DESIGN AND ANALYSIS OF RAILWAY UNDER BRIDGE (RUB) BY USING BOX PUSHING METHOD

M.A.Rahman¹, G. Raju²
1Associate Professor, 2Student of M.Tech, 
Department of Civil Engineering, Guru Nanak Institutions, Hyderabad, Telengana.

ABSTRACT: The project entitled analysis and design and execution of cross traffic works in railways using box pushing technique (RUB), illustrates about the work to be carried out for the widening of existing roads using box pushing techniques for rail under bridges. It also explains about the methodology involved in execution of box pushing technique. The design will be carried out as per Indian standards, particularly Indian railways standards, IRC, IRS, and IS CODES. In which the design of major components thrust bed, precast box used for the widening are done as per IRS codes. The design of pre cast box is done using STAAD pro, it also includes the layout of reinforcement details of two important structures used in this method apart from conventional method i.e., thrust bed (main bed and auxiliary bed), pre cast box. In railways whenever there is a need to make a underpass ,either for canal crossing, RUB’S(Rail under bridges), programme of widening existing railway culverts etc. BOX PUSHING TECHNIQUE is used. Since the work has to be done without interruption to rail traffic, box pushing technique is largely favoured in comparison to conventional methods. Present day Intensity of Traffic, both Rail & Road due to the fast development, is very heavy it cannot the disturbed, for construction of under bridges or Canal Crossings, drainage etc. by conventional i.e. open cut system. Box Pushing Technique is developed where in R.C.C. Boxes in segments are cast outside and pushed through the heavy embankments of Rail or Road by Jacking.

Keywords: Cross Traffic Works, Box Pushing Technique, Rail Under Bridge (RUB),IRC,IRS, IS Codes.

I. INTRODUCTION

1.1 General
In railways whenever there is a need to make a underpass ,either for canal crossing, RUB’S(Rail under bridges), programme of widening existing railway culverts etc. BOX PUSHING TECHNIQUE is used. Since the work has to be done without interruption to rail traffic, box pushing technique is largely favored in comparison to conventional methods. Transportation is one of the main objects in the infrastructure of a developing country like India. Most of the Indian intra national transportation is done by railways. Railways were first introduced to India in 1853 from Bombay to Thane. In 1951 the systems were nationalized as one unit, the Indian Railways, becoming one of the largest networks in the world. Comprising 115,000 km (71,000 miles) of track over a route of 65,000 km (40,000 miles) and 7,500 stations. Sixteen Zones in 2003. Each zonal railway is made up of a certain number of divisions, each having a divisional headquarters. There are a total of sixty-eight divisions.

1.2 Comparison with Other Conventional Methods
Box pushing technique is much better when compared with the other conventional methods like open-cut systems, as the open-cut method requires excavation, digging, placing etc., which causes inconvenience to the movement of vehicles and traffic problems., but whereas the box pushing technique does not make any disturbance to the existing traffic but also provides widening of existing road within a short period of time.

1.3 The Need of Box Pushing Technique
• Present day Intensity of Traffic, both Rail & Road due to the fast development, is very heavy it cannot the disturbed, for construction of under bridges or Canal Crossings, drainage etc. by conventional i.e. open cut system.
• Box Pushing Technique is developed where in R.C.C. Boxes in segments are cast outside and pushed through the heavy embankments of Rail or Road by Jacking.

1.4 OBJECTIVES
In the present dissertation work on ANALYSIS & DESIGN OF BOX PUSHING TECHNIQUE. Analytical models of BOX PUSHING TECHNIQUE are prepared and analyzed by using STAAD PRO software. In the current study, work is carried out on the methodology of the box pushing technique, which provides widening of existing RUB at Chicksugur, Raichur dist.

II. METHODOLOGY

2.1 General
• Excavation
• Casting of Thrust Bed
• Fabrication of Front and Rear shield
• Box Casting and placing
• Pushing-shifting pushing operation
• Miscellaneous works
• Precautions

2.2 Box Pushing Operation
• To push precast box segment, reaction is obtained from thrust bed. For this, screed is dismantled at pin pocket location, pin pockets are cleaned, pins are inserted and Hydraulic Jacks- 8/10 nos. are installed
between pins and bottom slab of the box with packing plates and spacers.

- A 20mm thick plate is provided, butting against bottom slab of box, in front of the Jacks to avoid damage to concrete surface.
- Nail anchor plates are removed and earth is manually excavated in front of cutting edge in a way to get annular clear space of 300mm all-round.
- Anchor plates are refixed in position and uniform pressure is applied to the jacks through Power Pack.
- After complete push (maximum 300mm) jacks are released, protruding nails are gas cut/driven and jacks again packed with packing plates and spacers.
- Process is repeated till front box is pushed to required position.
- Then 2nd box segment is slewed and brought in position behind 1st box segment.
- 8 nos. Jacks, each of 200 Tons capacity, are housed between two box segments in addition to 8 nos. Jacks already provided between thrust bed and 2nd box segment.
- 3 nos. Jacks, each of 100 Tons capacity, are provided in 3 slots made in each sidewall to facilitate correction of line and level of box during pushing.
- Earthwork is now done in front of 1st box segment and it is pushed. Protruding nails are gas cut/driven and anchor plates are refixed in position.
- Thereafter, jacks housed between two box segments are released and then 2nd box segment is pushed.
- Process is repeated till both the box segments are pushed to required position.
- Cutting Edge is dismantled & front face of 1st box segment is cast in plumb.

2.3 Stages in Execution of Work
1. Excavation for thrust bed and auxiliary bed.
2. Concreting of thrust bed & pin pockets.
3. Casting of box segments.
4. Protection of track & embankment.
5. Arrangement of adequate capacity jacks with power pack.
6. Pushing operation.
7. Construction of Wing wall/Toe wall/Return WALL.

2.4 Major Components of Rub:
1. THRUST BED
2. PRECAST BOX
3. FRONT SHIELD
4. REAR SHIELDS
5. PINS POCKET
6. HYDRAULIC JACKS

III. RESULTS AND DISCUSSIONS
3.1 Analysis and Design of Thrust Bed
3.1.0 Introduction
This report contains design of Thrust Bed for precast RCC single box to be pushed inside the embankment for “Proposed RUB, at Chicksukur Railway station, Near Sakthinagar in Raichur –Karnataka district”, on either side of existing RUB with Box of size 7.5 x 5.5 mt at Railway Km 205/200-300 Phase –I.

3.1.1 Design Data
- Rail level = 108.907
- Formation level = 108.232
- Size of box = 7.500x5.650
- Top of bottom slab of box = 101.257
- Top of box = 107.657
- Top of thrust bed (top of screed) = 100.507
- Earth cushion (from top of box) = 0.575
- Thickness of top slab = 0.750
- Thickness of bottom slab = 0.750
- Thickness of wall: outer wall = 0.750
- Out to out width of box = 9
- Out to out height = 7.150
- Total pushing length = 22
- No of segments = 2
- Length of first and second segments = 11.00
- Thickness of thrust bed = 0.750
- Concrete grade = M25
- Steel grade Fy = 500
- Bulk density of soil = 2.10 t/m³, taken on conservative

3.1.2 Dead Loads
3.1.2.1 Vertical Loads
As normally in railways, total weight of 6750kg/m including track str.is to be taken

Hence for total no of tracks = 1x6750 = 6750 kg/m
Total weight of P.Way on top of box unit = 6750x11 (length of box unit) = 74250 kgs = 74.25 T

3.1.2.2 Earth Filling Cushion
So total UDL on top of slab of box will be = 1.208x9(o/o width) x11 = 119.54 T
Hence Total Weight at Top = 74.25+119.54 = 193.79 T

Load on Bottom Surface = load on top +self-weight of box
Weight of Box = 9.00X0.750X2X2.50 = 33.75
Weight of Vertical Walls = 5.650X1.50X1.25 = 21.19
Haunches = 4.00X0.15X0.075X2.50 = 0.11
Total Weight per Meter = 55.05
Weight of One Segment = 55.05X11 = 605.5 T
Load on Bottom Surface = 193.79+605.55 = 799.3 T

3.1.2.3 Earth Pressure
From bottom of the box
Soil parameters θ = 28.00 δ = 9.33
Active earth pressure co-efficient ka 0.3344
[B] EARTH PRESSURE [Ref: cl – 5.7 of IRS code for sub str. & Foundation]

\[
Ka = \frac{\cos^2(\theta - \alpha)}{\cos^2\alpha \cos(\alpha + \delta) \left(1 + \frac{\sin(\theta + \delta) - \sin(\theta + \alpha)}{\sin(\theta - \delta) \cos(\theta + \alpha)}\right)^2}
\]

\[
\cos(\theta - \alpha) = 0.7797
\]
\[
\cos(\alpha + \delta) = 0.9868
\]
\[
\sin(\delta + \delta) = 0.6064
\]
\[
\sin(\theta + i) = 0.4694 \\
\cos(\alpha - \delta) = 0.9868 \\
\cos(\alpha - i) = 1.0000 \\
K_a = 0.3344
\]

Hence earth pressure at top of box = 0.50 x 0.14 x 10.20 = 7.15

Earth pressure at the bottom of box = 5.43 x 10.20 = 7.73

Earth pressure at bottom of the box = 0.3344 x 2.10 x 7.73

Hence total earth pressure on wall = 0.50(0.40 + 0.53) x 7.15 = 20.840

Hence total load on wall = 20.840 x 10.00 = 229.242

3.1.2.4: Live Load Surcharge: Ref Design Of Box Para: 3.5
For two tracks pressure at top = 1142.51 kg/sq.m
For two tracks pressure at bottom = 675.29 kg/sq.m
Hence total load = 0.50 (1.14 + 0.68) x 7.15 = 6.499

Hence total load on wall = 6.499 x 11.00 = 71.49 T

Live load for box: as at the time of pushing, there will not be any train
3.1.2.5: Total Pressure on Box Segment
THE LOADS BELOW ARE FOR 1 UNIT OF BOX.
On top surface = 193.79 x 1.00 = 193.79
On bottom surface = 799.34 x 1.00 = 799.34
On two walls = 2.00 x 229.24 x 1.00 = 458.47
Live load surcharge = 2.00 x 71.49 x 1.00 = 142.97
Live load of train = 1.00 x 131.00 x 1.00 = 131.00
Total load of box = 193.79 + 799.34 + 458.47 + 142.97 + 131

= 126.39 x 2.50 = 315.99
Additional resistance required = 804.12 – 147.25 = 656.87 T

This additional resistance will be available from thrust wall provided at rear of thrust bed, the resistance available from keys is also calculated.
3.1.3.3: Passive Pressure on Thrust Wall
Thrust wall at end has been provided Passive earth pressure co-efficient for vertical face of wall:

\[
K_p = \frac{\cos^2(\theta + \alpha)}{\cos^2(\alpha - \delta)} \frac{1}{\sqrt{\frac{\sin(\theta + \beta) - \sin(\delta + \gamma)}{\cos(\alpha - \delta) - \cos(\beta + \gamma)}}}
\]

\[
\cos(\theta) = 0.7660 \\
\cos(\theta + \alpha) = 0.7660 \\
\cos(\alpha) = 1.0000 \\
\cos(\alpha - \delta) = 0.9730 \\
\sin(\theta + \delta) = 0.8021 \\
\sin(\theta) = 0.6428 \\
\sin(\theta + i) = 0.8192 \\
\cos(\alpha - i) = 0.9659
\]

Passive earth pressure Co-efficient Kp = 22.45

Passive pressure with cohesion is given by

\[
P_p = 0.5 x W x H x K_p + 2 \times 10.20 x H [K_p]^{1/2}
\]
[1] [2]

Hence advantage of adhesion at two locations can be taken.

[1] PASSIVE RESISTANCE AVAILABLE FROM THRUST WALL
W = 1.80 T/cu.m, bulk density taken conservatively
H for wall in front = i.e. only one thrust wall
H for end wall at end of the Bed = 2.00 [0.80 = 1.20 below the Bed]
Kp = 22.45 [wall above the Bed 7th bed]
L for end walls only = 10.20
C = Kg/sq.cm Ref: Soil report at th-bed level
For M20 concrete, effective depth required factor will be 1.7. Considering jack load as load due to earth pressure, design load = 46.68 = 32.33X1
Hence max. BM in the thrust wall taking section at the bottom of the thrust bed:

Design BM = 1.70X46.48 = 79.354 T-m = 79.49 KN-m
For M20 concrete, effective depth required factor will be 1.7.

Max force = 824.49 T
Max force to be resisted by thrust wall = 824.49 T
Hence forces per meter will be = 829.29/10.20 = 80.83
The equivalent passive force diagram will have the magnitude of above
Hence the ordinate of the resisting force will be = 1/2 x base x height = 80.83
Hence base = 80.83
And ordinate at bottom of the thrust bed = 32.33
Ordinate at de away from bottom of thrust bed = 58.20
Hence max. BM in the thrust wall taking section at the bottom of the thrust bed:
Rectangle+Triangle
= (32.33X1.20X1.20/2.00)+(0.50X48.50X1.20X1.20X0.67)
= 46.68
Considering jack load as load due to earth pressure, design factor will be 1.7.
Hence

\[ B = 0.5 \times w x h x k p + 2 c h (k p) \]
(V+0.4-SVC)= 1.43-0.43= 1.00
0.87xFy =0.87x415.00 = 361.05
Asv =150000x1.00/361.05= 417.13
Hence provide 10mm rings connecting 2 bars 150 c/c
As main bars are provided at 140 c/c no’s of legs in 1 m
strip=7
Hence area of shear steel provided will be =7.00x78.54
=549.78 549.78 which is >417.13 Hence safe

3.1.5 Design of Thrust Bed
3.1.5.1 Data
Thickness of thrust bed = 750.00mm
Width of thrust bed = 10200.00mm
Concrete grade = M25
Jacking force required = 804.12T

Actually, this is a temporary structure, hence it can be
designed without load factors, or less factors can be used,
however, as per IRS code following been assumed.

\[
\text{FORCE PER METER OF BOX} = \text{loads x factor}
\]

On top surface:
\[
\begin{align*}
\text{On top surface} &= 193.79x1.40 = 271.31 \\
\text{On bottom surface} &= 799.34x1.40 = 1119.08 \\
\text{On two walls} &= 458.47x1.70 = 779.40
\end{align*}
\]

Live load surcharge:
\[
\text{Live load surcharge} = 142.97x1.70 = 243.05
\]

Live load of train:
\[
\text{Live load of train} = 131.00x1.70 = 222.70
\]

Total Load:
\[
\begin{align*}
\text{Total Load} &= 271.31+1119.08+779.40+243.05+222.70 \\
&= 2635.54
\end{align*}
\]

Factored friction force will be:
\[
\text{Factored friction force will be} = 2635.54\times0.466
\]

Hence factored force per pin will be:
\[
\text{Hence factored force per pin will be} = 1228.16
\]

Jacking pins provided in the bed in a row are=6.00

Jacking force per pin = 204.69 T

Eccentricity = 0.3000

Max BM for thrust bed = 1228.16X0.300
= 368.449 T m

Hence factored moment = 1.00\times10\times368.45
= 3684.49 KN-m

Hence moment per meter will be:
\[
\text{Hence moment per meter will be} = 3684.49/10.20
\]= 361.22KN-m

Effective depth of bed = 750.00-80.75
= 662.50

3.1.5.3 Reinforcement Calculation:

\[
\begin{align*}
\text{BM} &= 361.22\text{KN-m} \\
\text{Effective depth} &= 750.00-75.00-12.50 \\
&= 662.50
\end{align*}
\]

To calculate Mu for given percentage of steel
\[
\begin{align*}
\text{Fy} &= 500.00, \text{so} 0.87\text{ Fy} = 435.00 \\
\text{Pst} &= 0.2374, \\
\text{soPst/100} &= 0.0024
\end{align*}
\]

Hence provide 10mm rings connecting 2 bars 150 c/c
As main bars are provided at 140 c/c no’s of legs in 1 m
strip=7
Hence area of shear steel provided will be =7.00x78.54
=549.78 549.78 which is >417.13. Hence safe

3.1.5.4 Tension, taken by concrete

\[
\begin{align*}
\text{Tension Taken By Concrete Will Be:} &= \text{Total Width Of The} \\
\text{Bed Thickness Of Thrust Bed Below Pocket X6.1kg/Cm²} \\
\text{Area of thrust bed} &= 1020x75 = 76500 \\
\text{Less area of pockets} &= 1x6x2750 = 16500 \\
\text{Total area of plain concrete will be} &= 60000
\end{align*}
\]

Tensile force taken by concrete:
\[
\text{=60000x6.1/1000} = 366 \text{T} \text{ref: IRC}21, \text{cl}303.3)
\]

Total required force =1228.16 T factored force, with load factors as per IRS

Hence steel required for force=1228.16-366=862.16 T

Hence area of steel required for axial tension:
\[
\text{= 862.16x1000x1x10/ (0.87x415) = 238.79 cm²}
\]

Hence area required per meter will be 238.79/10.20=23.41

This steel will be divided at top and bottom of the thrust bed.

Hence tension steel at top = 0.475/0.75x23.41
= 14.83 cm²
Hence tension steel at bottom=23.41-14.8 =8.58 cm2
However take 50% at bottom =23.41/2 =11.71
Hence total area of steel required at bottom will be
=11.71+15.73=27.43 cm2
Provide 20mm, main bars, so the spacing will be
= (3.14/27.43)x1000=114.52
OR
Provide 25mm, main bars, so the spacing will be
= (4.90/27.43)x1000=178.93
HENCE PROVIDE 20 MM BARS AT 100 MM C/C
OR
PROVIDE 25 MM BARS AT 160 MM C/C
REINFORCEMENT AT TOP OF THE THRUST BED:
Reinforcement required at top is=14.83 cm2
By providing 16mm steel spacing required will be
=(2.01/14.83)x100=13.56 cm
However provide 16mm bars at 130mm c/c
3.1.5.5 Distribution Steel
0.12% AS RINGS are provided to form a complete beam,
there is no need of distribution steel
However provide 0.12%
(0.12x100x66.25)/100 = 7.95
On each face = 3.98 cm2
Inside the all, provide 10mm bars at 170mm c/c, through steel
Ast provided = 4.62 cm2>3.98 cm2
Hence safe

3.1.6: Design of secondary thrust bed for pushing of second box, casted behind first box
3.1.6.1 Force per pin
Thicknes of Thrust Bed = 750.00mm
Width of thrust bed = 10200.00mm
Concrete grade = M-25
Self-weight of box = 605.55 T,(ref Para 2.2)
Hence jacking force required = 605.55x0.466= 282.19
Jacking force required = 282.19 T
As length of second box is less=605.55x11.00/11.00 =605.55mm
Force per meter of box on bottom force =605.55x1.70
=1029.44
Factored friction force will be=1029.44x0.466
= 479.72
Hence factored force per pin will be=479.72/3.00
=159.91

3.1.6.2: Jacking force
Jacking force will be applied against jacking pin and jacking pin will transfer the load inside the pocket, as couple, hence eccentricity =0.300
Jacking pins provided in the bed in a row are=3.00
Jacking force per pin =159.91 T
Max BM for thrust bed =159.91x0.300=47.972 T
Hence factored moment = 1.00x10.00x47.97=479.72 KN-m
Hence moment per meter will be=479.72/1.00=479.72 KN-m
3.1.6.3 Reinforcement Calculation
BM = 479.72 KN-m
Effective depth = 750.00-75.00-12.50= 662.50
Total calculated Mu for given % of steel

FY = 500
Pst = 0.266
Fck = 25
B = 1250.00
De = 662.50
So, 0.87xFy = 435.00
So, Pst/100 = 0.0027
Fy/Fck = 20.00
Bd2 = 548632813
Hence Mu = 0.87Fyx
(Pst/100) x [1-1.1xFy/Fck(Pst/100)]bd2
Mu/bd2 Based on Pst
= 435.00x0.0027 (1.00-1.100x20.00x0.0027) =1.09
Mu/bd2 Based on BM
= (479.72x1000000)/(1000x662.50x662.50) =1.09
As both sides are equal Pst calculated is OK
Pst required = 0.266
Hence area of steel = 125.00x66.25x0.00266 = 22.04
Hence areas required per meter will be = 44.29/1 =44.29
This steel will be divided at top and bottom of the thrust bed i.e.,44.29/2=22.14
Hence total area of steel will be=22.145+22.04
= 44.19sq.cm
Provided 25mmmain barsno of bars required
=44.19/4.91x1.00=9.00
However provide 25mm bars 10 no’s
Reinforcement at Top of Thrust Bed:
The reinforcement required at top is =22.14 sq.cm
Hence provide 6 no’s 20mm bars+3 no’s 16mm bars
Ast provided =24.88cm>22.14cm
Hence safe
3.1.7 Detailing in the Keys
The keys are provided for additional safety.
Hence provide steel 10mm bars of 160 c/c as main links connecting to thrust bed, and 9 bars @8mm bars as distribution steel.
3.1.7.1 Design of Keys in Thrust Bed
Pressure at top of key = 30.31(ref Para 3.3(2))
Pressure at bottom of key = 54.56
Max BM in key =42.44x0.60x0.60/2.00=7.64 T-m
Hence factored moment= 1.70x10.00x7.64=129.86KN-m
Hence moment per meter will be= 129.86x1.00
=129.86 KN-m
Effective depth of key = 600.00-87.50 =512.50
Reinforcement Calculation:
BM = 129.86KN-m
Effective depth = 600.00-50.00-12.50 = 537.50
To calculate Mu for given % of steel

Copyright 2018. All rights reserved.
www.ijtre.com
Design of Plates at Top and Bottom and Sides:

3.1.7.2 Design of Front Cutting Edge:
The front cutting edge has been provided with face plate of 10 mm with holdfast at the time of casting of box. With this face plate cutting edge will be welded, and for support to the cutting edge, stiffeners are provided at 450 c/c at top, and 450 c/c at bottom.

**Plate thickness provided at top portion of cutting edge:**
- 20mm thick

**Plate thickness provided at bottom portion of cutting edge:**
- 16mm thick

**Loads on Stiffener: Plate on stiffeners will transfer the load from top on to the stiffeners.**

**Load on plates: DL+LL**

**Intensity of load from design of box**

Using 10mm thick plate Z will be 1/6 bd²

Using 12mm thick plate, Z will be 1/6 bd²

Using 20mm thick plate, Z will be 1/6 bd²

Hence safe.

3.1.7.3 Check at Bottom Cutting Edge:

**BM in cutting edge**

Using 10mm thick plate Z will be 1/6 bd²

Using 12mm thick plate Z will be 1/6 bd²

Using 20mm thick plate, Z will be 1/6 bd²

Hence OK

3.1.7.5 Design of Stiffeners at Top, Bottom and Sides

- **Check At Top**
  - BM in stiffeners = 5.22x1.250x1.250/2
  - 4.08T-mts
  - Section modulus required = 0.94x100000/1500
  - 271.70

- **Using 10mm thick plate Z will be 1/6 bd²**
  - = 1125 cm³

Hence OK

**Check At Bottom**

- BM in stiffeners = 5.22x0.600x0.600/2
  - = 0.94 T-mts

- Section modulus required = 0.94x100000/1500
  - = 62.60

- Using 10mm thick plate Z will be 1/6 bd²
  - = 937.50 cm³

Hence OK

3.2 Analysis of Precast Box (Tunnel)

3.2.1 Design data:

- **Size of box: single RCC precast box:** = 7.50 x 5.650
- **Length of each box** = 22.00 mts
- **No. of segments** = 2.00
- **Length of box unit-1** = 11.00 mts
- **Top of bottom slab** = 101.257 mts

**Proposed road level** = 101.407 mts

**Clear length inside** = 7.50 mts

**Clear height inside** = 5.650 mt

**Thickness of top slab** = 0.750 mts

**Thickness of bottom slab** = 0.750 mts

**Thickness of end walls** = 0.750 mts

**R.L. of top of box** = 107.657 mts

**R.L. of formation level** = 108.232 mts

**R.L. of rail level** = 108.907 mts

**Cushion up to the formation** = 0.575 mts

**Out to out of box** = 9.00 mts

**Total height of the box** = 7.150 mts

**C/c of outer to central wall** = 8.250 mts

**Effective height of the box** = 6.40 mts

**Effective span of the box** = 8.250 mts

**Soil parameters:**

- **Bulk density** = 2.10 T/cu.mts

- **Angle of internal friction** = 28.00 degrees, taken as per soil report

A: the design has been done as per railway standards and the
following codes
Indian railway bridge rules
Loading: H.M.LOADING (which is safe for 25 T loading)
IRS bridge substructures & foundation code
B: STRUCTURAL MATERIALS
Reinforced concrete = box 35
Reinforcement: high yield bars Fy = 500 N/mm²

METOD OF DESIGN: LIMIT STATE AS PER IRS LATEST CODE OF PROVISION.

3.0: Recapitulation of loads on box for analysis purpose

<table>
<thead>
<tr>
<th>Load case</th>
<th>Dead loads</th>
<th>On top slab</th>
<th>On bottom slab</th>
<th>Left wall top</th>
<th>Left wall bottom</th>
<th>Right wall top</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1875.0</td>
<td>4784.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2735.5</td>
<td>2735.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Earth pressure</td>
<td>1190.92</td>
<td>5665.78</td>
<td>1190.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Live loads</td>
<td>4035.0</td>
<td>4035.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>L.L. Surcharge</td>
<td>1142.51</td>
<td>475.29</td>
<td>1142.51</td>
<td>2817.57</td>
<td></td>
</tr>
</tbody>
</table>

TABLE NO: 2 B.M. at Corners and Mid Span for Bottom Slab

<table>
<thead>
<tr>
<th>Nodes</th>
<th>Le. No</th>
<th>Max Design moments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corner moments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left of member 1</td>
<td>11</td>
<td>881.31</td>
</tr>
<tr>
<td>Right of member 2</td>
<td></td>
<td>644.28</td>
</tr>
<tr>
<td>Corner moments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left of member 3</td>
<td>11</td>
<td>1095.00</td>
</tr>
<tr>
<td>Right of member 4</td>
<td></td>
<td>851.90</td>
</tr>
<tr>
<td>Mid span Moments</td>
<td>MAX as per output</td>
<td></td>
</tr>
<tr>
<td>Member no:1</td>
<td>11</td>
<td>978.65</td>
</tr>
<tr>
<td>Member no:2</td>
<td>11</td>
<td>819.00</td>
</tr>
<tr>
<td>Member no:3</td>
<td>11</td>
<td>339.00</td>
</tr>
<tr>
<td>Member no:4</td>
<td>11</td>
<td>475.00</td>
</tr>
</tbody>
</table>

(2) TABLE for shear forces at corners: All the shear forces are in KN-m, with load factor as per IRS codal provisions

<table>
<thead>
<tr>
<th>Nodes</th>
<th>Le. No</th>
<th>Max design shear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recapituation of max SF for corners</td>
<td>Top &amp; bottom sh(bat face of wall)</td>
<td>Design Shear</td>
</tr>
<tr>
<td>Left of member 1</td>
<td>11</td>
<td>873.70</td>
</tr>
<tr>
<td>Right of member 2</td>
<td></td>
<td>649.00</td>
</tr>
<tr>
<td>SF at 0.25 m from support</td>
<td>11</td>
<td>490.00</td>
</tr>
<tr>
<td>SF at 0.25 m from support</td>
<td>11</td>
<td>269.00</td>
</tr>
</tbody>
</table>

From the above data, Final DESIGN details of precast box are as follows:

3.3.2 Reinforcement
3.3.2.1 Reinforcement Calculations for Bottom Slab
Mu/bd² based on Pst = 2.30
Mu/bd² based on B.M = 2.30
As both sides are equal Pst calculated is ok

Pst = 0.582
Ast provided = 47.36 cm²
Pst = 0.686, hence ok
Ast = 351.80
Hence provide 10 mm rings connecting 2 main bars @ 150 c/c
As main bars provided 170 c/c no of legs in 1 m strip will be
= 6 nos
Hence area of shear steel provided will be = 6 x 78.54 = 471.24 > 351.80
Check for shear after 2.25 m from support
SF at section = 493.00 KN
Shear stress V/bd = 0.71
Ast provided = 180.86
Hence provide 8 mm rings connecting 2 main bars @ 150 c/c
As main bars are provided 170 c/c no of legs in 1 m strip = 6 nos
Hence area of shear stress provided will be = 6x 50.27 = 301.62 > 180.86
3.3.2.2 Reinforcement Calculation at Mid Span for Bottom Slab
Mu/bd² based on Pst = 2.092
Mu/bd² based on B.M = 2.092
As both sides are equal Pst calculated is ok
Pst = 0.524
Ast provided = 47.36 cm²
Pst = 0.686, hence ok
Hence provide 20 mm bars 170 c/c, through steel + 25 mm bars at 170 c/c
Ast pro = 36.96 cm² hence ok
3.3.2.3 Reinforcement Calculation at Mid Span for Top Slab
Mu/bd² based on Pst = 1.751
Mu/bd² based on B.M = 1.751
As both sides are equal Pst calculated is ok
Pst = 0.432
Hence provide 20 mm bars 170 c/c, which are from vertical + 20 mm bars at 170 c/c of top slab steel
Ast pro = 36.96 cm² hence ok
3.3.2.4 Reinforcement Calculation at Mid Span for Vertical Wall
Mu/bd² based on Pst = 1.016
Mu/bd² based on B.M = 1.015
As both sides are equal Pst calculated is ok
Pst = 0.243
Ast provided = 28.8 cm² hence ok
Hence provide 25 mm bars 170 c/c, which are from vertical + 25 mm bars at 170 c/c of top slab steel
Ast pro = 28.88 cm² hence ok
Design of vertical wall: as per cl. No:15.7.1.1 .of IRS concrete bridge code, if axial force is less than 0.1 fckAc, the wall shall be treated as slab, and shall be designed accordingly.
Hence provide 16 mm bars @ 170 c/c through steel + 0 mm bars @ 0
Ast pro = 11.83 cm²
3.3.3 Calculation for Steel along the Box with Pushing Force on Box
3.3.3.1 Vertical Loads

TABLE: 4 Vertical Loads
<table>
<thead>
<tr>
<th>S.NO</th>
<th>LOADS DUE TO</th>
<th>LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AT TOP OF BOX UNIT</td>
<td>273.24</td>
</tr>
<tr>
<td>2</td>
<td>AT BOTTOM OF BOX</td>
<td>878.79</td>
</tr>
</tbody>
</table>

3.3.3.2 Earth Pressure
(REF: cl-5.7 of IRS code for sub structure and foundation)

Ka, as calculated in design of box = 0.3344

Total load on the wall = 229.24 T

Total pushing force required will be 878.00 T

4.4.3.3 Serviceability Limit State: Crack Width Calculations
(Ref: cl: 15.9.8.2, of IRS code)

Design crack width =3 aarem/(1+2 (acr-cnom)/(h-dc))

=0.1784 mm<0.20 mm

(ref table: 10, of IRS concrete bridge code)

IV. CONCLUSION OF RESULTS

4.1 Conclusion
- With the box pushing technique, there is no interruption to the traffic moving around.
- Better quality control due to the provision of precast boxes.
- Quantities will be less as compared to the conventional method of construction.
- The cost of construction is less as compared with the conventional method.

4.1.1 Precast box
- For the 7.5m span, we got the wall thickness as 750mm.
- For 6.4m clear height, we got the wall thickness as 750mm.

4.1.2 Thrust bed
- We have provided thickness of thrust bed 750mm for length of box 1m.
- The reinforcement details of precast box (tunnel), thrust bed is shown in the Drawing sheet.
- Various unexpected situations are likely to occur during the box pushing operations. Since the safety of running trains is directly affected, proper planning and implementation is essential for smooth completion of work. Advance analysis of site, likely problems that may arise and planning to tackle the same will help the executive for speedy and safe completion of the work.

V. FUTURE SCOPE OF WORK

- This was done for present need, for future expansions box can be extended cast-insitu as there are no tracks, thereby it can be done simpler & easier way, instead of present box pushing technique.
- The present work done is on RCC box, pre stressed concrete can also be done, thereby the reinforcement can be reduced greatly, and cost of PSC is more.

REFERENCES
[2] Dynamics of Structures by Clough and Penzien
[8] SP16:1984
[9] IRS, IRC Codes.

M.A.RAHMAN
Associate Professor
Department of Civil Engineering
Guru Nanak Institutions
Hyderabad, Telengana.

G.RAJU
Student of M.Tech
Department of Civil Engineering
Guru Nanak Institutions
Hyderabad, Telengana.