*International Journal For Technological Research In Engineering*
*Volume 5, Issue 10, June-2018* *ISSN (Online): 2347 - 4718*

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

M.A.Rahman[1], G. Raju[2]
[1]Associate Professor, [2]Student 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.

1.3The 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 POCKECTS
6. HYDRAULIC JACKS

## III. RESULTS AND DISCUSSIONS

3.1Analysis 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 (2) | = | 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 walls | = | 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/mt$^3$, 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 =74.25T

3.1.2.2 Earth Filling Cushion

So total UDL on top of slab of box will be =1.208x9(o/o width) x11 = 119.54T

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 | =5.650X1.50X1X2.5 | = | 21.19 |
| Haunches | =4.00X0.15X0.075X2.50 | = | 0.11 |
| Total Weight per Meter | | = | 55.05 |
| Weight of One Segment | =55.05X11 | = | 605.5T |
| 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]

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

| | | |
|---|---|---|
| $\cos(\Theta-\alpha)$ | = | 0.7797 |
| $\cos(\alpha+\delta)$ | = | 0.9868 |
| $\sin(\Theta+\delta)$ | = | 0.6064 |

  

$\sin(\Theta + i)$ = 0.4694
$\cos(\alpha - \delta)$ = 0.9868
$\cos(\alpha - i)$ = 1.0000
Ka=0.3344
Hence earth pressure at top of box =0.58x0.3344x2.10
=0.404 t/sq.mt
Earth pressure at the bottom of box: ht =0.58+7.15
=7.73
Earth pressure at bottom of the box =0.3344x2.10x7.73
= 5.43t/sq.mt
Hence total earth pressure on wall =0.50(0.40+5.43) x7.150
= 20.840t/m
Hence total load on wall =20.840x11.00
= 229.24T

3.1.2.4: Live Load Surcharge: Ref Design Of Box Para: 3.5
For two tracks pressure at top = 1142.51 kg/sq.mt
For two tracks pressure at bottom = 675.29 kg/sq.mt
Hence total load = 0.50(1.14+0.68) x7.150
= 6.499 t/m
Hence total load on wall = 6.499x11.00
= 71.49 T

Live load for box: as at the time of pushing, there will not be any train

3.1.2.5Total Pressure on Box Segment

THE LOARDS BELOW ARE FOR 1 UNIT OF BOX.
On top surface =193.79 x 1.00 =193.79
On bottom surface =7.99.34 x 1.00 =799.34
On two walls=2.00x229.24x1.00 =458.47
Live load surcharge = 2.00x71.49x1.00 =142.97
Live load of train: one train =1.00x 131.00x 1.00
= 131.00
Total load of train = 193.79+799.34+458.47+142.97+131
= 1725.58
Total force for box = 1725.58 x 1.00 =1725.58
Taking angle for friction between soil and concrete = 25
Jacking force required to overcome friction as per soil mechanics
Handbook = Tan (25)
Tan (25) = 0.466
Hence total Jacking force required = 1725.58 x 0.466
= 804.12
As suchtwo boxes are to be provided, hence
Pushing force for which thrust-bed is to be designed
= 1.00 x 804.12 = 804.12
On thrust bed for jacking operation use total 6.00 No's of pockets in a Row.
Hence Max force per pocket = 804.12/ 6.00 = 134.020
The jacking force will be resisted by weight of thrust bed and partly by thrust wallIf due to any reason jacking force required is more, in that case,To share the jacking force in two rows of keys, at the time of jacking two rows of pins will be provided; hence force per pin will be half in that case.

3.1.3.0Thrust Bed and Thrust Wall

3.1.3.1 The thrust will be provided as shown in the fig.

Thrust bed has been designed in such a manner that, it can accommodate 1st, Box and after that with provision of pushing, there will be auxiliary thrust. Bed for another two boxes
1.15m for cutting edge+Box+0.90 Jack+0.5 pocket+0.25 gap+0.7 thrust wall = 14.500 m
LENGTH OF THRUST BED = 14.500 METERS
WIDTH OF THRUST BED = 10.200 METERS
No. OF POCKETS = 57.000 on Main th. Bed=42.00 + 15.00 on auxi. THB
SIZE OF POCKET:At Main th-b= 0.500 x 0.50 x = 0.14
At Auxiliary th-bed = 0.500 x 0.50 x 0.55 = 0.14
NO OF KEYS = 2.000 no's

3.1.3.2 Weight of Thrust Bed

Volume of concrete: Main bed=14.50 x 10.20 x 0.75 =11.93
Volume of concrete: Axui-bed =50mm screeding
=14.50 x10.20 x 0.05= 7.40
Thrust wall: 1 = 1.20x 10.20 x0.70 = 8.57
Thrust wall: 2 =1.20x10.20x0.70= 8.57
Keys = 2.00x10.20x0.36 = 7.34
Less pockets =-57.00 x 0.14 = -7.84 = 26.39
Total weight of bed in T = 126.39 X 2.50 = 315.99
Resistance offered by bed =315.99 x 0.466 = 147.25
Additional resistance required=804.12 – 147.25 = 656.87 T
This additional resistance will be available from thrust wall provided at rear of thrust be, the resistance available from keys is also calculated.

3.1.3.3Passive Pressure on Thrust Wall

Thrust wall at end has been provided Passive earth pressure co-efficient for vertical face of wall:

Soil available at bottom of box is soft to Hard rock hence take, soil property as below
Passive earth pressure co-efficient,
Φ = 40.00, α = 13.33, i = 15.00

$$Kp = \frac{\cos^2(\Theta + \alpha)}{\cos^2\alpha\cos(\alpha - \delta)\left[1 + \frac{\sqrt{\sin(\Theta+\delta) - \sin(\Theta+i)]}}{\sqrt{\cos(\alpha-\delta) - \cos(\alpha-i)}}\right]}2$$

$\mathrm{Cos}(\Theta)$ = 0.7660
$\mathrm{Cos}(\Theta + \alpha)$ = 0.7660
$\mathrm{Cos}(\alpha)$ = 1.0000
$\mathrm{Cos}(\alpha - \delta)$ = 0.9730
$\mathrm{Sin}(\Theta + \delta)$ = 0.8021
$\mathrm{Sin}(\Theta)$ = 0.6428
$\mathrm{Sin}(\Theta + i)$ = 0.8192
Cos(α - i = 0.9659
Passive earth pr. Co-efficient Kp = 22.45
Passive pressure with cohesion is given by
Pp = 0.5 x W x HxH x Kp + 2 c H $[Kp]^{1/2}$
[1] [2]
Hence advantage of adhesion at two locations can be taken.

[1] PASSIVE RESISTANCE AVAILABLE FROM THRUST WALL
W=1.80 T/cu.mt, 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 mt
C= Kg/sq.cm Ref: Soil report at th-bed level

  

C= T/sq.mt
$P_R$= 0.5xwxhxhxkp+2ch $(kp)^{1/2}$
A= passive pressure at rear all =824.49
B= pass pressure at intermediate wall=0
A+B=passive pressure from walls =824.49-------- (I)
(2) PASSIVE PRESSURE AVAILABLE FROM KEYS:
Passive pr. with cohesion is given by
Pp= 0.5xwxhxhxkp+2ch $(kp)^{1/2}$
W= 1.80T/cu.mt
H= 0.60
Kp= 22.45
L= 10.20
Passive pr.at the bottom of the bed = (kp\xwx0.75)
= 1.80x22.45x0.75=30.31T/sq.mt
Passive pr.at the bottom of key =(kpxwx1.35)
= 22.45x1.80x1.35=54.56T/sq.mt
Passive pr.at the bottom of the key = 54.56
Hence average pr.
= (30.31+54.56)/2 = 42.44
Total passive resistance
= 42.44x10.20x0.60 = 259.71
Such 3 keys are provided below the thrust bed.
Passive resistance available
= 2.00x259.71 = 519.43T---- (II)
Total Passive Resistance Available = From Thrust Bed +Keys = 824.49+519.43=1343.91>656.87
SO SAFE
This force will be offered by passive resistance from wall, as well as keys and it will act at 1/3 of thrust wall
= 0.33x2.00 = 0.67mt
3.1.3.4Design of Thrust Wall
As Max capacity of the thrust wall is
= 829.49 T
Max force for which wall is to be designed will be
= 824.49T
Max force to be resisted by thrust wall
= 824.49
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
DESIGN BM=1.70x46.48=79.354T-m =793.49 KN-m
For M20 concrete effective depth required
= $\{(793.49x1.306)/ (2.76x1000.00)\}^{1/2}$
= 536.19 mm
Effective depth of wall = 700.00-50.00-12.5
= 637.50mm
3.1.4.1 Reinforcement Calculation
BM = 793.49 KN-m
Effective depth= 700.00-50.00-10.00 = 640.00
To calculate Mu for given percentage of steel
Fy = 500.00, So 0.87 Fy = 435.00
Pst = 0.51, sopt/100 = 0.0050
Hence Ast= 0.501x (1000.00x640.00)/1000
=3207.63 sq.mm
Fck = 25.00.,Fy/fck= 20.00
B = 1000.00
De= 640.00
Hence Mu=0.87XFyXAsX (1-1.1XFyXAs)/(Fckbd)
0.87xFy xAs
=0.87X500.00X3207.63=1395319.17(1)
1.10X500.00X3207.631.1Fy
As /Fckbd=35.00x1000.00x640.00=0.0788
Hence 1-0.0633 = 0.9212 (2)
x (2)xd =1395319.17x0.92x640.00/10.20=822.67
Hence Mu=0.87XfyX(Pt/100)x(1-1.1xFy/fck(pt/100))xbd
Mu/bdbasedonpst=435.00x0.0050(1.00-1.100x20.00x0.0050) =1.94
Mu based on BM = (793.49X1000000)/(1000X640X640) =1.94
As both sides are equal pst calculated is OK
Pst required =0.501
Hence area of steel=100x64x0.00501=32.08
Hence provide 25mm bars at 140 c/c through steel
Ast provided =35.06$cm^2$>32.08 $cm^2$
Pst provided =0.54798%
Inside the wall. Provide 12mm bars at 140 c/c, through steel
Ast provided = 8.08 $cm^2$
3.1.4.2Designfor Shear in Thrust Wall
Max shear in thrust wall will be at effective depth away from bottom of thrust bed=1/2x (80.83+58.20)0.56=38.93T
<u>Check for Shear:</u>
Maximum Shear Forces Are
Max SF in wall = 38.93 T
Ultimate shear = 1.7x10xV
= 661.79 KN
Shear stress = Vs/bd=661.79/1000x640
= 1.03
For M20 grade concrete, from table 15.IRS concrete bridge code

Table 3.Table 15 of IRS Concrete Bridge Code

| % of steel | Tc |
|---|---|
| <0.15 | 0.31 |
| 0.25 | 0.37 |
| 0.50 | 0.47 |
| 1.00 | 0.59 |
| 2.00 | 0.74 |

Tc=0.4300 for Pst=0.5479
Vc=0.43x1000x640 = 275.20
bxSv =1000x150 = 150000

  

(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 =549.78 549.78which is >417.13Hence 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.
FORCE PER METER OF BOX
= loads x factor
On top surface
= 193.79x1.40 = 271.31
On bottom surface
= 799.34x1.40 = 1119.08
On two walls = 458.47x1.70
= 779.40
Live load surcharge
= 142.97x1.70 = 243.05
Live load of train
= 131.00x1.70 = 222.70
Total Load
= 271.31+1119.08+779.40+243.05+222.70
= 2635.54
Factored friction force will be = 2635.54x0.466
= 1228.16
Hence factored force per pin wills be= 1228.16/6
= 204.69
3.1.5.2 Jacking force: will be applied against jacking pin and jacking pin will transfer the load in the side pocket, as a couple take eccentricity 0.3m
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 = 1.00x10x368.45
= 3684.49 KN-m
Hence moment per meter will be = 3684.49/10.20
= 361.22KN-m
Effective depth of bed = 750.00-87.50
= 662.50
3.1.5.3 Reinforcement Calculation:
BM = 361.22KN-m
Effective depth = 750.00-75.00-12.50 = 662.50
To calculate Mu for given percentage of steel
Fy =500.00, so 0.87 Fy = 435.00
Pst = 0.2374,
soPst/100 = 0.0024
Hence Ast = 0.237x
(1000x662.50)/100 = 1572.8Sq.mm
Fck = 25
Fy/Fck = 20
B = 1000
De = 662.50
$Bd^2$ = 438906250
Hence Mu = 0.87 xFyxAs[1-1.1xFyxAs]/FckBd
0.87xFyxAs =0.87x500x1572.79
= 684164.8(1)
=1.10x500x1572.79
1.1xFy xAs/Fckbd =25x1000x662.50
= 0.0522
Hence 1-0.0633 = 0.9478(2)
(1)x(2)xd =684164.85x0.95x662.50/1.0E06
Moment of resistance = 429.59>361.22
Hence OK
To calculate Mu for given percentage of steel
Fy = 415
so 0.87Fy = 361.05
Pst = 0.2374,
soPst/100 = 0.0024
Fck = 25
Fy/Fck = 16.60
B = 1000
De = 662.50
$Bd^2$ = 438906250
Hence Mu = 0.87xFy x(Pst/1000)x[1-1.1 Fy/Fck(Pst/100)]bd
$Mu/bd^2$ based on Pst
=361.05x0.0024[1-1.1x16.60x0.0024]=0.82
$Mu/bd^2$ based on BM
=361.22X100000)/(1000X662.50X662.50)=0.82
As both sides are equal Pst calculated is OK
Provide percentage of steel=0.2374
Hence area of steel=100x66.25x0.00237=15.73
Along with this steel there will be axial tension due to couple, formed at the pin pocket location, this will also be taken care by additional steel for pure tension inside the thrust bed.
3.1.5.4 Tension, taken by concrete
Tension Taken By Concrete Will Be=Total Width Of The Bed Thickness Of Thrust Bed Below Pocket X6.1kg/$Cm^2$
Area of thrust bed =1020x75 =76500
Less area of pockets=-1x6x2750 =-16500
Total area of plain concrete will be =60000
Tensile force taken by concrete
=60000x6.1/1000 =366 T (ref: IRC21, cl303.3)
Total required force =1228.16T 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
= 862.16x1000x1x10/( 0.87x415) =238.79 $cm^2$
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.
As eccentricity from top is = 0.275
Hence tension steel at top = 0.475/0.75x23.41
= 14.83 $cm^2$

  

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
= (3.142/27.43)x1000=114.52
OR
Provide 25mm, main bars, so the spacing will be
= (4.909/27.43)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
Astprovided = 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
Thickness 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 =605.55mt?
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 wills 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 –m
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
Along with this steel there will be axial tension due to couple formed at pin pocket location.
This will also be taken care by additional steel provided for pure tension inside the thrust bed
Total required force = 159.91T
Hence area of steel required for axial tension
= (159.91x1000x1x10)/(0.87x415)
=4428.90sq.mm = 44.29sq.cm
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=22.145
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-mts
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
FY = 500

  

Pst = 0.106
Fck = 25
B = 1000.00
De = 537.50
So,0.87xFy = 435.00
So, Pst/100 = 0.0011
Fy/Fck = 20.00
Bd2= 288906250
Hence Mu=0.87Fyx(Pst/100)x[1-1.1xFy/Fck(Pst/100)]bd2
Mu/bd2 Based on Pst =435.00x0.0011(1.00-1.100x20.00x0.0011) =0.45
Mu/bd2 Based on BM = (129.86x1000000)/(1000x537.50x537.50) =0.45
Hence min steel can be provided, orotherwise depth of key can be reduced.
Pst required = 0.12
Hence area of steel = 100x53.75x0.00120
= 6.45
Hence provide 12mm bars at 160 c/c, through steel
Ast provided = 7.07 cm2>6.45 cm2
Hence safe.

3.1.7.2 Design of Front Cutting Edge:

The front cutting edge has been provided with face plate of 10mm 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 is 20mm thick

Plate thickness provided at bottom portion of cutting edge is 16mm thick

Plate thickness provided at two side portion of cutting edge is 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
=7557.55+4035.03=11.59 T/mt$^2$
(ref Para 4.0 of box design)

Loads on Stiffener: Plate on stiffeners will transfer the load to the stiffeners

Hence total intensity = 11.59 T/mt$^2$

Design of Plates at Top and Bottom and Sides:

As the cutting edge is supported on stiffeners and max spacing of stiffeners
At bottom spacing is = 0.450mts c/c
At top spacing is = 0.45 mts c/c

3.1.7.3 Check at Bottom Cutting Edge

BM in cutting edge =11.59x0.450x0.450/10
= 0.23 T-mt
Section modulus required = 0.23x100000/1500
= 15.65
Using 16 mm thick plate Z will be 1/6 bd2
= 42.67 cm3>15.65 cm3

3.1.7.4Check At Top Cutting Edge:

BM in cutting edge = 11.59x0.450x0.450/10
= 0.23 T-mt
Section modulus required = 0.23x100000/1500
= 15.65
Using 20mm thick plate, Z will be 1/6 bd2
= 66.67 cm3
Hence OK

3.1.7.5 Design of Stiffeners at Top, Bottom and Sides

Check For Stiffeners:
At bottom spacing is = 0.450mts c/c
At top spacing is = 0.45mts c/c
Hence load on stiffeners will be
At top = 11.59x0.45
= 5.22T
At bottom = 11.59x0.45
= 5.22T

Check At Top
BM in stiffeners = 5.22x1.250x1.250/2
= 4.08T-mts
Section modulus required = 4.08x100000/1500
= 271.70
Using 12mm 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 Analysisof 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 | = | 101.257mts |
| 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 |

3.2.2 Design criteria

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 MATERAILS
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: 1 Load on Box for Analysis Purpose

| Load case | Dead loads | On top slab | On bottom slab | Left wall top | Left wall bottom | Right wall top |
|---|---|---|---|---|---|---|
| 1 | Dead wt of concrete | 1875.0 | 4784.09 | | | |
| 2 | Super imposed loads | 2773.5 | 2773.5 | | | |
| 3 | Earth pressure +DL surcharge | | | 1190.92 | 5685.78 | 1190.92 |
| 4 | Live loads | 4035.0 | 4035.0 | | | |
| 5 | L.L. Surcharge | | | 1142.51 | 675.29 | 1142.51 |
| 6 | Longitudinal forces | | | 9016.22 | | 2817.57 |

3.3 Design of Precast Box
3.3.1 Table of B.M at Corners and Mid Span for Members
All B.M. are in KN-m, with load factors as per IRS codal provision
As per IRS code moments are to be considered at face of support,
3.3.1.1 Recapitulation of Bending Moment
(1) Table of B.M. at corners and mid span for bottom slab
All B.M. are in KN-m, with load factors as per IRS codal provision

TABLE N0: 2 B.M. at Corners and Mid Span for Bottom Slab

TABLE N0: 2 B.M. at Corners and Mid Span for Bottom Slab

| Nodes | Lc.no | | Max Design moments |
|---|---|---|---|
| Corner moments | | Moments are at face of support | |
| Left of member :1 | 11 | 881.31 | 881.31 |
| Right of member:2 | | 644.28 | |
| Corner moments | Vertical walls: at face of support | | |
| Left of member :3 | 11 | 1095.00 | 1095.00 |
| Right of member:4 | | 851.50 | |
| Mid Span Moments | MAX as per output | | |
| Member no:1 | 11 | 978.66 | 978.66 |
| Member no:2 | 11 | 819.00 | |
| Member no:3 | 11 | 339.00 | |
| Member no:4 | 11 | 475.00 | |

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

TABLE N0:3 Shear Forces at Corners

| Nodes | Lc. No | | Max design shear |
|---|---|---|---|
| Recapitulation of max SF for corners | Top & bottom slab(at face of wall) | | Design Shear |
| Left of member :1 | 11 | 873.70 | 873.70 |
| Right of member:2 | 11 | 649.90 | |
| SF at | 2.25 m from support | | |
| Left of member :1 | 11 | 493.00 | 493.00 |
| Right of member:2 | 11 | 269.00 | |

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

3.3.2Reinforcement
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
Asv = 351.80
Hence provide 10mm 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 = 493.00KN
Shear stress V/bd = 0.71
Asv = 180.86
Hence provide 8mm rings connecting 2 main bars @150 c/c
As main bars are provided 170 c/c no of legs in 1m 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 20mm bars 170 c/c,through steel +25 mm bars at 170 c/c
Ast pro =47.36 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 20mm 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
3.3.2.4Reinforcement 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 25mm bars 170 c/c, which are from vertical +25 mm bars at 170 c/c of top slab steel
Ast pro = 28.88$cm^2$ 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 + 0mm bars @0
Ast pro =11.83 $cm^2$

3.3.3 Calculation for Steel along the Box with Pushing Force on Box
3.3.3.1 Vertical Loads
TABLE: 4 Vertical Loads

  

| S.NO | LOADS DUE TO | LOAD |
|---|---|---|
| 1 | AT TOP OF BOX UNIT | 273.24 |
| 2 | AT BOTTOM OF BOX | 878.79 |

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 acrem/(1+2 (acr-cnom)/(h-dc))
=0.1784 mm<0.20 mm
(ref table: 10, of IRS concrete bridge code)

## IV. CONCLUSION OF RESULTS

4.1Conclusion

- 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 11m.
- 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

[1] Advanced Structural Analysis by Ashok k. Jain, New Channel Brothers.
[2] Dynamics of Structures by Clough and Penzien McGraw Hills, New York
[3] Design of steel structures P.Dayaratnam, Publishers S.Chand Edition 2011-2012
[4] Bridge Deck Behaviour by E.C. Hambly.
[5] Design of concrete Bridges By M.G Aswini,V.N.Vazirani and M.M. Ratwani
[6] Analysis of Bridge by STAAD Pro.
[7] IS 456-2000
[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.
.

  