all the four faces. The readings of these targets (Figure 10) were taken at every three hours with total station.

It is extremely satisfying to state that that no set-tlements were observed during the entire period of construction.

Figure 9a: Target on existing bridge pier

Figure 9b: Target on existing Bhiwandi bridge abutment

Figure 9c. Target on OHE mast near Bhiwandi bridge

Figure 9b: Target on existing Bhiwandi bridge abutment

b) Sand bags were placed on the Railway bank slopes to cater for any settlement of the bank.

c) During the progress of the work, it was observed that the projection of the soldier pile on Railway bank side was slightly more than the calculated one. Hence a third layer of waler was introduced (above the level 1 waler on the Railway bank side) as seen in Figure 1.

5 CONCLUSIONS

The bridge was constructed without any hassle, with the adoption of the temporary protection measure described above. The following conclusions may be drawn from the temporary protection method adopted for solving the challenge of retaining the Railway bank, during the construction of Bhiwandi bridge foundations for the heavy haul system along Mumbai sub-urban tracks:-

a) Properly designed temporary work avoids any type of impact on nearby structures and running lines (including speed restriction)and helps in building confidence among the utility owners, which ensures smooth progress of the work.

b) The method is fast and can be adopted in all types of soils.

c) The adoption of the monitoring mechanism of targets on structures ensures timely detection of any settlements and the consequent remedial ac-tion.

6 RECOMMENDATIONS

Based on the experience gained from the challenges faced during the construction of soldier pile box for the protection of Railway bank, following recom-

mendations can be made for the design and construction of the temporary works:-

a) The type of the temporary protection measure chosen should be based not only on the type of the soil conditions but also on the nearby utilities and structures to be protected.

b) Temporary works need to be designed with same degree of sincerity as the main structure.

c) Monitoring of the settlement of surrounding structures need to carried out with high accuracy instrument like total station and necessary recti-fication should be done timely.

d) Additional safety measures like provision of cross angles for lateral support of laggings, reducing the spacing of the soldier piles on the Railway side than calculated, fixing of targets on the soldier piles, using good quality wood for laggings with sufficient thickness (100 mm in this case), additional waler on Railway side etc as per site requirement should be adopted. This ensures practically NIL settlement, thereby helps in building confidence regarding safety in the minds of the utility owners for the DFCCIL works.

7 ACKNOWLEDGMENTS

The author is thankful to the various utility owners like Railways, MCGMetc who understood the importance of the project and who had full faith in the design and construction methods adopted by the freight corridor. Besides, the authors are thankful to the designers of the Larson & Toubro and Project Management Consultancy firm OCGC who provided their inputs and helped to work out the optimal solution to the design and layout of the protection method.

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Technical Paper on Challenges Faced to Obtain NOC/Clearance from Inland Waterways Authority of India for Narmada River Bridge of Western Corridor

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Synopsis:

The Western Corridor alignment is traversing through Baruch district of Gujarat State, where the alignment crosses the Narmada River. As per memorandum issued by Inland Waterways Authority of India (IWAI), Narmada River has been designated as one of the three National Waterways. This paper discusses in detail various steps of seeking the clearance from IWAI.

1. Introduction

1.1. The Western Dedicated Freight Corridor (herein after called as WDFC) alignment is traversing through Bharuch district of Gujarat State, where the alignment crosses the Narmada River (one of the important river of India). An Important longest River Bridge of Western Dedicated Freight Corridor was proposed at this location based on Topography Survey and Hydraulic calculations. A model study was carried out Irrigation Research Institute, Roorkee in Feb-2008 to decide the Span configurations, effect of Hydrology on Bridge structure, river Bed, subsoil, existing embankments and also to decide the protection arrangements,

1.2. As per IWAI Office Memorandum WAI/PL-NW3/9/98-Vol-I dated 27.08.2007, there were only 03 National Waterways which are as under :

SN	National Water Ways	Stretch		Class
		From	To	
1(a)	NW-1 (Ganga)	Sagar	Patna	VII
1(b)		Patna	Allahabad	VI
2(a)	NW-2 (Brahmaputra)	Bangladesh Border	Dibrugarh	VII
2(b)		Dibrugarh	Sadiya	VI
3(a)	NW-3 (West Coast Canal)	Kottapuram	Kollam	IV
3(b)	NW-3 (Udhyogmandal Canal)	Kochi	Pathalam	IV
3(c)	NW-3 (Champakkara Canal)	Kochi	Ambalamughal	IV

1.3. Model study of the Narmada River Bridge for DFCCIL project, was carried out by RITES, in Feb 2008. Based on the Model study Report, an Important Bridge having span configuration of 29 x 48.15m with super structure as Under Slung Steel Girder with RCC Deck Slab was proposed over Narmada River on WDFC Alignment between Sarfuddin & Kukarwada villages of Bharuch District(proposed longitudinal section is as shown in Fig. 01).

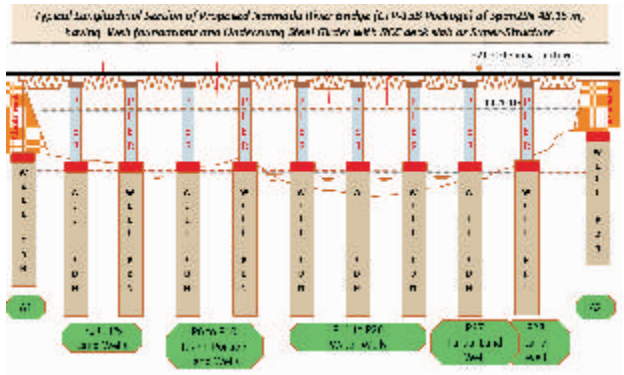

Figure 01

1.4. The said bridge is located approx. 37Km upstream of sea mouth and 8 Km downstream of the existing Railway Bridge (Silver Bridge) near Bharuch railway station. The span configurations was decided based on design discharge of 72,452 cusec with HFL of 13.26m for 100 years of return Period.

1.5. Vide letter no DFCCIL/BRC/Pkg 15B/15-16/IWAI-01 dated 24.07.2015, Vadodara unit of DFCCIL requested the Inland Water Way Authority (IWAI) for navigational clearance for construction of bridge. But nothing was heard from the IWAI.

1.6. The tender for construction of the proposed Narmada bridge under tender package of CTP-15B was invited in Feb-2014 and work was awarded to the M/S IIS-L&T consortium under Design and Build Lump Sum Contract at a contract Price of INR 283.05 Cr.& JPY 79.79 Cr. with equivalent INR 330.71 cr vide letter of acceptance no 2013/HQ/EN/PWC/PQ.15-A,15-B & 15-C dated 03.06.2015and Contract Agreement No HQ/EN/PWC/Phase-II/Pkg.-15B/D&B/6/IIS-L&Tdated 06.08.20154 was signed.The work was commenced on 15.10.2015.

1.7. Based on the survey in March 2016, cross-section was plotted. From this cross section, it is seen that the water stream flows between span P12 to P26 but the depth of water and velocity of current is more in between Span P13 to P19. (please see fig. 02)

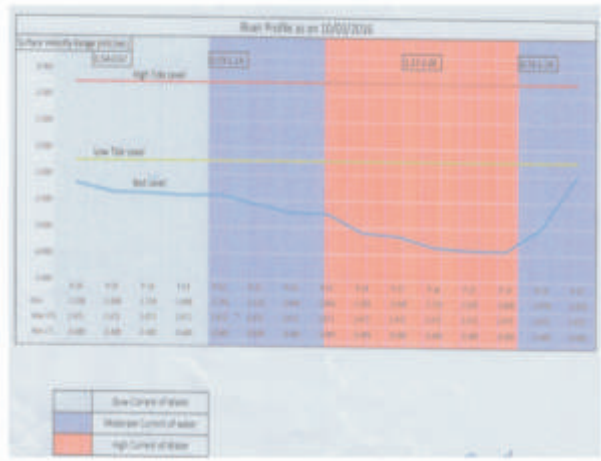

Figure 02

1.8 As per the contract Condition, the Technical Design of the Bridge shall be completed in 38 weeks (up to 15.06.2016). Construction of Well foundation had commenced from 4th March 2017.

2 Technical Requirements of IWAI and Classification of Waterway:

2.1 Classification of Inland Water Way : (As per Gazette Notification No 3 dated 20th Jan 2007)

2.1.1 Through Gazette Notification No 18 dated 26th March-2016 of National Water Way Act, 2016, approx. 100 Km stretch length of Narmada River from confluence of Narmada with Arabian Sea at Gulf of Khambhat (upstream of sea mouth Latitude 21° 38'27''N, Longitude 72° 33'28''E) to Pandhariya (Latitude 21° 57'10''N, Longitude 74° 08'28''E), has been notified as Class VII National Water way-73 (Refer Page 11 Sr no 73 of Gazette Notification No 18 dated 26th March-2016, National Water Way Act). The Proposed Narmada Bridge under CTP-15B is approx. 41 Km upstream of the confluence of Narmada with Arabian Sea at Gulf of Khambhat.

2.1.2 As the proposed Bridge lies in the stretch of National Water Way-73, the DFCCIL sought clearance/NOC on 18.10.2016, from IWAI for construction of an Important Narmada river bridge having span 29x48.15 m (clear span 45.7m).

2.1.3 The water ways are classified in 7 categories from Class-I to Class-VII, for self-propelled vessels up to 2000 t Dead Weight Tonnage (DWT) and Tug boat- Barge formation in push-tow units of carrying capacity up to 8000 tonne. Vessel size has also been defined for the respective class of water way.

2.1.4 The IWAI has classified, the Narmada River channel (from confluence of Narmada with Arabian Sea at Gulf of Khambhat to Pandhariya approx. 100Km as Class VII water ways. The technical requirements of the Class-VII water ways for rriver (as per Gazette Notification No 3 dated 20.01.2007) and entitled vehicles are as under : (Table-1)

a)	**River**
i.	Water Depth : Min 2.75 m (Draft)
ii.	Bottom Width of Channel : 100 m and above
iii.	Bend Radius of Channel : 900m
iv.	Vertical Clearance : 10 m (As per Gazette notification no 398 of 8th Nov 2016, the vertical clearance has been Relaxed up to 8m)
v.	Horizontal clearance: 100 m
b)	**Requirements for Vessels:**
i.	Vessel Dead Weight Tonnage : 2000 T
ii.	Approx Size : Over all length : 86 m, Moulded Width : 14 m
iii.	Loaded Draft : Approx : 2.5 m
c)	**Requirements for Tug Boat & Two Barge Combination**
i.	Dead Weight Tonnage : 4000 T
ii.	Approx Size : Over all Length 210 m, Moulded width : 14 m
iii.	Loaded Draft : Approx : 2.5 m

3. Technical Details and Justification submitted to IWAI for NOC :

In terms of para 6 of the Gazette Notification no 398 of 8th Nov 2016, the required details as under (as per format of annexure of the said Gazette Notification)were provided to IWAI and clearance was sought from the Inland Waterway Authority.

3.1. Typical span cross section showing details of Formation Level, HFL, HTL, LTL, Girder Soffit level, Horizontal clearance between Well and Well cap, top and calculated National Flood Level are as shown in the (fig. 03.)

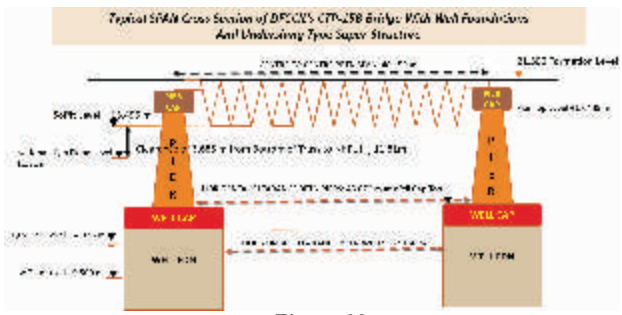

Figure 03

3.2. Technical details of the Narmada bridge as per GAD approved

(Please see following table -02)

SN	Description	Details
1	Location A1 (WGS-84, co-ordinates)	X = 287160.674, Y = 2397297.001
2	Location A2	X = 286789.760, Y = 2398643.187
3	Rail Level	22.306
4	Formation Level	21.5m
5	Span (nos. x Length C/C)	29 x 48.15m
6	Clear Span required at HFL	45.70m
7	Clear Span available at HFL	46.271m
8	Soffit Level of Super Structure	15.495
9	HFL (m)	13.26
10	HTL(m)	4.355
11	LWL(m)	2.43
12	Design Discharge	72452 cusec
13	Vertical Clearance available at HFL (at Design discharge 72452 cumec)	2.235m
14.	Pier cap top level	RL:18.945m
15.	Pier cap bottom Level	RL:17.445m
16.	Pier Top thickness	1.5m
17.	Width of Pier cap	2.5m
18.	Length of Pier cap	15.08m
19.	Pier Bottom thickness	2.5m
20.	Pier height	10.96m
21.	Well cap Top level (RL)	6.485m
22.	Well cap Dia	11.0m

3.3. Clear span as per GAD : 45.65m

3.4. Distance From existing Structure: Existing railway Silver Bridge is located 6.7 km on up stream side.

3.5. Calculation of Navigational High Flood Level (NHFL) :

3.5.1. Gazette Notification no.3 dated 26.01.2007, page 61 (last para) states that reference level for vertical clearance for, rivers shall be over NHFL (Navigational High Flood Level) which is the highest flood level at frequency of 5% in any year over period of last 20 years. As the value of Navigational High Flood Level (NHFL) has not been provided by the IWAI, therefore, the gauge readings (of Last 20 years) of Garudeshwer Dam (101 Km up stream) and Bharuch (7.0km upstream) of the proposed Narmada bridge) were collected from CWC(Please see following Table-3).

(Table-3)

Sr no.	Year	Flood discharge (m3/sec) at Gurudeshwar	Flood discharge (m3/sec) at Golden bridge	Tp (Years)	ln(Tp)	Flood discharge (m3/sec) at Golden bridge
1	1994-1995	60642	63427.65	42.00	3.73767	63427.65
2	1990-1991	52000	54388.67	21.00	3.04452	54388.67
3	1984-1985	49500	51773.83	14.00	2.63906	51773.83
4	1978-1979	40745	42616.66	10.50	2.35138	42616.66
5	1973-1974	40428	42285.10	8.40	2.12823	42285.10
6	1986-1987	34700	36293.98	7.00	1.94591	36293.98
7	1975-1976	30477	31876.99	6.00	1.79176	31876.99
8	1974-1975	29905	31278.71	5.25	1.65823	31278.71
9	1996-1997	28200	29495.39	4.67	1.54045	29495.39
10	1979-1980	27475	28737.09	4.20	1.43508	28737.09
11	2012-2013	26586	27807.25	3.82	1.33977	27807.25
12	1998-1999	25600	26775.96	3.50	1.25276	26775.96
13	1977-1978	24700	25834.62	3.23	1.17272	25834.62
14	1999-2000	23400	24474.90	3.00	1.09861	24474.90
15	1980-1981	23138	24200.87	2.80	1.02962	24200.87
16	1981-1982	22883	23934.15	2.63	0.96508	23934.15
17	1988-1989	22600	23638.15	2.47	0.90446	23638.15
18	1991-1992	22500	23533.56	2.33	0.84730	23533.56
19	2006-2007	22226	23246.97	2.21	0.79323	23246.97
20	1997-1998	21849	22852.65	2.10	0.74194	22852.65
21	1993-1994	20973	21936.41	2.00	0.69315	21936.41
22	2002-2003	18250	19088.33	1.91	0.64663	19088.33
23	1983-1984	18150	18983.74	1.83	0.60218	18983.74
24	1976-1977	16375	17127.20	1.75	0.55962	17127.20
25	1982-1983	15722	16444.20	1.68	0.51879	16444.20
26	1985-1986	14500	15166.07	1.62	0.47957	15166.07
27	1989-1990	14200	14852.29	1.56	0.44183	14852.29
28	2011-2012	11632	12166.33	1.50	0.40547	12166.33
29	1995-1996	11168	11681.01	1.45	0.37037	11681.01
30	1987-1988	10800	11296.11	1.40	0.33647	11296.11
31	2009-2010	10684	11174.78	1.35	0.30368	11174.78
32	2007-2008	10601	11087.97	1.31	0.27193	11087.97
33	2004-2005	10550	11034.62	1.27	0.24116	11034.62
34	1992-1993	10150	10616.25	1.24	0.21131	10616.25
35	2003-2004	9850	10302.47	1.20	0.18232	10302.47
36	2001-2002	8200	8576.67	1.17	0.15415	8576.67
37	2005-2006	7550	7896.82	1.14	0.12675	7896.82
38	2010-2011	4543	4751.69	1.11	0.10008	4751.69
39	2000-2001	4460	4664.87	1.08	0.07411	4664.87
40	1972-1973	1085	1134.84	1.05	0.04879	1134.84
41	2008-2009	741.1	775.14	1.02	0.02410	775.14

Data taken from CWC

#No discharge data available for Golden bridge with either CWC or irrigation however, discharge of GArudeswar is available.

#To arrive at discharge at Golden bridge a coefficient of ((93316/87892)^0.75 is taken for adjustment of higher catchment(source-Model study).

3.5.2. Using the gauge readings for these two stations, High Flood Level of (for 20Years return period) 11.81m was derived by applying "Best Fit Curve" (Refer Fig-4) and the vertical clearance 3.685m was worked out above this NHFL level as i.e. 11.81m to soffit of Girder i.e. 15.495m.

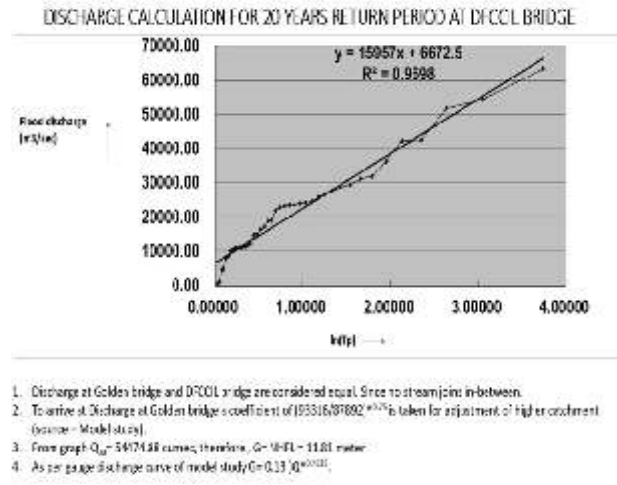

Figure 04

3.6. Vertical Clearance above Navigational High Flood Level atvarious structures on up stream of proposed Narmada River Bridge has been calculated as shown in following table(Table-04)and presented to IWAI.)

(Table 04)

Details of Bridges on Up stream side of propoesed Nramada River Bridge of CTP-15B, in Bharuch Dist								
Sr. No.	**Structure Name**	**Soffit Bottom (in Meters)**	**Horizontal Clearance (in Meters)**	**HFL (in Meters)**	**NHFL (in meters)**	**Vertical clearance from NHFL (in meters)**	**Distance of Bridge from Sardar Sarovar Dam in Kms**	**Remarks**
1	3rd Narmada Bridge	17.53 m	144 m	13.9 m	Not Available	NA	98 Km	Newly Opened in March-2017
2	New Road Bridge in lieu of	17.53 m	55.05 m	13.9 m	11.3 m	6.05 m	103 Km	Under Construction
3	Golden Bridge - 135 years old Road Bridge	17.53 m	55.05 m	13.9 m	11.3 m	6.05 m	103 Km	Existing
4	Existing Indian railway BG Bridge No. 502 - Silver Bridge	15.030	80.860	13.900	11.300	3.730	104 Km	Existing
5	DFCC CTP-15B Railway Bridge	15.495	45.650	13.600	11.810	3.685	112 Km	Under Construction

3.7. Depth of the water at the proposed Narmada bridge is only 2.43 mas against requirement of 2.75 m for Class-VII of navigational channel.

3.8. The application of the DFCCIL for IWAI clearance was based on the premise that vertical clearance at the existing railway silver bridge (6.7 kmon upstream of the proposed Narmada bridge) is 3.73 m which is approximately same asthe vertical clearance of 3.685 m at the proposed Narmada bridge. Since the existing railway silver bridge is located just at the South end of the Bharuch station and it is not possible to raise the level of the existing railway silver bridge and thus, required vertical clearance of 8 m is not possible at the existing railway bridge and therefore should also not been insisted upon for the proposed Narmada bridge and IWAI should grant the clearance for the proposed Narmada bridge. This contention of DFCIL was also presented in the meeting held on 27.04.2017 with IWAI.

4. Outcome of the meeting held on 27.04.2017

4.1. After Submission of the proposal along with the declaration given as Annexure -1 (Gazette notification no 398 of 8th Nov 2016) seeking NOC from IWAI, a meeting was fixed with IWAI on 27.04.2018 at office of IWAI-Noida Sector 13, UP.

4.2. During the meeting, IWAI was requested to grant NOC in the view of justification brought out under para 3.9 above.

However, IWAI vide MOM circulated under its letter No IWAI/NOC/NW-73(Narmada)/2017 dated 12.05.2017, did not agree with the contention of DFCCIL and asked DFCCIL as under :

A. Keeping in mind the low depth of water in Narmada at the proposed bridge site as 2.43 m, IWAI modified this stretch of Narmada river as Class-IV from the original classification of Class-VII(Official Memorandum regarding change in classification was issued by IWAI vide memorandum no IWAI/NW-5/64/Nav.Clearance/217 dated 08.12.2017). This resulted into lesser requirement of clearances to be provided at the proposed Narmada bridge which are as under :

The technical requirements of the Class-IV water ways for River (as per Gazette Notification No 3 dated 20.01.2007) are as under :

(Table- 05)

a)	**River :**
i.	Water Depth : Min 2.0 m (Draft)
ii.	Width of Channel : 30 m at bottom
iii.	Bend Radius of Channel : 800 m
iv.	Vertical Clearance : 10 m (As per Gazette notification no 398 of 8th Nov 2016, the Vertical clearance has been Relaxed up to 8m).
v.	Horizontal clearance: 50 m
b)	**Requirements for Vessels:**
i.	Vessel Dead Weight Tonnage : 1000 T
ii.	Approx Size : Over all length : 70 m, Moulded Width : 12 m
iii.	Loaded Draft : Approx : 1.8 m
c)	**Requirements for Tug Boat & Two Barge Combination**
i.	Dead Weight Tonnage : 2000 T
ii.	Approx Size : Over all Length 170 m, Moulded width : 12 m
iii.	Loaded Draft : Approx : 1.8 m

B. IWAI suggested that vertical clearance of 8 m may be made available by reversing the direction of steel trusses i.e. Underslung girder may be converted to Through type girder.

C. IWAI agreed not to insist for provision of 8 m of vertical clearance for all the water way spans from P12 to P26 but only for the deepest river bed from P13 to P19 and for horizontal clearance, relaxation was also made up to 48.15m has been provided subject to piers shall be provided with fenders. With the above change, IWAI asked DFCCIL to construct proposed bridge under CTP-15B project with the required clearance.

D. Thus, in MOM the IWAI has asked the DFCCIL to convert the Super Structures of Navigational Spans i.e. P13 to P19, into Through type Girders. At that time well foundation work on 09nos.land wells was in progress, which further increased the difficulty for the DFCCIL to full fill the said requirements as while the centre to centre track distance on the under slung girders (i.e. on the either side land wells) is 6 m and minimum track centre to centre distance for through type girders is 8 m.

5. Impact of the IWAI Requirements:

5.1. The suggestion of reversal of super structure from Under slung to Through Type Girders was an ill solution for the health of the Project of CTP-15B and it would have led to complete change (thereby creating major contractual complication) in the lumpsum contract for construction of said Narmada bridge-CTP-15B:

5.1.1. The centre to centre track distance of the proposed Narmada bridge would have increased from 6m to 8m due to change in superstructure from underslung to through type of girder. It would have been very complicated to design and construct a bridge with underslung girder from A1 to P13 with 6 m centre to centre track distance, then change it to through type of girder with 8 m centre to centre track distance from P13 to P19 (due to provision of two separate through type girder placed side by side as it is difficult to design a single through girder for double line track with axle load of 32.5 T)and then again reduce the track centre to 6 m with underslung girder.

5.1.2. It shall lead total change in design of super structure, pier cap, pier and approach embankment(of CTP-15B including some length of CTP- 13 adjoining to interface of both side approaches of CTP-15B) thereby undoing all the design and construction work executed upto 27.04.2017. As a result, the design phase of the project and construction stage of project would have prolonged substantially. The said requirement would have meant financial impact of more than 100 crores

5.2. Thus the IWAI requirement for CTP-15B project, conveyed by IWAI on 12.05.2017 extremely difficult challenge that was required to be resolved in interest of project.

5.3. Since the main issue was to complywith the requirement of vertical clearance of 8m above the navigational flood level, therefore, availability of vertical clearance was once again analysed by integrating various factors and effect of various structures on the hydrology/water level of Narmada river around the CTP-15B bridge location.

5.4. In view of above, DFCCIL- Vadodara unit has made integrated study and comparative of the current scenario by considering various factors not limited to following:

5.4.1 Impact of raising of height of existing Sardar Sarovar dam located at 112Km upstream of the CTP-15B,

5.4.2 Upcoming projectof Bhadbhut Barrage (Esteemed project of the Gujarat Govt) approx 16 km. in the downstream of CTP-15B,

5.4.3 Clearance available at existing Silver Bridge located approx. 6.7Km on up stream side from the CTP-15B bridge.

5.5. To meet the above objective, DFCCIL Vadodara unit collected following details:

5.5.1 Stipulated Discharge from Sardar Sarovar Dam sought vide letter dated 16.08.2017 addressed to Narmada control authority.

5.5.2 Gauge level reading of nearest gauge station (Golden Bridge Bharuch, situated on upstream side approx. 8.3 km from CTP-15B Bridge) was sought from the CE, Narmada, vide letter dated 21.08.2017.

5.5.3 Details of proposed Bhadbhut Barrage (approx 16 Km on downstream of CTP-15B).

5.6. DFCCIL-Vadodara unit presented the integrated comparative study of present scenario of the existing structures and proposed structures in terms of their Hydrology and its effect on IWAI requirement of Class-IV waterway for CTP-15B Narmada Bridge location.

6. Technical Gist of the existing & proposed structure on the water level in the Narrmada river.

6.1. Present scenario of the Bridge structures (other than the DFCC's Bridge) on Navigation Channel: Existing BG railway bridge do not comply the required clearance of 8m as desired by IWAI. The list of structures and available clearance are as under.

(Table-06)

SN	Particulars of Structure	Location from Sea Mouth (Appx.)	Soffit Bottom (in meter)	High Flood Level (in meter) as provided by IWAI	Vertical Clearance above HFL (in meter)	Remarks
1	Proposed DFCCIL Bridge	37 km Upstream	15.50	8.90	6.6	**Under Construction**
2	IR existing BG Bridge No. 502-Silver Bridge	43.70 km upstream	15.030	8.90	6.13	Existing

6.2 Analysis of Technical Facts about the 160 km Stretch of Narmada upstream of the Sea mouth:

6.2.1 Fixing of Navigational Flood level & Impact of existing as well as proposed Irrigation/ Hydraulic Projects :

I. Sardar Sarovar Dam :

The well-known Sardar Sarovar Dam located approximately 160 km upstream of sea mouth, was initially commissioned in June 2006 with Reservoir Level (FRL) of 121.92m. Subsequently, raising of height of the dam has also been completed with installation of 30 nos. of radial gates in June 2017. Now Full Reservoir Level to be maintained is 138.68 m. This is to be noted that High Flood Level of 8.90 m as provided by IWAI is of the year 2012 when the Sardar Sarovar dam height was not raised. However, now due to raising of gates to 138.68 m, flood scenario in the down steam of dam has completely changed.

Due to raising of the height of Sardar Sarovar Dam, the capacity of the reservoir has been increased substantially and now only 600 cusecs (equivalent to 1.35 m)of water in the river downstream as environmental release is being released from Sardar Sarovar. At present, water level at Narmada is due to tidal effect as well as environmental release and maximum observed gauge level was 5.0 m during July 2017.Now in this situation, the draft availability will be only 1.35 m excluding tidal effect.

II. **Garudeshwar weir** is also being constructed

at 12 Km down stream of Sardar Sardar Sarovar which will further intercept incoming flood water after its completion. This will further reduce water level in the downstream of the Garudeshwar weir. Thus, the water level at the proposed bridge site will further reduce.

III. **CWC Data :**

Central Water Commission data for Narmada river, states that water level at Bharuch varied from 5.00 m to 10.90 m (during 2013) during the peak monsoon flood after 2006, when the Gates on Sardar Sarovar Dam were not installed and FRL was approx. 121.92m.

IV. **Bhadbhut Barrage :** Government of Gujarat has come up with a proposal to build a barrage across river Narmada at approximately 21 km upstream of sea mouth. This barrage is named as Bhadbhut Barrage Project.

Objective of Bhadbhut Barrage Project. :

i. Protection of water quality of Narmada river from salinity due to tidal influence and checking the problems of salinity ingress and deterioration of ground water quality in the upper reaches of Narmada river;

ii. Storage of the regulated release of water from Sardar Sarovar Dam and runoff from free catchment for irrigation, domestic and industrial water supply;

iii. Flood protection of about 400 sq km low lying area covering 17 villages on the left bank of river Narmada; and

iv. Road connectivity between left and right banks, shortening route from Surat/Hajira to Dahej region. There is provisions for ship lock-type arrangement for allowing boat passage between upstream and downstream of the barrage.

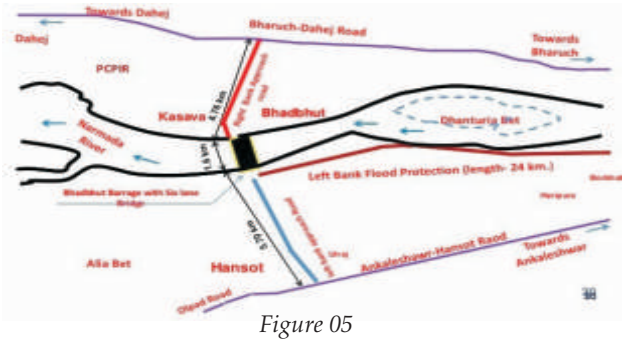

Figure 05

Impact of the Bhadbhut Barrage :

Case1: If Bhadbhut Barrage is Constructed - Full Reservoir Level of Barrage will be 7.5 m of from right from barrage to the Garudeswarwier in the upstream of the barrage.

In such condition, the DFCC Bridge having soffit level of 15.495 m, has vertical clearance of 7.95 m which is almost equal to 8.0 m.

Case 2: If Bhadbhut Barrage Not Provided –In addition to the regulated release of water from Sardar Sarovar dam, there will be discharge from free catchment area downstream of Sardar Sarovar Dam which will be further modified by the tidal effect.

Factors governing the water level : Rise of water level due to tidal effect is very low. During high tide, the sea water enters into Narmada river up to 50 km upstream. As observed from previous data, tide level hardly reaches to 4.5 m. Hence, Hence, the water level would not reach upto 8.90 m recorded during all over the years prior to construction especially raising of height of Narmada dam except for few days of peak monsoon. This conclusion is also evident from the critical analysis of data in para 6. In addition, it is important to note that during the However, in monsoon period during high flood, navigation is statutorily not permitted.

V. Critical analysis of daily gauge data as provided by IWAI reveals that,

A. During 2004

Daily data available from 15th June 2004 to 15th October 2004. This includes the peak monsoon period and pertains to the time when the height of Sardar Sarvoar dam was not raised.

On 13 no. days, gauge equalled or exceeded 5.0 m (during 4th August to 2nd September).

- 5.00 m to 5.50 m - 5 days (more than 5.50 m occurred on 8 days during 15th August to 31st August).
- 5.50 m to 6.50 m - 5 days (more than 6.5 m occurred on 3 days during 26th August to 28th August).
- 6.50 m to 7.50 m - 3 days (more than 7.5 m - Nil)maximum gauge of 7.00 m occurred on 27th August.

B. During 2011

Daily gauge data available from 1st June 2011 to 31st December 2011. On 21 days, gauge exceeded 5.0 m during 28th August to 30th September. This includes the peak monsoon period and pertains to the time when the height of Sardar Sarvoar dam was not raised.

- 5.00 m to 5.50 m - 7 days (more than 5.50 m occurred in 14 days during 28th August to 13th September).
- 5.50 m to 6.50 m - 10 days (more than 6.5 m occurred during 4 days from 28th August to 5th September).
- 6.50 m to 7.50 m - 4 days (maximum 7.00 m occurred on 29 August), not exceeded 7.50 m.

C. During 2012

- gauge exceeded or equalled 5.00 m during 19th August to 19th September on 19 days. This includes the peak monsoon period and pertains to earlier time when the height of Sardar Sarvoar was not raised.
- 5.00 m to 5.50 m - 9 days (more than 5.50 m occurred during 9th August to 13th September or 10 days)
- 5.50 m to 6.50 m - 5 days (more than 6.50 m occurred during 9th August to 8th September or 5 days)
- 6.50 m to 7.50 m - 2 days (more than 7.50 m occurred during 9th August to 8th September or 3 days)

More than 7.50 m - 3 days, (maximum 8.90 m occurred on 7th September which may be a combination of high rainfall coupled with high tide).

D. During 2013

Data is available for the duration of 1st January to 31st May. Thus, the data is not of relevance.

E. During 2014

Daily data available from 1st June to 31st Dec. On 5 days gauge exceeded or equalled 5.00 m. This includes the peak monsoon period and pertains to the earlier time when the height of Sardar Sarvoar was not raised.

- 5.00 m to 5.50 m - 1 days (more than 5.50 m occurred on 4 days during 9th September to 12th September).
- 5.50 m to 6.50 m - 4 days (more than 6.50 m nil)
- Maximum gauge of 6.50 m occurred on 10th September.

6.2.2 Above observations are summarised as below :

(Table-07)

Year	No. of days on which flood equalled or exceeded 7.5m	Max. recorded flood in year	Period
2004	Nil	7.0 m	7.0 m on 27/08/2004
2011	Nil	7.0m	7.0 m on 29/08/2011
2012	03 days	8.9 m	7.7 m on 09/08/2012
			8.2 m on 08/09/2012
			8.9 m on 07/09/2012
2014	Nil	6.5 m	6.5 m on 10/09/2014

6.2.3 As per CTP-15 B bridge site data from April - 2017 to Sep-2017, as per the gauge observed on regular basis in the monsoon season, the water level including tidal effect is not more than 5m.

Thus, taking the overall picture of the two cases namely whether the Bhadbhut Barrage is constructed or not, the maximum water level at the both sides shall be 7.5 m. Now, if 7.50 m is taken as Navigational High Flood Level (NHFL) then navigation would be restricted for once or twice in a year that too during peak monsoon flood.

7. Revision in proposal of NOC on Basis Integrated study and factual Data:

7.1. DFCCIL Vadodara on 05.09.2017revised its proposal seeking clearance of IWAI, incorporating the above-mentioned facts and details along with the revised Declaration attached as Annexure-1. The salient features of revised proposal are as under:

7.2. Location Plan on google map :

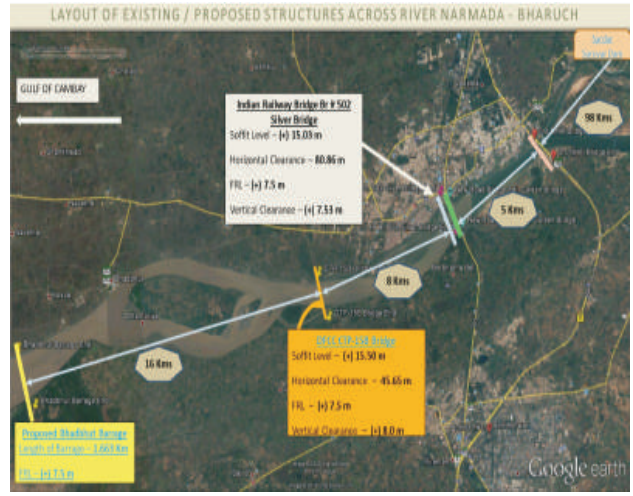

Figure 06

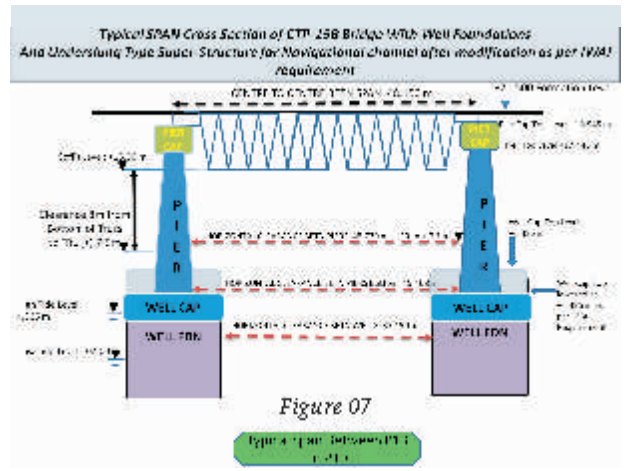

Figure 07

7.3. Typical Span Cross Section of Navigational Span i.e. (P13 to P19) after NOC of IWAI :

7.4. Salient Feature:

The details of horizontal and vertical clearance available as per revision in GAD (Navigational span P13 to P19) by considering the NHFL as 7.5m and to meet the requirement of IWAI are tabulated as under :

(Table-8)

SN	Descriptions	Details as per Approved GAD
1	Navigational Flood Level	RL : 7.5 m
2	Soffit Level of Girder	RL:15.50m
3	Clear Span at NFL(RL 7.50m)	45.73m
4	Clear Span at Pier bottom Level (RL 6.485m)	45.650m
5	Clear Span between well cap	37.15m
6	Vertical clearance between NFL and Soffit of Girder	8.0m

7.5. The above facts were strongly presented by DFCCIL to IWAI and it was pointed out that in the stretch of Waterway -73 (Narmada River water way) categorised as Class-IV water way, due to integrated effect of Sardar Sarover dam and proposed Bhadbhoot Barrage, the FRL of 7.5m will remain throughout year (except once or twice. Hence NHFL earlier calculated as 11.81m shall be corrected as 7.5m and thus, the vertical clearance required for Class-IV water ways shall be available even without changing the super structure fro under slung to Through type Open web girder. DFCCIL requested IWAI to go through the facts and grant NOC to DFCCIL with the available vertical clearance without any change in planned super structure.

7.6. Grant of NOC/Clearance By IWAI:

In light of the Integrated study and factual data presented by DFCCIL Vadodra Unit, IWAI reviewed its decision (conveyed on date 12.05.2017) and gave its NOC to CTP-15B Project (Navigational spans) vide its letter No IWAI/PR/NOC/NW-73(Narmada)/2017 dated 11.12.2017 by relaxing the requirement of horizontal clearance of 50m to 48.468m. The NOC accorded by the IWAI is as under:

The NOC was accorded by the IWAI for construction of aforementioned DFCCIL bridge with minimum horizontal clearance 45.468m between piers, vertical clearance of 8m above NHFL subject to provision of required number of fenders in piers in Navigational channel with lowering of Well cap by 2.0m as to provide Vertical clearance of 3.015m between NHFL and top of the well Cap for the safe movement of Vessels.

7.7. Impact of Final NOC/Clearance By IWAI:

7.7.1 In this regard, it is brought out that in revised proposal the vertical clearance between NHFL (7.5m) and Top of Well Cap (6.485 m) was only 1.015 m. To full fill the requirement of IWAI, DFCCIL lowered the well cap top by 2 m and hence revised well Cap top level from 6.485 m to 4.485 m. As a result, the Horizontal clearance at revised Pier Bottom Level (4.485 m) of 45.468 m was achieved.

7.7.2 As a Result of IWAI requirement under final NOC, the GAD was revised by lowering the well Cap of Navigational spans P13 to P19, by 2.0m and the Wells have been redesigned considering the thrust of barges. As a result, the thickness of well foundations has been increased from 1.0m to 1.75m and the Founding Level of wells have also been increased by 5.0m to 8.0m for providing additional anchorage.

7.7.3 The height of the bridge soffit was raised by 50.0 mm to provide for the vertical clearance of 8.0 m above NHFL of 7.5 m.

7.7.4 The additional Cost approved by Engineer on account of Variation is 21.46 crores. Thus, the effort of DFCCIL Vadodara unit has saved more than 80.00 Crores in addition to time delay and contractual complications that would have happened had the IWAI original recommendations been implemented.

8. Conclusion:

Civil engineering structures are designed compatible to the natural, topographical and environmental requirements. These requirements may get modified due to other projects in the vicinity of the proposed structure. Therefore, a good knowledge of projects which modify the requirements and are being executed or already constructed needs to be kept in mind while designing the structure. This will help in construction of structure that are more relevant and suitable in the changed circumstances.

Jump-Form Shuttering for concreting of Pier of 2.75 Km long Bridge (No. 92) viaduct near Aravalli range in Sohna yard under Rewari-Dadri section of Western Corridor

डेडीकेटेड फ्रेट कारीडोर कारपोरेशन ऑफ इंडिया लि.

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