IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

PRECAST POST-TENSIONED 6-LANE ELEVATED HIGHWAY

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ACKNOWLEDGEMENT

It gives me great pleasure in bringing out the seminar entitled **"PRECAST POST-TENSIONED 6-LANE ELEVATED HIGHWAY".**

I express my deep sense of gratitude and sincere regards to my guide **Prof. Shashikant Deshmukh.** His timely guidance and friendly discussion had helped me immensely in selecting this topic and completing the seminar work.

Finally, I would like to thank all those who directly or indirectly helped me during my work.

ABSTRACT

We have discussed here about the construction of structure with precast, pre-stressing, post-tensioning methods & design philosophy & its characteristics & proper placement of the segments & different parts of the structure.

I. INTRODUCTION

2.1. Terminology

Various terms commonly used in the study of prestressed concrete are outlined below. The definitions detailed in this section largely comply with those recommended in the relevant Indian standard code of practice.

2.1.1. STRANDS

A few wires are spun together in a helical form to form a prestressing strand. The different types of strands are as follows.

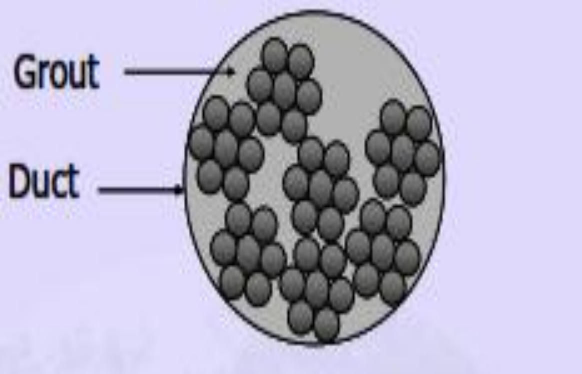
1) Two-wire strand: Two wires are spun together to form the strand.

2) Three-wire strand: Three wires are spun together to form the strand.

3) Seven-wire strand: In this type of strand, six wires are spun around a central wire. The central wire is larger than the other wires.

2.1.2. Tendon

A stretched element used in a concrete member of structure to impart prestress to the concrete. Generally, high tensile steel wires, bars cables or strands are used as tendons. A group of strands or wires are placed together to form a prestressing tendon. The tendons are used in post-tensioned members. The following figure shows the cross section of a typical tendon. The strands are placed in a duct which may be filled with grout after the post-tensioning operation is completed.



1-7.1 Cross-section of a typical tendon

Figure 1-7.2 Forms of reinforcing and prestressing steel

Fig. 1

2.1.3. ANCHORAGE

A device generally used to enable the tendon to impart and maintain prestress in concrete. The commonly used anchorages are the Freyssinet, MagnelBlaton, Gifford-Udall, Leonhardt-Baur, LeeMcCall, Dywidag, Roebling and B.B.R.V. systems.

2.1.4. PRE-TENSIONING

A method of prestressing concrete in which the tendons are tensioned before the concrete is placed. In this method the prestress is imparted to concrete by bond between steel and concrete.Pre-tensioned concrete is cast around already tensioned tendons. This method produces a good bond between the tendon and concrete, which both protects the tendon from corrosion and allows for direct transfer of tension. The cured concrete adheres and bonds to the bars and when the tension is released it is transferred to the concrete as compression by static friction. However, it requires stout anchoring points between which the tendon is to be stretched and the tendons are usually in a straight line. Thus, most pretensioned concrete elements are prefabricated in a factory and must be transported to the construction site, which limits their size. Pre-tensioned elements may be balcony elements, lintels, floor slabs, beams or foundation piles. An innovative bridge construction method using pre-stressing is the stressed ribbon bridge design.

2.1.4.1. PROPERTIES OF PRESTRESSING STEEL

The steel in prestressed applications has to be of good quality. It requires the following attributes.

1) High strength
2) Adequate ductility
3) Bendability, which is required at the harping points and near the anchorage
4) High bond, required for pre-tensioned members
5) Low relaxation to reduce losses
6) Minimum corrosion.

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

2.1.5. POST-TENSIONING

A method of prestressing concrete by tensioning the tendons against hardened concrete. In this method, the prestress is imparted to concrete by bearing.

2.1.5.1. BONDED PRESTRESSED CONCRETE

Concrete in which prestress is imparted to concrete through bond between the tendons and surrounding concrete. Pre-tensioned members belong to this group.

2.1.5.2. NON-BONDED PRESTRESSED CONCRETE

A method of construction in which the tendons are not bonded to the surrounding concrete. The tendons may be placed in ducts formed in the concrete members or they may be placed outside the concrete section.

2.1.5.3. TRANSFER

The stage corresponding to the transfer of prestress to concrete. For pretensioned members, transfer takes place at the release of prestress from the bulk-heads; for post-tensioned members, it takes place after the completion of the tensioning process.

2.1.6. TENSIONING DEVICES

The various types of devices used for tensioning steel are grouped under four principal categories, namely:

1. Mechanical,
2. Hydraulic,
3. Electrical(Thermal), and
4. Chemical.

Hydraulic jacks, being the simplest means of producing large prestressing forces, are extensively used as tensioning devices. Several commonly used patented jacks are due to Freyssinet, Magnel, Gifford Udall and for the range of 5 – 100 tonnes. Large hydraulic jacks for forces in the range of 200 – 600 tonnes have also been developed by Baur-Leonhardt. It is important that during the tensioning operation the force applied should be accurately measured. In most of the jacks, calibrated pressure gauges directly indicate the magnitude of force developed during the tensioning of the wires.

2.1.7. PRETENSIONING SYSTEMS

In the pretensioning system, the tenders are first tentioned between rigid anchor blocks cast on the ground or in a column or unit mould type pretensioning bed, prior to the casting of the concrete in the moulds. The tendons comprising individual wires or stands are stretched with constant eccentricity or variable eccentricity withtendon anchorage at the one end and jacks on other. With the forms in place, the concrete is cast around the stressed tendon.

High early strength concrete is often used in factory to facilitate early stripping and reuse of mould. When the concrete attains sufficient strength, the jacking pressure is released. The high tensile wires is tend to shorten but are checked by bond between concrete and steel. In this way the pressure is transferred to the concrete by bond, mostly near the ends of beam, and no special anchorages are required in pretensioned members.

2.1.8. POST-TENSIONING SYSTEMS

2.1.8.1. PRINCIPLES OF POST-TENSIONING

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ISSN (P) 2319 - 8346

In post-tensioning, the concrete units are first cast by incorporating ducts or grooves to house the tendons. When the concrete attains sufficient strength, the high tensile wires are tensioned by means of jack bearing on the end face of member and anchored by wedges or nuts. The forces are transmitted to the concrete by means of the end and, when the cable is curved, through the radial pressure between the cable and the duct. The space between the tendons and the duct is generally grouted after the tensioning operation.

Most of the commercially patented prestressing systems are based on the following principles of anchoring the tendons:

1. Wedge action producing a frictional grip on the wires.
2. Direct bearing from rivet or bolt heads formed at the end of the wires.
3. Looping the wires around the concrete.

2.1.8.2. POST-TENSIONING ANCHORAGES

There are different systems used in post-tensioning methods depending upon the requirement and design of the structures. The different post-tensioning systems are Freyssinet anchorage system, the Grifford-Udall system, the B.B.R.V. post-tensioning system, etc.

In the elevated structure, the Freyssinet post-tensioning system is used.

Freyssinet system was introduced by the French Engineer Freyssinet and it was the first method to be introduced. High strength steel wires of 5mm or 7mm diameter, numbering 8 or 12 or 16 or 24 are grouped into a cable with a helical spring inside. Spring keeps proper spacing for the wire. Cable is inserted in the duct.

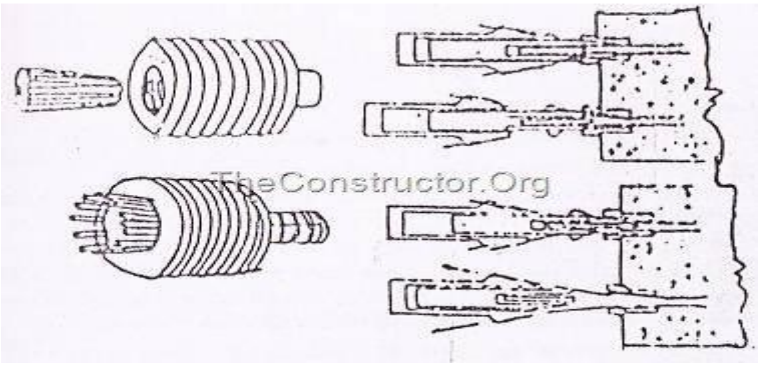

Fig. 2.

Freyssinet system of Post-tensioning

Anchorage device consists of a concrete cylinder with a concentric conical hole and corrugations on its surface, and a conical plug carrying grooves on its surface (Fig.). Steel wires are carried along these grooves at the ends. Concrete cylinder is heavily reinforced. Members are fabricated with the cylinder placed in position. Wires are pulled by Freyssinet double acting jacks which can pull through suitable grooves all the wires in the cable at a time. One end of the wires is anchored and the other end is pulled till the wires are stretched to the required length. An inner piston in the jack then pushes the plug into the cylinder to grip the wires. At present, tendons capable of developing forces are available under this system. The Freyssinet system provides for simultaneous stressing for all the wires in a tendon. After the desired extension of the tendon is reached, a threaded nut is screwed to the anchor, which transmits the forces by bearing against end plate.

2.1.8.3. APPLICATIONS OF POST-TENSIONING

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ISSN (P) 2319 - 8346

Post-tensioning is ideally suited for medium to long span in situ works where the tensioning cost is only a small proposition of the cost of the whole job. Hence it is more economical to use the cablesor bars with large force in each than a large no. of small ones. Post tensioning may be used with advantage to fabricate large members, such as long span bridge decks of the box girder type by presenting together a number of smaller pre cast unit. Apart from this advantage, the chief merit of post tensioning is that it allow the use of curved and stopped off cables which helps the designer to vary the prestress distribution at will from section to section so as to counter the external loads more efficiently.

Post tensioning is ideally suited in concrete construction work involving stage prestressing. Most of the long span bridge structures are constructed using post tensioning systems.

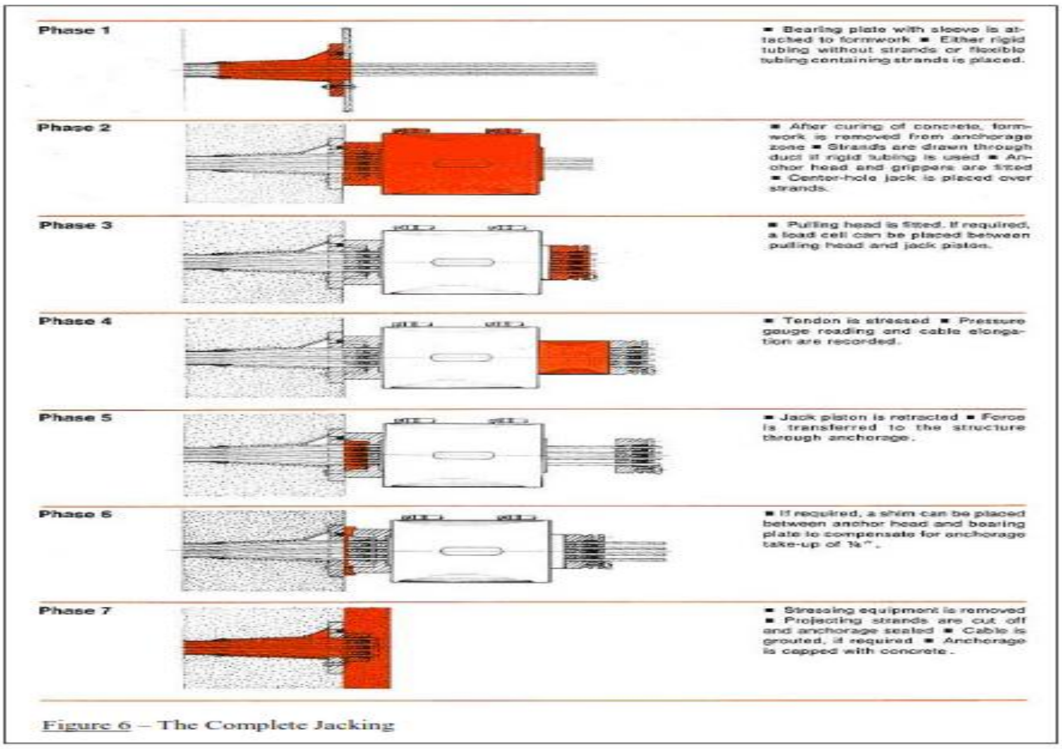

Figure 6 – The Complete Jacking

Fig. 3

III. DETAILS ABOUT THE PROJECT

3.1 PROJECT PARAMETERS

The Project consists of a length of 22.12 kms of road from Udayagiri Village to Hebbal on NH-7 in the state of Karnataka in India.

Table 1

Road Section	From	To (km)	Total (km)
UdayagiriVillage to Hebbal	534+720	556+840	22.12

Salient features and details of the Project are listed below in Table

Table 2

1.	Employer	**NATIONAL HIGHWAYS AUTHORITY OF**
2.	Number of Contract Package	NS-2/BOT/KNT-02
3.	Name of Contract Package	UP Gradation ,Operation and Maintenance of km 534+720 to km 556+840 of Hyderabad – Bangalore Section of NH-7 in Karnataka NHDP Phase –VII on Design , Build ,Finance, Operate and Transfer (DBFOT),Toll basis (Package No.NS-2+BOT+KNT-2)
4.	Location	km 534+720 to km 556+840
5.	Length km	22.12 km
6.	Concession period	20 years from the Appointed Date
7.	Notification Date	1st October 2010
8.	Issue of RFP document	23rdDecember2009
9.	Name of the Concessionaire	**NavayugaDevanahalliTollway Private Limited**
10.	Letter of Acceptance Date	8th February 2010
11.	Agreement Date	30th April 2010
12.	Development period	180 days from the Agreement date
13.	Commencement Date	19th November 2010
14.	Appointed Date	25th April 2011
15	Construction period	24 months from the Commencement date
16.	Schedule date of Project	17thNovember 2012
17.	Tentative date of Project	-
18.	Total Project Cost	Rs. 680 Cores
19.	Grant Amount	Rs. 61.20 cores
20.	EPC Contractor -1	Navayuga Engineering Company Limited
21.	Independent Engineers	**The Louis Berger Group, Inc. USA in association with Louis Berger Consulting Pvt.**

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Table 3

Sl.	Item	Total
1	Service Roads a) DBM b) BC	 42.22 km
2	Main Carriageway a) Widening (under Elev. Hwy) b) Overlay	 3.09 km 42.22 km
3	Elevated Highway(3722m)	126 Spans
4	Kogilu Flyover (614m)	16 Span
5	Vidyanagar Flyover (573m)	15 spans
6	Pipe Culverts	7
7	Box Culverts	10
8	Minor Bridges	3
9	Road Under Bridge	1
10	Vehicular Underpass a) Bagalur b) Hunsmaranhalli c) Depressed Underpass RHS d) IAF underpass extension	(Total 4 No.) 1 1 1 1

As per the project plan, the 3.72 km stretch from the Hebbal flyover to the beginning of Yelahanka bypass (near GKVK) will be an elevated stretch.From the Yelahanka bypass to the trumpet inter-change (the gateway to BIA), all the major junctions will be made signal-free. To this end, two flyovers will come up at the Kogilu Cross and Vidyanagar junctions, while four underpasses will come up at other crucial junctions.

Officials said the Rs 680-crore project has a 24-month deadline and will allow motorists to reach the airport within 15-20 minutes from Hebbal, as against 45 minutes now. Notably, it will be the first six-lane elevated highway corridor in the city.

Currently, Bangalore has two elevated corridors — the Electronics City expressway and the Tumkur Road expressway — both of which are four-lane. The airport expressway will be built on a single pier. "Six-lane flyovers are constructed on two piers.However, with improved technology, we are set to construct it on a single pier. The advantage is it takes up less-space."

The project was announced by then Union minister of state for surface transport K H Muniyappa a few years ago. However, due to recession and other issues, it has been a delayed starter. With the airport having only a road link as yet (work is yet to start on the high-speed rail link), the Hyderabad NH-7 is over-utilised.

» **First six-lane highway to be built on a single pier**

» **Signal-free corridor from Hebbal to BIA**

» **Tolled road**

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3. ROAD

3.1. SITE

The site of the Upgradation Project Highway comprises the section of National Highway & commencing from Km 534.720 to Km 556.840 of Hyderabad- Bangalore section in the Sate of Karnataka. The land, carriageway and structures comprising the site are described below. An index map and location plan of the Project Highway is given as Figure A-1

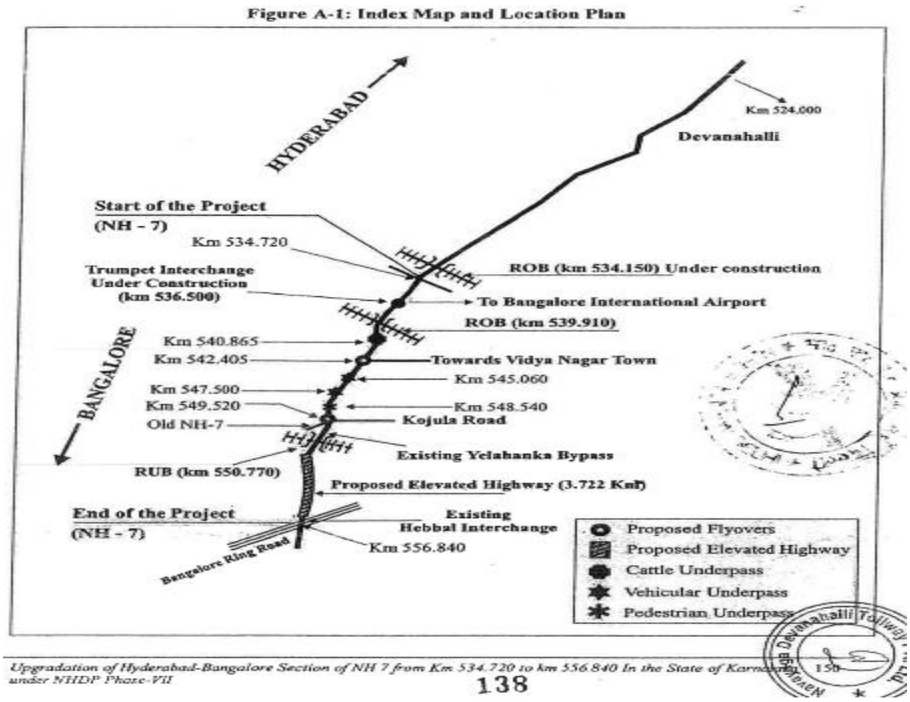

Fig. 4

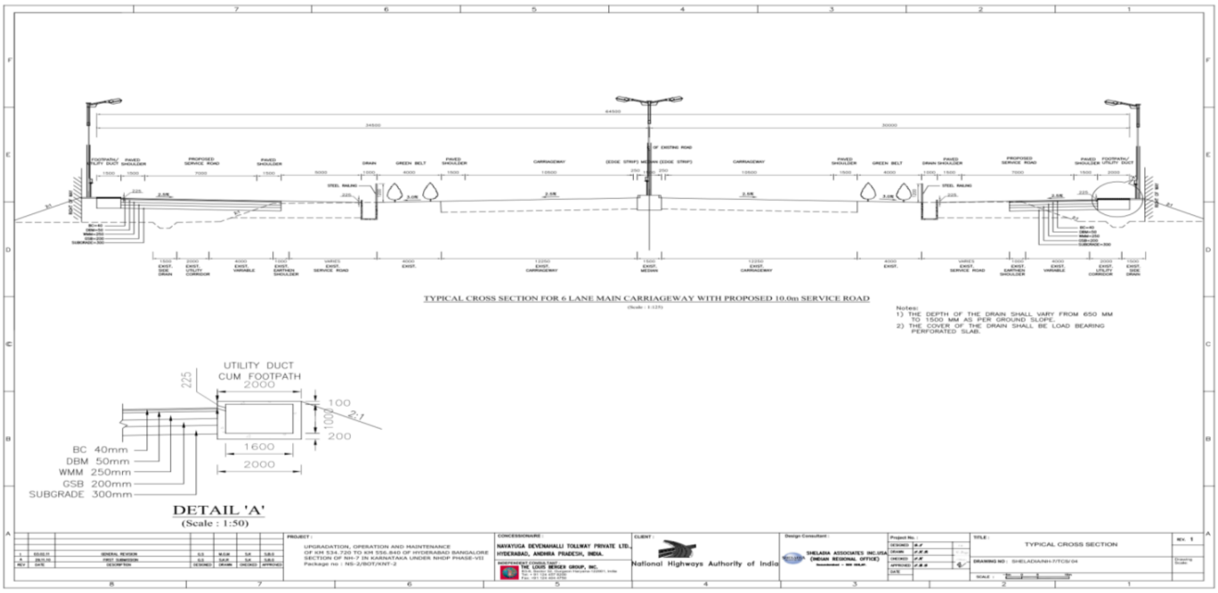

Fig. 5

IV. STRUCTURAL DESIGN CRITERIA FOR FLYOVER

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4.1. DESIGNSTANDARDS

4.1.1. CODES & STANDARDS

The designofvarious components ofthe structure, ingeneralare based onprovisions of IRC/ISCodes.WhereverIRCcodeissilent,reference ismadetoother Indian/International codesandstandards.ThelistofIRCCodes(latestrevisions)givenbelowwillserveasa guide forthe designofstructures.

IRC: 5-1998 Standard Specifications and Code of Practice for Road Bridges, SectionI –GeneralFeatures of Design.

IRC: 6-2010 Standard Specifications and Code of Practice for Road Bridges, Section-II –Loads andStresses.

IRC: 21-2000 Standard Specifications and Code of Practice for Road Bridges, Section-III –CementConcrete.

IRC: 18-2000 Design Criteria for Pre-stressed Concrete Road Bridges (Post Tensioned Concrete)(Third Revision).

IRC: 22-1986Standard Specificationsand Code of Practice for Road Bridges, Section-VI – CompositeConstruction.

4.2. MATERIALSANDFINISHES

4.2.1. CONCRETE

The Design Stresses for concrete are based on standard cube strength.

4.2.2. PRE-STRESSING STRANDS

The pre-stressing reinforcement used will be uncoated, seven wire low relaxation strands conforming to IS 14268 and IS 6006 with ultimate strength of 1862.5 N/mm2.

4.2.3. NON-PRE-STRESSED REINFORCEMENT

All non-prestressed reinforcement is to be deformed uncoated round bars with grade designated as S-500 confirming to IS- 1786 with minimum yield strength 500N/mm2.

4.2.4. GROUT

Grout used will be non-shrinkage grout with a minimum compressive strength of 30 MPa at 7 days and 50 MPa at 28 days. Grout admixture will be a balanced blend of expanding, fluidifying, and water reducing agents containing no calcium chloride, nitrates or other chemicals causing steel corrosion.

4.2.5. DUCTS

Ducts for bonded post-tensioning strand shall be flexible, galvanized, interlocked, mortar and grout tight, and fabricated of not lighter than 28-gauge steel. Ducts shall be at least 6mm larger than the nominal diameter of the strand or wire bundles and the cross sectional area shall be at least twice that of the net steel area. The ducts shall have grout openings at each end, and shall be vented at their high and low points.

4.2.6. EXPANSION JOINT

Armored, skid resistant, elastomeric bridge deck joints shall be provided. The joint shall be watertight, easy to install, maintain and replace. All fixings shall be in stainless steel. Anchor bolts shall be 12mm diameter.

4.2.7. ANY OTHER JOINTS

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Joint fillers in expansion joints for structures shall consist of a compressive non-extruding board manufactured from bitumen impregnated fibers.

The sealant applied shall be a cold applied, multi-component, gun-applied material of a grade suitable for hot climate with a service temperature of up to 70o C and high resistance to ultra-violet exposure.

4.2.8. BEARINGS

The bearings and their supports shall be designed and detailed according to IRC= 83. POT PTFE bearings are to be provided with lower and upper steel anchor plates to allow for simple exchange of bearing.

4.2.9. CONCRETE COVER

The following minimum concrete cover shall be provided for reinforcement: Concrete cast against and permanently exposed to earth 75mm Concrete exposed to earth or weather 40mm Concrete deck slabs Top reinforcement 40mm Concrete not exposed to weather or in contact with ground 50mm

4.2.10. REINFORCING STEEL PROTECTION

The reinforcing steel used in the structure will generally be normal high tensile strength reinforcing steel without epoxy coating. It is considered that adequate cover and high quality concrete will provide sufficient reinforcement protection.

4.3. Method of Construction of Superstructure Girders

Un-propped composite construction using precast post-tensioned girders are used for construction of superstructure girders of flyover for all spans. Sequence of construction of superstructure deck is as follows :

(i) Cast the girders on temporary supports on piers

(ii) Stress all the cables after concrete attain a minimum cube compressive strength of 40Mpa

(iii) Remove the shuttering with provision of sufficient lateral support for girders on pier

(iv) Position the bearings on pedestals with anchor bolts in diaphragm

(v) Provide shuttering for superstructure slab and diaphragm by taking support from already cast girders

(vi) Lay reinforcement and concrete the diaphragm and deck slab

(vii) Jackup and remove the support for diaphragm and girders on pier to transfer the loads permanently on bearings

(viii) Construct crash barrier and lay wearing course

The girders are designed for loading during construction stages and service stages as follows :

[1] During construction stage (For the girder section only)

1. Self weight of girder
2. Self weight of wet concrete during construction stage
3. Construction loads
4. Self weight of shuttering during construction stage

[2] During service stage (For the composite section)

1. Superimposed dead load
2. Live load

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For secondary restraint forces, separate analysis is done using moment distribution. Additional reinforcement if required is provided for shrinkage restraint forces and creep restraint forces due to dead load and pre-stress from the output of the analysis.

For the design of additional shear friction reinforcement for the interface of precast girders and cast in situ diaphragm, guidelines as per AASHTO shear friction procedure is followed.

4.3.1. MISCELLANEOUS

4.3.1.1. DRAINAGE PROVISION

Drainage spouts are provided @ 5m interval on either side of the girder with down take pipes to dispose the water below soffit of the girder.

4.3.1.2. GROUND CONDITIONS

Soil pressures and other soil parameters for design shall be determined in consultation with the geotechnical engineer. Allowable bearing pressures for soil or rock shall be based on the soil parameters and provided by the Geotechnical Engineer.

V. ELEVATED HIGHWAY

A 6-lane elevated highway with overall deck width of 24.5 m (0.5m + 11m + 1.5m + 0.5m) supported on a single row of piers is to be constructed from km 551.261 to km 554.983.

Span arrangement for the elevated highway is as follows :

Table 4

Name and Location	Tentative Span Arrangement (m)	Overall Length (m)
Elevated highway between km 551+261 to Km 554+983	13 x 30 + 5 x 27.38 + 5 x 30 + 1 x 46 + 8 x 30 + 6 x 27.38 + 15 x 30 +4 x 27.38 +1 x 46 +16 x 30 +3 x 27.38 + 3 x 30 + 1 x 46 + 9 x 30 + 15 x 27.38 + 8 x 30 + 5 x 27.38 + 1 x 46 + 7 x 27.38	Total length of elevated highway is 3772 m including four obligatory spans of 46m at km 551.960, km 552.980, km 553.670 & km 554.770.

International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 03 , March 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
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Fig. 6

VI. RETAINING WALL

Fig. 7

Here counterfort retaining wall has been provided as shown in the picture.

VII. PIERS

7.1 PREMISE

7.1.1. UNITS

Allunitsaremetricsystemunits:

- Distance: mm,m(meters)
- Weight: kg,t(kilogramsandtons)

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- Time: s(second)
- Force: N,kN,MN(newtons)
- Stress: kPa,Mpa(Pascal)

7.1.2. CODESOFPRACTICE

Calculation is based on the following codes

IRC:6-2000 Standard Specifications and Code of Practices for Road Bridges, Section II–Loads & Stresses (Fourth Revision)

IRC:21-2000 Standard Specifications and Code of Practices for Road Bridges, Section III–Cement Concrete (Plain & Reinforced)

(Third Revision)

IRC:78–2000 Standard Specifications and Code of Practice for Road Bridges, Section VII Foundations and Substructure (Second Revision)

IRC:18-2000 Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete) (Third Revision)

IRC AmendmentsandNotifications

Other Codes and Publications

AASHTO Standard specifications for Highway Bridges,16th edition,1996

AASHTO Guide Specifications for Design and Construction of Segmental Concrete Bridges, Secondedition,1999

AASHTO LRFD Bridge Design Specifications, SIunits, 2nd Edition,1998

7.1.3 MATERIALS

7.1.3.1. CONCRETE

Theme chanical properties of pier's concrete are listed below:

˜ fc=40Mpa(TypicalPiers)

˜ fc=50Mpa(Cantilever Piers)

˜ Conservatively elasticity modulus of32500Mpaor(Es/Ec) ratioof6.2isadopted for flexural stress calculationswhileIRC-21-2000section303permitsaratio(Es/Ec)of10 is permitted.

˜ Density25t/m^3

˜ Expansion coefficient=0.000012C$^{\circ -1}$

The concrete cover for the piers shall beas follow:

˜ Exposedfaces: 50mm

˜ Internalfaces: 40mm

7.1.3.2. REINFORCEMENT

ReinforcementbarsshallbeHighYieldStrengthDeformedBars(gradedesignationFE500)conformingtoIS:1786,orMildSteelBars(GradeDesignationS240)conformingtoIS:432

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MildSteel(IS:432PartI): fy=240MPa

HighYield,DeformedSteel(IS:1786): fy=500MPa

Theelasticitymodulusshallbe200000Mpaforflexuralstresscalculations.

7.2 TYPICAL PIERS

Onlyonesection(atthebottomofthepier)ateachpierlocationisverifiedforthe typicalpiers.

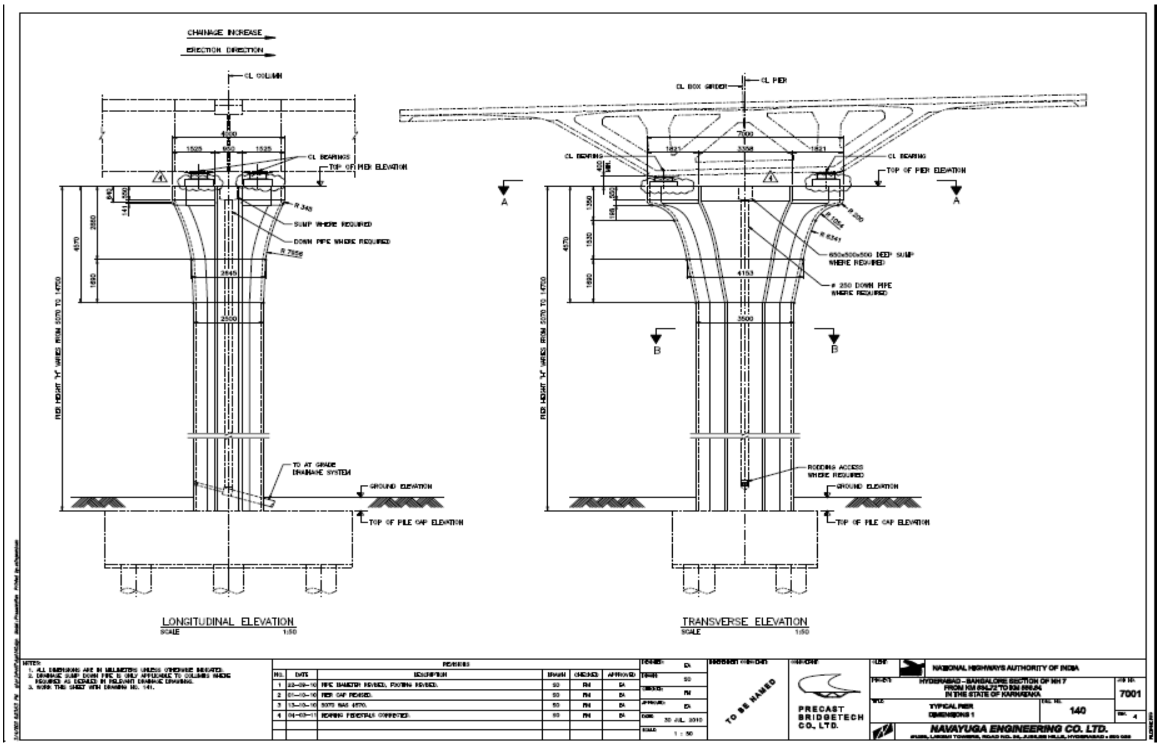

Fig. 8

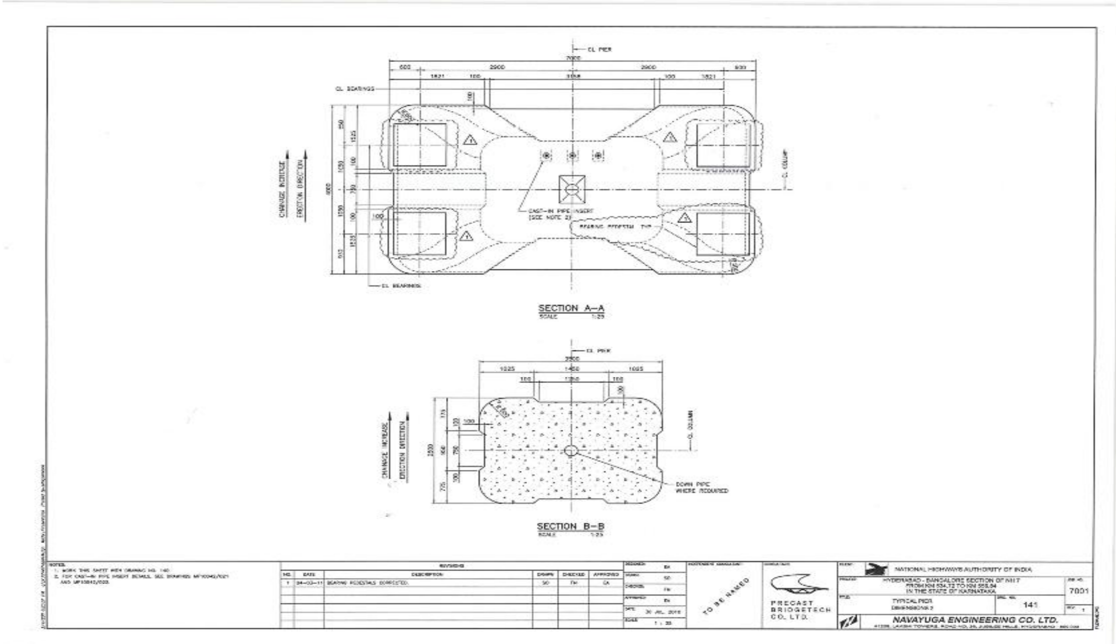

Fig. 9

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ISSN (O) 2319 - 8354
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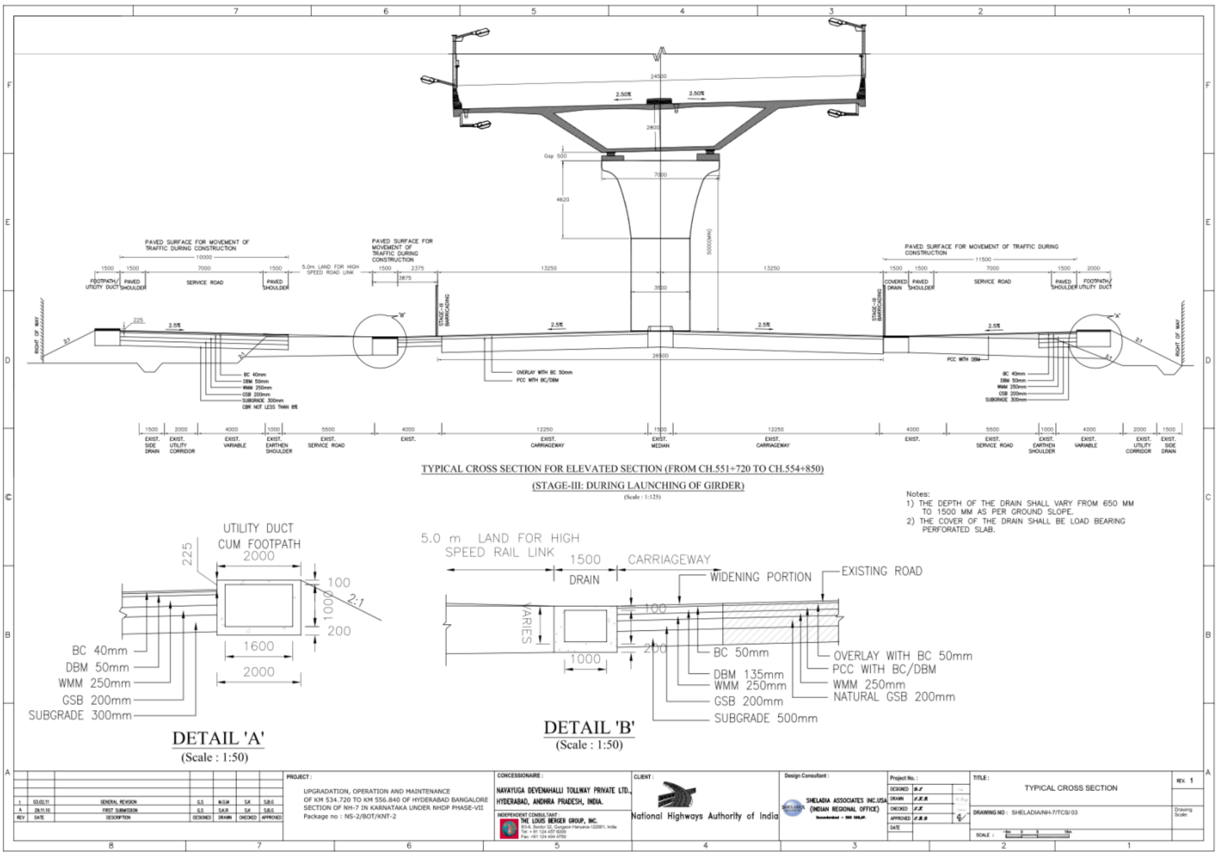

Fig. 10

Fig. 11

In the above photograph, we can seen the detailing of the typical pier and the water drainage duct pipe can also be seen in the photo.

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Fig. 12

In the above photograph, we can see the detailing of the bearing plate slab or pedestal slab at the top of pier.

Fig. 13

In the above photograph, we can see the formwork of the typical pier.

Fig. 14

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In the above photograph, we can see the detailing reinforcement of the typical pier.

7.3 CANTILEVERPIERS

Thecantilever piershavethelongitudinal reinforcement continuous frombottomofthepier sectiontothetopofpier.Therefore,thecontrollingsectionforcantileverpiersisatthebottom of thepier.Thereinforcementforthecantilevercap isvariedundertheseparatesectionas CantileverPierCap. These piers are provide where the large junction is present below the elevated highway.

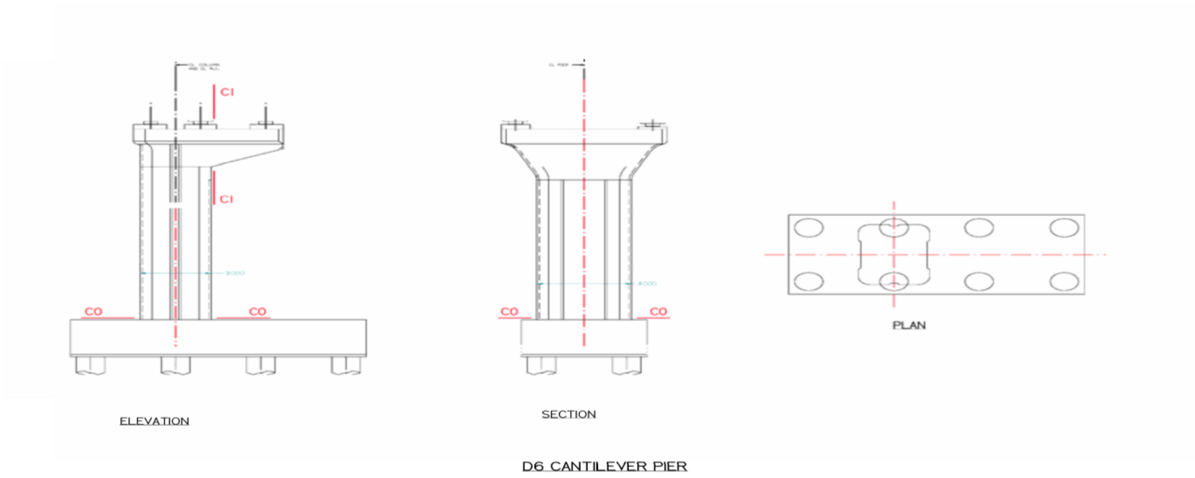

Fig. 15

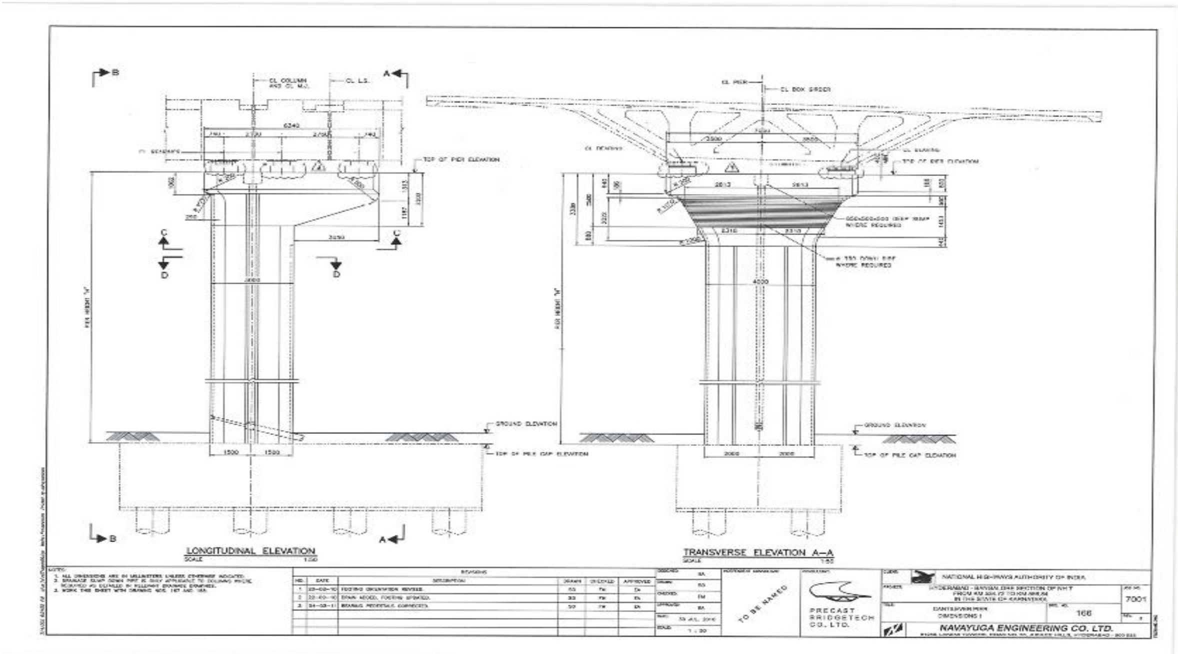

Fig. 16

In the above drawing, we can seen the front view and side view of the cantilever pier.

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ISSN (O) 2319 - 8354
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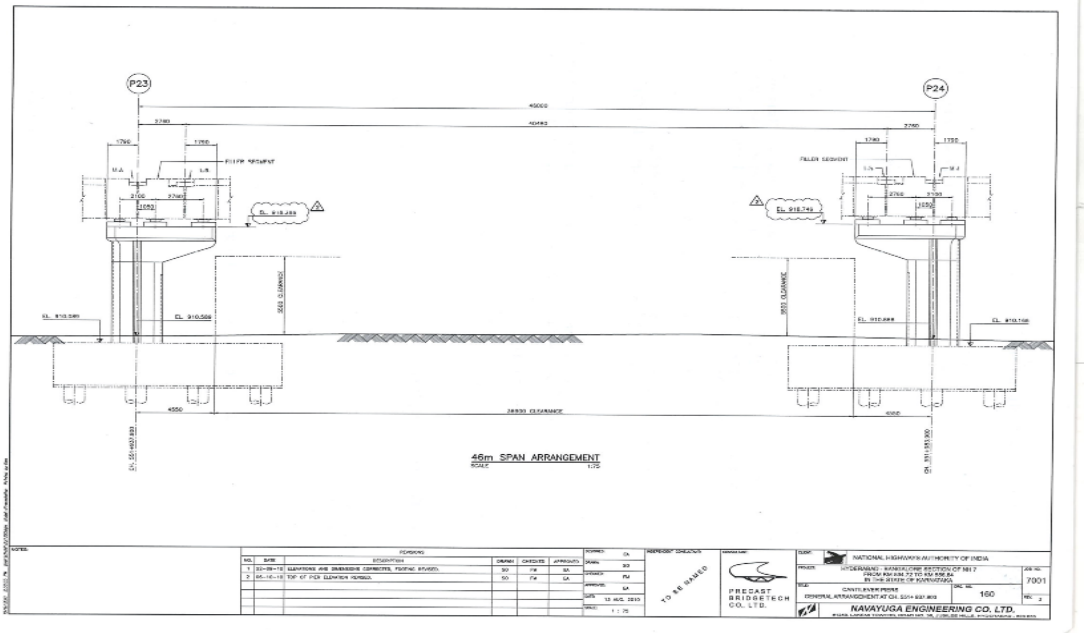

Fig. 17

In the above drawing, we can see the side view and c/c distance between two cantilever piers.

Fig. 18

In the above picture, we can see that the segment is not casted completely due to large section or distance between the two cantilever piers. Hence the remaining portion is being casted of constructed on site after placing of segments and post-tensioning is completely done. In the above picture, the scaffolding is provided and formwork is done for construction of remaining slab of segments.

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Fig. 19

VIII. BEARING PLATES

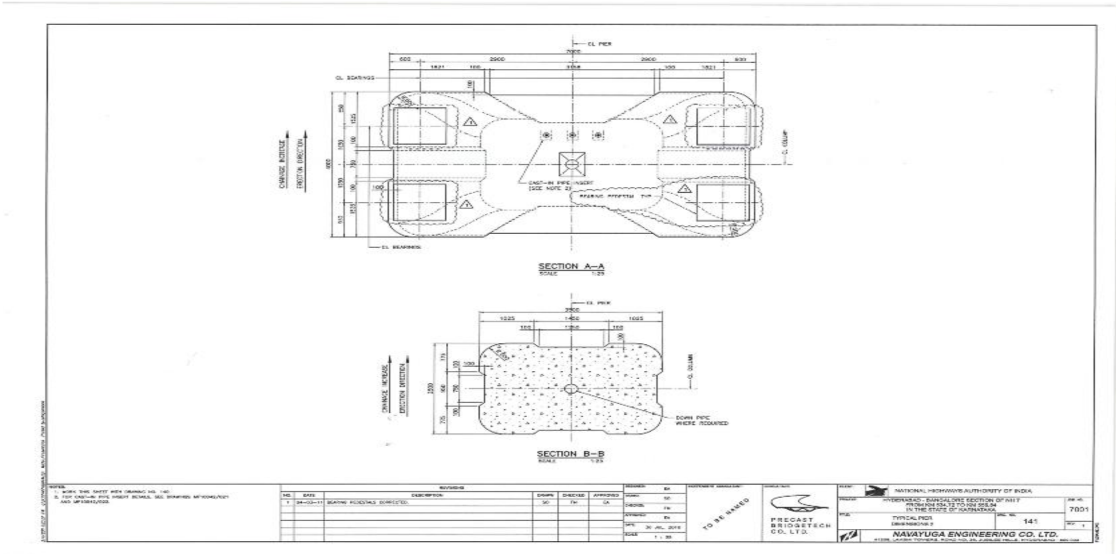

Fig. 20

In the below pictures, bearing plates and slabs can be seen on the top cap of the pier.

Fig. 21

IX. TENDONS

A stretched element used in a concrete member of structure to impart prestress to the concrete. Generally, high tensile steel wires, bars cables or strands are used as tendons.

Fig. 22

In the above picture, a 7 strand high tensile carbon steel tendon is shown which is used in post-tensioning of the elevated structure.

X. ANCHORAGES

A device generally used to enable the tendon to impart and maintain prestress in concrete. The commonly used anchorages are the Freyssinet, MagnelBlaton, Gifford-Udall, Leonhardt-Baur, LeeMcCall, Dywidag, Roebling and B.B.R.V. systems.

In this structure different sizes (i.e. with different hole numbers.) of Freyssinet anchorage systems are used for post-tensioning of structure.

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Fig. 23

In the above picture, a 7 strand high tensile carbon steel tendon is shown which is anchored by using 19 holed Freyssinet system.

XI. SEGMENTS DESIGN STRUCTURE

In this structure two types of segments are used. First, which has a small section and the second with a large section of structure. The smaller sectioned segment structure is used in middle or intermediate of two larger section segments like sandwiched between the two larger sectioned segments.

These larger section segments are placed or rested on bearing plates of the pier which carries and transfers high moment to the pier.

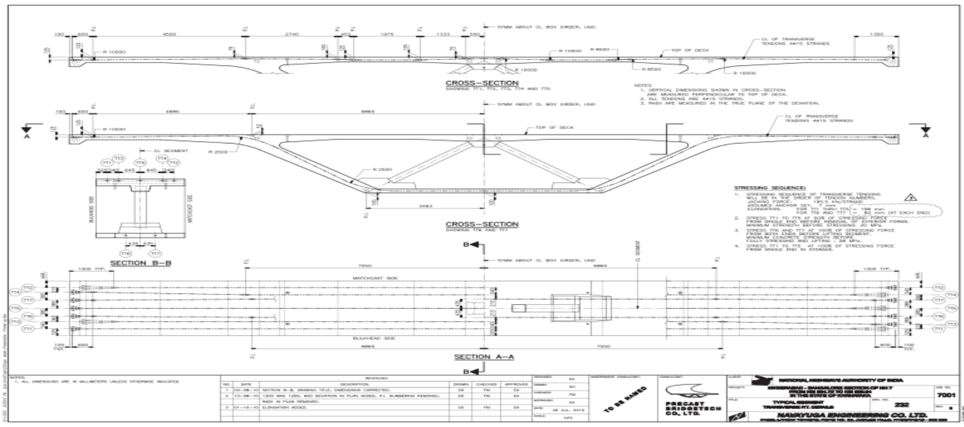

Fig. 24

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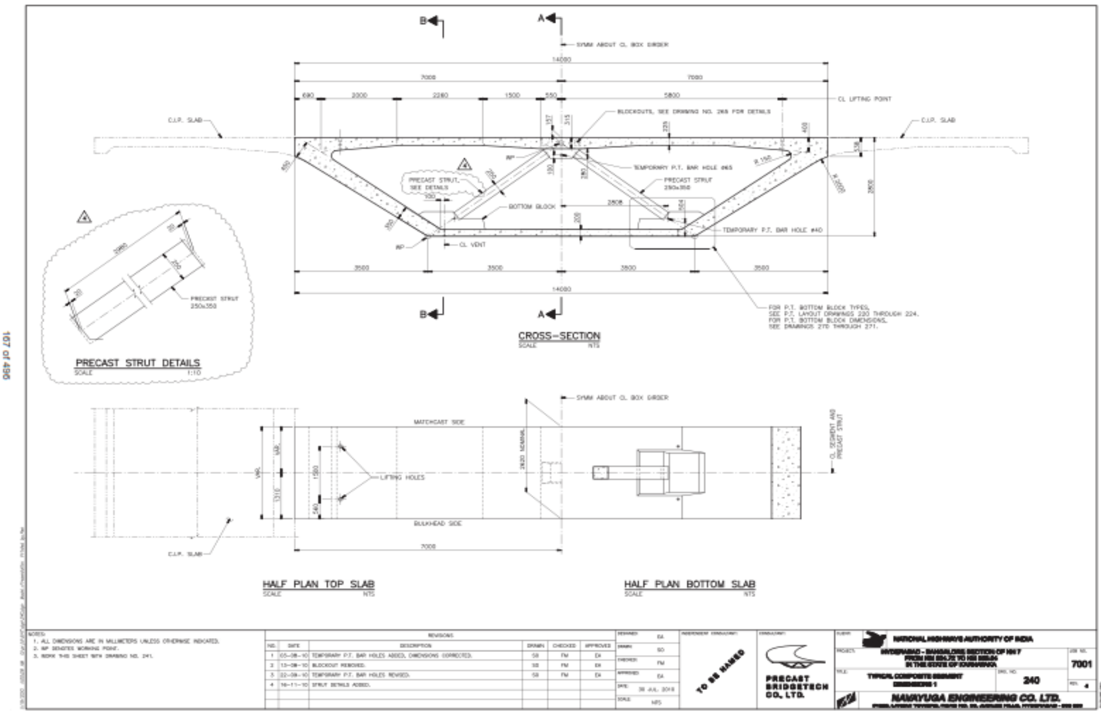

Fig.25

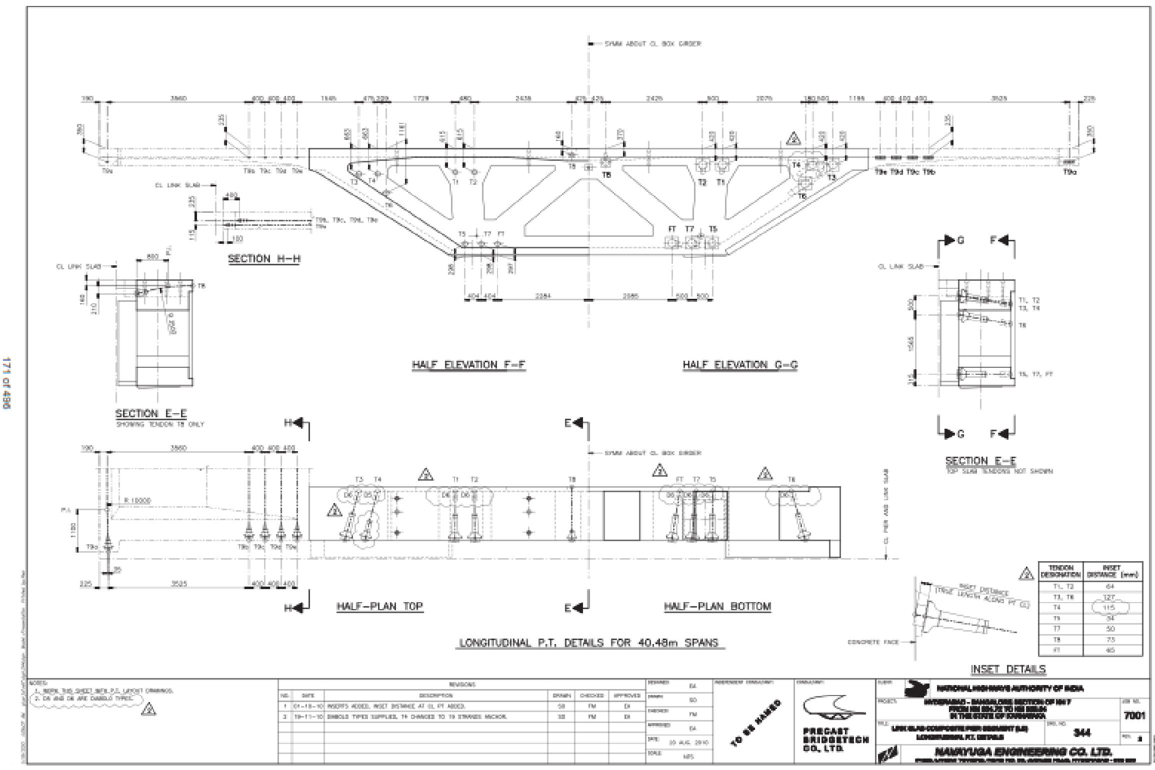

Fig. 26

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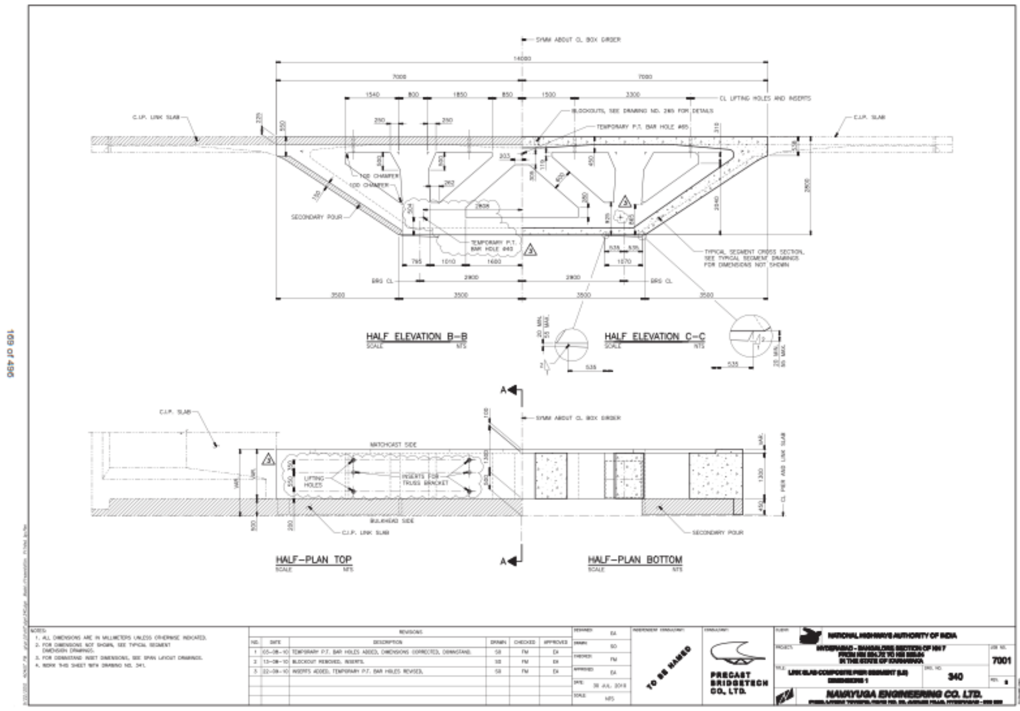

Fig. 27

In the below two drawings, the section of segments are shown and placing of post-tensioning tendons duct pipes are shown.

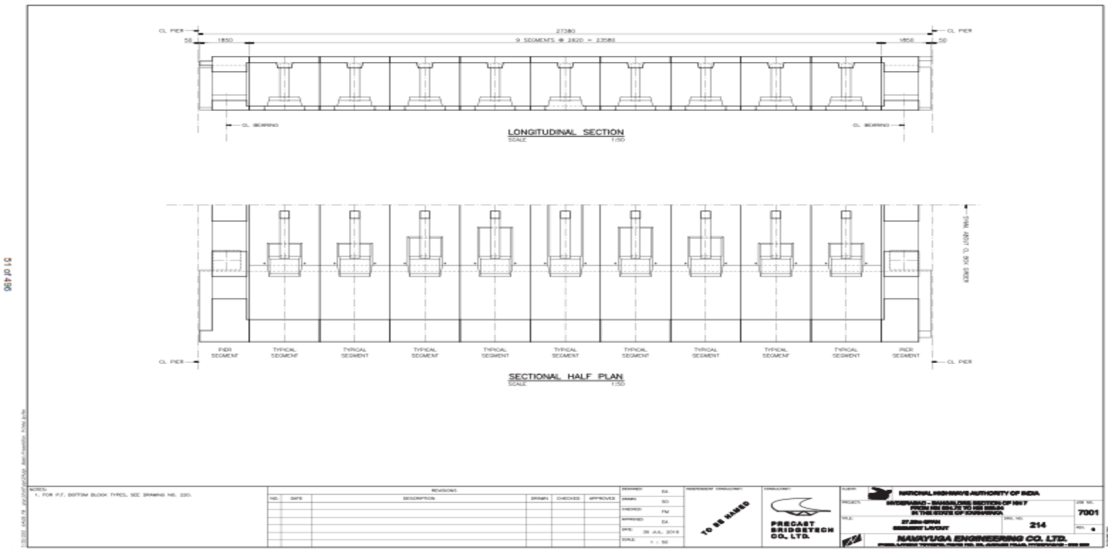

Fig. 28

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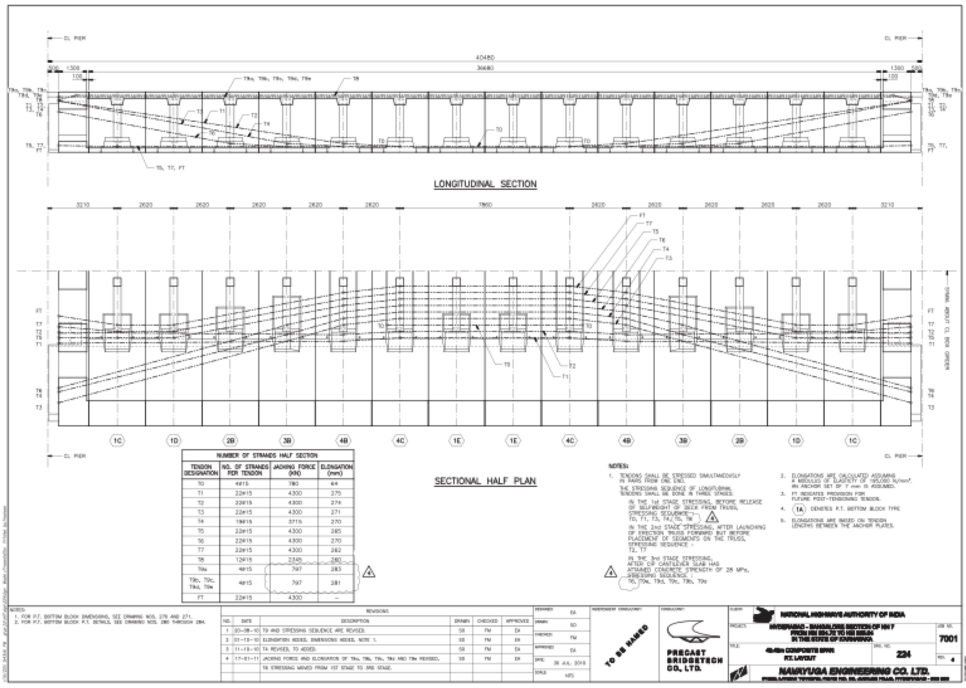

Fig.29

In the below picture, typical segment is shown.

Fig. 30

We can see the interior part of the elevated highway after placing and joining of segments in the below picture.

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Fig. 31

In the below picture, we can see the attachment of vibrators to the mould of segment used for precasting.

Fig. 32

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Fig. 33

In the above picture, the spider machine is being rested on the piers and the placing of the segments are taking place.

Fig. 34

In the above picture, the mould of the segment and the reinforcement of the segment can be seen.

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Fig. 35

In the above picture the reinforcement of the top slab can be seen with conduit sheets/pipes carrying prestressed tendons in transverse direction.

In the below pictures, high sectioned reinforced segment are shown which is placed on the piers.

Fig. 36

Fig.37

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XII. TRANSVERSE PRESTRESSING IN SEGMENTS

In the below photographs, we can see the prestressed tendons in the transverse direction in the segments.

Fig. 38

XIII. POST-TENSIONING

Fig. 39

In the above pictures, the conduit pipes can be seen passing through the holes of the segments, thus post-tensioning the segments.

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Fig. 40

In the above picture, the prestressing conduits carrying 6 tendons each can be seen. The end reinforcement which can be seen erected are used for tieing of bars with pre-casted crash barriers on the elevated highway.

Fig. 41

In the above picture, the prestressing conduits carrying 6 tendons each can be seen.

XIV. PRECASTED STRUTS

The size of the pre-casted strut is 2980 x 250 x 300 mm.

Fig. 42

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In the above photograph, the precastingmoulds of struts can be seen.

Fig. 43

In the above photograph, the curing of the precasted struts is going on.

Fig. 44

In the above two pictures, the tie up of reinforcements of the struts to the segments is shown.

XV. WATER DRAINAGE SYSTEM FROM ELEVATED HIGHWAY

Fig. 45

In the above two pictures, the conduit pipe and drainage facility can be seen from top slab surface to the drainage system through the pier.

Fig. 46

In the above pictures, the conduit pipe and drainage facility can be seen provided through the pier to the drainage system below the ground level.

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XVI. EXPANSION JOINT

The expansion joint is provided on the pier between two spans. These joints are provided to relieve the stresses induced in the structure due to expansion in the structure due to temperature variation etc.

Fig.47

XVII. TRANSPORTATION

The below picture shows the transportation of The below picture shows the transportation of segment segment by the girder in the casting plant site. By trailor from casting plant to actual construction site.

Fig.48

XVIII. PLACEMENT AND FIXING OF SEGMENTS

For carrying and placing of segments, the SPIDER WEB machine is used. It carries the total number of segments at a time between the erected span of structure and fixes the segments according to the male-female combination in an alignment.

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Fig. 54

XIX. ADVANTAGES OF PRECAST PRESTRESSED POST-TENSIONED BRIDGES AND ELEVATED HIGHWAYS

19.1 Benefits to Owner Agencies

- ✓ Reduction in the duration of work zones
- ✓ Reduced traffic handling costs
- ✓ Reduced accident exposure risks
- ✓ Less inconvenience to the traveling public
- ✓ Fewer motorist complaints
- ✓ Fast constructionbenefits owner agencies by reducing the duration of the work zone. Fast construction reduces traffic handling costs and accident exposure risks. There's less inconvenience to the traveling public, fewer delays, and fewer motorist complaints. The speed and variety of precast prestressed products and methods give designers many options.
- ✓ Due to B.O.T system of contract good quality of structures can be built up by the contractors.

19.2 Benefits to Contractors

- ✓ Reduced exposure to hazards
- ✓ More work -- less time
- ✓ Fewer weather delays
- ✓ Lower costs
- ✓ Contractors benefit from reduced exposure to traffic hazards. More work can be accomplished in less time, with fewer weather delays. Costs are lower for forms, skilled field labor, scaffolding and shoring, and cranes.

19.3 Scheduling Control

After foundations have been completed, scheduling can be controlled by a single contractor working with a familiar material.

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19.4 Stockpiled in Advance

Fully-cured precast concrete structural elements can be stockpiled in advance of need.

Fig. 70

19.5 Immediate Delivery and Erection

19.6 No Curing Time

There's no curing time required at the jobsite, as with cast-in-place concrete. Bridge piers can be erected in a day, and beams can follow immediately.

XX. CONCLUSION

The pre-cast, prestressed, post-tensioned structures are highly reliable and the construction work period is also less. It has a smaller section as compared to cast-on-site structure and can carry heavier stresses and loads on it. Hence, this kind of construction practice is generally used every-where in the construction of bridges in the world.

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