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A Study on Design and Analysis of Precast Box for Road Bridge Construction using STAAD Pro: Review

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ABSTRACT

Transportation always plays an important role in economic growth & globalization for a country. Road transportation is one of the main transporting way in India. Therefore it requires connectivity of cities. Hence bridges & culverts are constructing to connect Roads.

Box Culvert can be defined as a structure having box shape which is constructed below the embankment to drain water from one side of the bank to the other side of the bank. Failure reasons of a Box Culverts are maintenance failure, erosion and increase in scour depth, and Installation Failures. To improve the problems occurring in the Structure are described briefly. Box Culverts are normally constructed without RCC cut off and curtain walls. Due to which structure gets damaged easily. In previous researches Box Culvert are constructed with PCC cut off & curtain walls while taking various parameters in design.

Movements of people and transportation will not be affected because structure will not be constructed number of times because life of structure will be very long. Seepage pressure is less in box culvert with RCC Cut off & curtain walls because the gripping in RCC structure is good as compare to PCC Structure, and Seepage pressure is directly proportional to voids that makes PCC structure unstable against seepage pressure. BM of PCC walls is also less than as compare to RCC walls. Life of structure will also increase around two times, & also Government planning will not be affected because project will be for long time period. In designing of structure the two major factors should be kept in mind i.e. economy and safety. If the load is overestimated than the structure will be uneconomical whereas if the load is underestimated the safety of structure will be compromised. Hence the calculation of load and their combination should be done very precisely The study included estimation of PCC & RCC Cut off & Curtain walls through comparative results in SOR 2017.

KEYWORDS: *BOX Culvert, CUT OFF Wall, Curtain Wall, Estimation, Structure, Analysis, & comparative Results*

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1. INTRODUCTION

1.1. GENERAL

It is well known that railway tracks need to cross through the roads in and around extremely populated, well - established cities and towns, so a level crossing is provided in those points but these level crossings may be manned or unmanned, and further causes a traffic jam whena train passes. As both population and traffic are increasing day by day, delays and the risk of accidents at the level crossings are also increasing. About 30-40 % of train accidents were at level crossings, in terms of causalities it contributes 60-70 %. So Indian Railways has to decide either go for road over bridges (ROB's) or road under bridges (RUB's) where ever necessary in populated areas.

A. **Road over Bridges (ROB's)** - Road over bridge are constructed to continue the roadway in the presence of obstruction like railway tracks, valleys, rivers etc. to provide passage over the obstructions. They are preferred when there is no other option of a vehicular pathway over the obstructions.

Figure 1.1 over Bridge

B. **Road under Bridges (ROB's) -** A bridge that allows traffic to pass under a road, river,railway etc.

Figure 1.2 under Bridge

As the cities are well established, the land acquirement for construction of ROB is difficult and sometimes not possible, so under such conditions engineers go for RUB's. There are three main methods for construction of road under bridge: Box pushing method, rolling technique using RH girder and cut & cover method.

C. **Box pushing method -** In Box pushing method pre cast Box segments are used and pushedthrough the heavy embankments of rail or road by Hydraulic Jacks and process is called Jacking. The required thrust is generated through thrust bed and the line & level of precast boxes are also controlled by thrust bed.

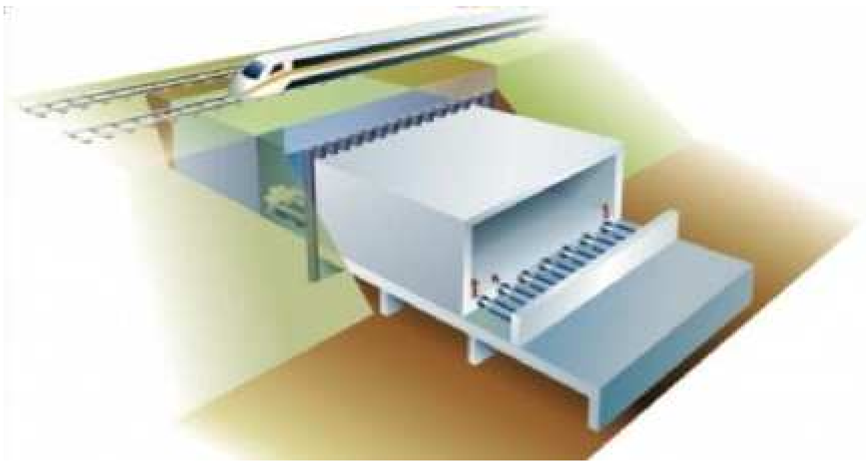


Figure 1.3 Box pushing technique

D. **Rolling technique using RH girder -** This technique is similar to cut and cover method except in the sense that RH girder is inserted because of less duration of availability of traffic block and the boxes are inserted under running traffic.

E. **Cut and Cover method** - In cut and cover method, the structure is built inside an excavation and covered over with backfill material when construction of the structure is completed. Cut and cover construction is used when the tunnel profile is shallow and the excavation from the surface is possible, economical, and acceptable.

In this report a detailed analysis and design of RCC Box, Thrust bed for RUB through an embankment of a rail line is given.

1.2. TERMINOLOGY

A. Thrust Bed

The thrust bed mainly consists of thrust wall, thrust bed with pin pockets on bed, keys for additional resistance. The basic feature of the thrust bed is to provide necessary resistance needed for the jacking operation. For this purpose, a well-designed RCC slab will beconstructed outside the bridge with its top level being kept exactly at the proposed bottom level of the RCC box.

B. Front Shield

It is a MS Plate which is made up of mild steel material and used in the site for cutting the soil surface under the railway track. It has cutting edges in the front which helps to cut the soil and move the box segment easily.

C. Rear Shield

It is made up of mild steel will be fixed on rear end of the first unit of the box. This is connected to the back side of the RCC box segment which helps the box to move properly without and tilting under the railway track.

D. Drag Sheets / Epoxy Coating

Drag sheets are provided at the top of box if required or the top of the box is coated with epoxy coating to reduce the friction between the box and the soil.

E. Plumb Bob

This is a process to know that the box is moving in the correct position or not. Axis lines are drawn on the box slab which gives the information of box moment.

F. Piston

It is a cylindrical machine which is used to push the constructed box to its position in road under bridge. The pressure which is applied to push the box is of 400kN to 600KN.

G. Pockets

Pockets are holes which are made at the construction site and filled with red sand of 70cm height before covering up with concrete. Pockets are used for marking at the construction site after RCC work.

1.3. TYPE OF LOADS AND LOAD COMBINATIONS

In designing of structure the two major factors should be kept in mind i.e. economy and safety. If the load is overestimated than the structure will be uneconomical whereas if the load is underestimated the safety of structure will be compromised. Hence the calculation of load and their combination should be done very precisely. The total loads acting on the box are determined and the resulting bending moments, shear forces and axial forces actingon the box are calculated for each combination of loads and then it is designed for the most adverse combination of loads.

Various loads acting on a structure are given below:
1. Dead loads
2. Live loads
3. Dynamic effects
4. Longitudinal force
5. Earth pressure
6. Surcharge pressure

The various load combination used in analysis and design of structure are as follows:
1. Dead Load + Earth pressure + Dead load surcharge
   DL + 1.7 EP + 1.7 DLS
2. Combination 1 + Live load intensity of BM + Live loadsurcharge
   DL + 1.7 EP + 1.7 DLS + 1.75 LLbm + 1.7 LLS
3. Combination 1 + Live load intensity of BM + Live load surcharge + longitudinalforce
   DL + 1.7 EP + 1.7 DLS + 1.75 LLbm + 1.7 LLS + 1.75 LF
4. Combination 1 + Live load intensity of SF + Live loadsurcharge
   DL + 1.7 EP + 1.7 DLS + 1.75 LLsf + 1.7 LLS
5. Combination 1 + Live load intensity of SF + Live load surcharge + longitudinal force
   DL + 1.7 EP + 1.7 DLS + 1.75 LLsf + 1.7 LLS + 1.75 LF

2. LITERATURE REVIEW

GENERAL

Box pushing technique is most widely used because of its various advantages over the other conventional methods i.e. cut and cover method and rolling technique using RH girder, box pushing technique is easy and convenient to construct in an active junction of rail and road over conventional methods. In Box pushing technique, pre cast R.C.C. box segments areused and pushed through the heavy embankments of Rail or Road by Jacking. The required thrust is generated through thrust bed, as well as the line and level of precast boxes is also controlled by the thrust bed. This underpass RCC Bridge is pushed into embankment by means of hydraulic jacks which is detailed explained in this report, since the availability of land in the city is less, such type of bridge utilizes less space for its construction. Hence constructing Underpass Bridge by Box pushing technique is a better option where there is a constraint of space or Land.

Mahto D et al. (2018) A Review on Bridge Construction Technology: This paper describes the details about the bridge construction technology. This paper also review the existing various types of bridges with the history of worldwide bridges and their classification based on materials used in the performance.

K. Asudullah Khan (2017) the study of problems involved during execution of Railwayunder bridge using box pushing technique and its remedies: This paper gives attention towards problems that arises during execution of RUB using box pushing technique and its remedies. Italso explains about the methodology involving in application in subway construction.

Manisha D. Bhise et al. (2015) Analysis of push back Bridge: The design steps of RCC Box explained in this paper. Design has been examined by 2D frame with various load combinations and soil stiffness. Importance of RCC box type underpass also described.

Mohankar R. H. et al. (2015) Parametric Study of Underpass Bridge: 3D model of box bridge structure has been analyzed in this paper. The comparison of various conditions for the sheer force, bending moment, stiffness and other factors of design have been compared inthis paper.

G. Sampath Kumar (2015) Box pushing technique on Railway under bridge for cross traffic works: This is a case study of Railway under bridge (RUB) construction by box pushing technology. The design of pre-cast box prepared by using STAAD pro software.

Jha et al, (2015) had done Comparative Study of RCC Slab Bridge by Working Stress (IRC: 212000) and Limit State (IRC: 112-2011) and found that the thickness of slab was 500mm for WSM which was reduced to 400mm for both carriageways still there was about 20% saving in amount of concrete and 5-10% saving in amount of reinforcement for LSM i.e. LSM was considerably economical design compared to WSM.

Lingampally Maithri Varun et al. (2015) Analysis, design and technology that is pushing box (Bridge): The pushing of RCC Box methodology has been explained in detail. Tools and supporting instruments/structures required for box pushing technology, such as, thrust bed, front shield, rear shield, pin box, jacks, etc. are also described.

Shivanand and Shreedhar (2015) had done Comparative Study of Slab Culvert Design using IRC 112:2011 and IRC 21:2000 and found that in limit state method of design, the utilizationcapacity of limiting moment increased with increasing the span which was up to 65%.

A. Nagaraju and B. Vamsi Krishna (2015) Analysis, Design and Execution of Cross Traffic Works Using Box Pushing Technique for Railway under Bridge: This paper describes the case study of road widening while crossing through the Railway track. It explains about the methodology involve in execution of pushing technique and detailed arrangement of thrust bed is explained.

Mali et al., (2014) studied some of the design parameters of box culverts like angle of dispersion or effective width of Live load, effect of Earth pressure and depth of Cushion and without provided on top and bottom slab of box culverts . They concluded that box with zero Cushion have low design moments and shear stress as compared to the box having Cushion. So steel required was less in the box with no Cushion case as compared to box with Cushion.

Vinayak Demane et al. (2013) Soil Structure Interaction of Underpass RCC Bridge: This paper describes soil structure interaction of RCC box Underpass Bridge. The study conducted by comparing the structure in conditions of rigid support and soil structureinteraction applied to base and sidewalls.

Dina Mahmoud Mansour et al. (2013) Value Engineering Analysis in the Construction of Box Girder Bridges: This paper describe, a model which is developed to determine the most appropriate box-girder bridge construction method, using the Value Engineering concepts, which is used for comparing the different construction methods for achieving the required basic function after considering the main significant factors.

C. Lyons et al. (2012) Cardinia Road Railway Station- Pedestrian Underpass Jacking: This paper consist the case study of Cordinia Road Station Pedestrian under pass. The analysis of structural design construction, construction and planning a beck analysis of the under pass jacking, analysis of tolerances are discussed in this paper.

Mohankar R. H. et al. (2012) Analysis of Underpass RCC Bridge: The design methodology of under pass bridge analysis is in this paper. The analysis is done on 2D model of box type structure. The comparison of 2D frame of RCC Box with soil stiffness and without soil

stiffness is also compared by the author.

Michael Peter et al. (2011) Railway Foundation Design Principles: This study describes sub grade failure under the Railway track and methods to design safe thickness of safe track bed.This paper describes various procedures and compares the thickness of track bed layers proposed by each for a number of hypothetical situations.

Geoff Casburn et al. (2009) Underpasses for moving livestock under expressways: Case study of under pass construction under expressway is described in this paper. RCC Box culvert tunnel constructed for crossing of livestock under the expressways and motorways are used.

B.N. Sinha et al. (2009) had studied box culverts made of RCC without and with the Cushion. In that study, design of RCC box culvert was done manually and by computer method using STAAD Pro. The structural design involved consideration of load Cases like box empty, full, surcharge load etc. and factors like Live load, effective width, impact force, coefficient of Earth pressure. Relevant IRC codes were referred in their paper. The designs were done to withstand maximum bending moment and shear force. Effective width in Case of box culvert played an important role without Cushion as the Live load became the main load on the top slab. They also told amount of required Steel Reinforcement confirmed by therequired depth of section.

A. Mouratidis (2008) the “Cut-and-Cover” and “Cover and-Cut” Techniques in Highway Engineering: The use of “Cut & Cover” and “Cover and Cut” methods are studied in this paper for construction of underground tunnels or subways. In this paper, the overview of both the methods is presented which includes describing main features, advantages and field applications.

Douglas Allenby et al. (2006) Creating underground space at shallow depth beneath our cities using jacked box tunneling. This paper describes the jack box tunnel method with example, its use and detailed about the sensitivity. Jack box tunnel is a method of construction that enables Engineers to create underground space at shallow depth in amanner that avoids disruption of valuable infrastructure and reduces impact on environment.

3. PROBLEM IDENTIFICATION & OBJECTIVES

3.1. PROBLEM IDENTIFICATION

No detailed study on suitability of materials has been done in past researches were conducted on different materials including RCC, prestress foam concrete however information on techno-economic feasibility of materials to be used in construct the tunnels and over-bridges using thebox culverts very rapid and the cost of construction is less and there is less risk and pushing technology.

3.2. OBJECTIVES

The aim of present study is to do the complete analysis and design of Subway at levelcrossing by box pushing technique. So the objective of present work is as follows-

1. Detailed analysis of pre-cast box segment using STAAD Pro.
2. Design of box segment using Limit state method manually.
3. Design of Thrust bed and thrust wall using Limit state method manually.
4. Design of shear key using Limit state method manually.

4. METHODOLOGY

Some standard specifications and guidelines for analysis of box segment are taken from Bridge Rules and IRS code.

4.1. BRIDGE RULES

Bridge rules specifying the loads for design of super-structure and sub-structure of bridges and for assessment of the strength of existing bridges.

4.1.1. LOADS

For the purpose of computing stresses, the following items shall, where applicable, be taken into account:

A. Dead load
B. Live load
C. Dynamic effects
D. Longitudinal force

A. Dead load

Dead load is the weight of the structure itself together with the permanent loads carried thereon.

For design of ballasted deck bridges, a ballast cushion of 400mm for BG and300mm for MG shall be considered. However, ballasted deck bridges shall also be checked for a ballast cushion of 300mm on BG and 250mm on MG

B. Live load

Railway Bridges including combined rail and road bridges shall be designed for one of the following standards of railway loading:

For Broad Gauge - 1676mm – "25t Loading-2008" with a maximum axle loads of 245.2 kN (25.0t) for the locomotives and a train load of 91.53 kN/m (9.33t/m) on both sides of the locomotives (Appendix-XXII)

Note:

1. Provided the Equivalent Uniformly Distributed Loads of a locomotive with any trailing load are within the EUDL of the Standard loading specified, a locomotive with axle loads heavier than the Standard loading or average trailing loads heavier than those specified in the standard, may be considered as falling under the corresponding standard for the particular span or spans. In such cases, the actual stresses are to be limited to the permissible stresses for the design stress cycles.
2. Diagrams of Standard loading and Equivalent Uniformly Distributed Loads on each track for calculating Bending Moment and Shear Force are shown in the accompanying Appendices XXII, XXIII & XXIII (a) respectively.
3. The above standard should be adopted for BG lines for all spans on routes as detailed below:
   A. Rebuilding/Strengthening/Rehabilitation of Bridges for all routes except Dedicated Freight Corridor (DFC) feeder routes and 25t routes.
   B. Rehabilitation/Strengthening of Bridges on Dedicated Freight Corridor (DFC) feeder routes and 25t routes.

   In any special case where any loading other than the standard is proposed, specific ordersof the Railway Board must be obtained.
4. EUDLs shall be used for simply supported spans. In case of continuous super-structures over supports, the Bending Moments and Shear Forces for design purposes at various sections shall be computed for loadings shown in Appendix-XXII.

For analysis and design of the new bridges, the EUDL approach shall be used. However, exact analysis for maximum Bending Moment and Shear Forces can also be carried out with the help of software "Moving Load" issued by RDSO.

4.1.2. LONGITUDINAL AND LATERAL DISTRIBUTION OF RAILWAY LIVE LOAD

For the design of various types of bridges, the loads as given in the Table below should beconsidered.

Table 4.1 Longitudinal and Lateral Distribution of Railway Live load

S. No.	Span and types	Loading
1	Simply supported span – ballasted deck.	
1.1	Spanning at right angle to the direction oftraffic for all spans.	A single sleeper load equal to the heaviest axle of relevant standard ofloading, allowing dispersal asindicated in Clause 2.3.4.2.
1.2	Spanning in the direction of traffic.	
1.2.1	Spans up to and including 8m for cushion up to and including 600mm under the sleeper.	EUDL for Bending Moment and Shearshall be as per values given in Appendices IV (a), IV (b), IV(c), IV (d), XXIII (a) and XXVI (a) for the relevant standard of loading.
1.2.2	Spans up to and including 8m for cushionabove 600mm under the sleeper.	EUDL for Bending Moment and Shearshall be as per the values for 600mm cushion given in Appendices IV (a),IV (b), IV(c), IV (d), XXIII (a) and XXVI (a) for the relevant standardof loading.
1.2.3	Spans above 8m both for BG and MG forall cushions.	EUDL for Bending Moment and Shearshall be as per the values given in Appendices IV, XXIII and XXVI for the relevant standard of loading.

4.1.3. DISPERSION OF RAILWAY LIVE LOADS SHALL BE AS FOLLOWS:

A. Distribution through sleepers and ballast: The sleeper may be assumed to distribute thelive load uniformly on top of the ballast over the area of contact given below:

Table 4.2 Area of contact

Type I	Type II
	Under each rail seat
BG 2745mm × 254mm	760mm × 330mm
MG 1830mm × 203mm	610mm × 270mm

The load under the sleeper shall be assumed to be dispersed by the fill including ballast at a slope not greater than half horizontal to one vertical and all deck slabs shall be designed for both types of sleepers.

B. Distribution through R.C. Slab:
When there is effective lateral transmission of Shear Force, the load may be further distributed in a direction at right angles to the span of the slab equal to the following:
i) ¼ span on each side of the loaded area in the case of simply supported, fixed andcontinuous spans.
ii) ¼ of loaded length on each side of the loaded area in the case of cantilever slabs.

Note:
1. In no case shall the load be assumed to be distributed over a width greater than the total width of the decking for slabs spanning in the longitudinal direction and minimum axle spacing in the case of slabs spanning in transversedirection.
2. No distribution through the slab may be assumed in the direction of the span of the slab.

C. The distribution of wheel loads on steel troughing or beams (steel or wooden) spanning transversely to the track, and supporting the rails directly shall be in accordance with Appendix H of Steel Bridge Code and the design shall be based on the continuous elastic support theory.

D. Dynamic effect

4.1.4. RAILWAY BRIDGES (STEEL)

For Broad and Metre Gauge Railway: The augmentation in load due to dynamic effects should be considered by adding a load Equivalent to a Coefficient of Dynamic Augment (CDA) multiplied by the live load giving the maximum stress in the member under consideration. The CDA should be obtained as follows and shall be applicable up to 160 km/h on BG and 100 km/h on MG

For single track spans:

$$CDA = 0.15 + \frac{8}{6+L}$$

Subject to maximum of 1.0 Where L is
A. The loaded length of span in metres for the position of the train giving the maximum
B. 1.5 times the cross-girder spacing in the case of stringers (rail bearers) and
C. 2.5 times the cross girder spacing in the case of cross girders.
D. For main girders of double track spans with 2 girders, CDA as calculated above may be multiplied by a factor of 0.72 and shall be subject to a maximum of0.72.
E. For intermediate main girders of multiple track spans, the CDA as calculated in Clause 2.4.1.1(a) may be multiplied by a factor of 0.6 and shall be subject to a maximum of 0.6.
F. For the outside main girders of multiple track spans with intermediate girders, CDA shall be that specified in Clause 2.4.1.1(a) or (b) whichever applies.
G. For cross girders carrying two or more tracks, CDA as calculated in Clause 2.4.1.1(a) may be multiplied by a factor of 0.72 and shall be subject to a maximum of0.72.
H. Where rails, with ordinary fish-plated joints, are supported directly on transverse steeltroughing or steel sleepers, the dynamic augment for calculating stresses in such troughing or sleepers shall be taken as

$$\frac{7.32}{B+5.49}$$

For BG &

$$\frac{5.49}{B+4.27}$$ For MG

Where B = the spacing of main girders in meters.

The same Coefficient of dynamic augment (CDA) may be used for calculating the stresses in main girders up to 7.5m effective span, stringers with spans up to 7.5m and also chords of triangulated girders supporting the steel troughing or steel sleepers.

2.4.1.2 For Narrow Gauge Railways of 762mm and 610mm gauges, the Coefficient of

Dynamic Augment shall be $\frac{91.5}{91.5+L}$

Where L = the loaded length of the span as defined in Clause 2.4.1.1 (a).

4.2. RAILWAY PIPE CULVERTS, ARCH BRIDGES, CONCRETE SLABS AND CONCRETE GIRDERS.

For all gauges

A. If the depth of fill is less than 900mm, the Coefficient of Dynamic Augment shall beequal to- [2-(d/0.9)] 1/2× CDA as obtained from Clause 2.4.1.1(a) Where, d = depth of fill in 'm'.
B. If the depth of fill is 900mm, the Coefficient of Dynamic Augment shall be half of thatspecified in clause 2.4.1.1(a) subject to a maximum of 0.5. Where depth of fill exceeds 900mm, the Coefficient of Dynamic Augment shall be uniformly decreased to zero within the next 3 meters.
C. In case of concrete girders of span of 25m and larger, the CDA shall be as specifiedin Clause 2.4.1.1.

Note:

For spans less than 25m, the CDA shall be computed as per sub-clause (a) or (b) as may be applicable.

1. The "depth of fill" is the distance from the underside of the sleeper to the crown of anarch or the top of a slab or a pipe.
2. The above coefficients are applicable to both single and multiple track bridges, subject to Note 3.
3. On multiple track arch bridges of spans exceeding 15m, 2/3rd of the above coefficient shall be used.
4. In case of steel girders with ballasted concrete slab decks, Coefficient of DynamicAugment for the steel spans should be as specified in Clause 2.4.1.1.

D. Longitudinal Forces

Where a structure carries railway track, provision as under shall be made for the longitudinal loads arising from any one or more of the following causes:

i) The tractive effort of the driving wheels of locomotives;
ii) the braking force resulting from the application of the brakes to all braked wheels;
iii) Resistance to the movement of the bearings due to change of temperature and deformation of the bridge girder. Roller, PTFE or elastomeric bearings may preferably be provided to minimize the longitudinal force arising on this account.
iv) Forces due to continuation of LWR/CWR over the bridges (Abeyance till further orders).

Total longitudinal force transferred to sub-structure through any bearing due to causes mentioned in Clause 2.8.1 shall not be more than the limiting resistance at the bearing for the transfer of longitudinal force.

For Railway Bridges, the value of longitudinal force due to either tractive effort or the brakingforce for a given loaded length shall be obtained from the Appendices VIII, VIII (a), XXIV and XXVII.

4.3. DISPERSION AND DISTRIBUTION OF LONGITUDINAL FORCES

In case of bridges having open deck provided with through welded rails, rail-free fastenings and adequate anchorage of welded rails on approaches (by providing adequate density of sleepers, ballast cushion and its consolidation etc., but without any switch expansion joints) the dispersion of longitudinal force through track, away from the loaded length, may be allowed to the extent of 25% of the magnitude of longitudinal force and subject to a minimum of 16t for BG and 12t for MMG or MGML and 10t for MGBL. This shall also apply to bridges having open deck with jointed track with rail-free fastenings or ballasted deck, however without any switch expansion or mitred joints in either case. Where suitably designed elastomeric bearings are provided the aforesaid dispersion may be increased to 35% of the magnitude of longitudinal force.

Note:

Length of approach for the above purpose shall be taken as minimum 30m.

4.4. IRS BRIDGE SUB-STRUCTURE AND FOUNDATION CODE

Guidelines for Earth pressure is taken from IRS Bridge sub-structure and foundation code.

1. Earth pressure

All earth retaining structures shall be designed for the active pressure due to earth fill behind the structure. The general condition encountered is illustrated in (Fig.4.1).

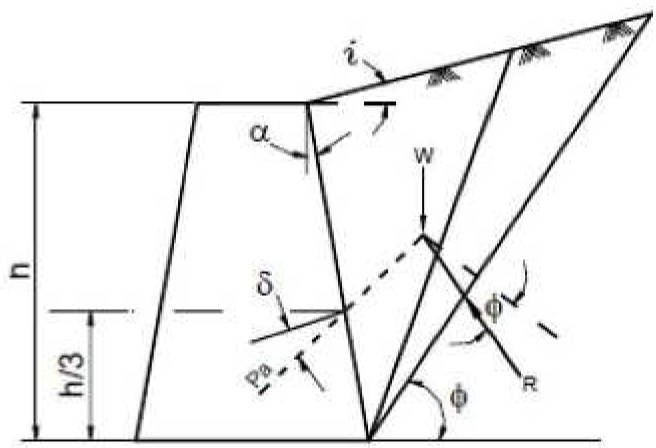


Figure 4.1 Active Earth pressure

The active pressure due to earth fill shall be calculated by the formula, based on Coulomb's theory for active earth pressure given below: -
Pa = ½ wh² Ka

Where:
Pa = Active earth pressure per unit length of wall.
W = Unit weight of soil. h = height of wall.
Ø = angle of internal friction of back fill soil.
δ = angle of friction between wall and earth fill

Where value of δ is not determined by actual tests, the following values may be assumed.
1. δ = 1/3 ø for concrete structures.
2. δ = 2/3 ø for masonry structures. i = angle which the earth surface makes with the horizontal behind the earth retaining structure.

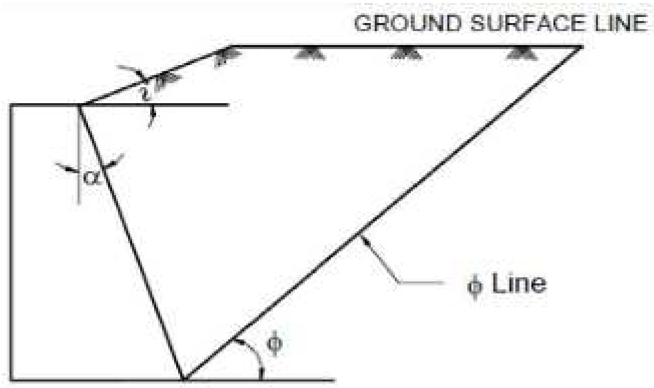
ka = Coefficient of static active earth pressure condition.

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

A. The point of application of the active earth pressure due to earth fill shall be assumed to be at a point on the earth face of the structure at a height of h/3 above the section where stresses are being investigated.

B. The direction of the active earth pressure shall be assumed to be inclined at an angle δto the normal to the back face of the structure.

C. The magnitude of active earth pressure can also be determined graphically by well- known graphical constructions such as Rebhann's or Culmanns construction particularly in case of wing walls, where the profile of earthwork to be supported is not easily susceptible to analysis.(Fig.4.2)



D. Figure 4.2 Earth pressure

E. These formulae for active earth pressures are based on the supposition that backfill behind the structure is granular and there is effective drainage. These conditions shall be ensured by providing filter media and backfill behind the structure as shown in Fig.2 and as described in clause 5.7.1 and 5.7.2

F. In testing the stability of section of abutments below the ground level, 1/3rd of the passive pressure of the earth in front of the abutment may be allowed for up to the level below which the soil is not likely to be scoured.

The passive pressure Pp due to the soil shall be calculated in accordance with the formula: Pp= ½ Wh²Kp

Where, Pp= Passive earth pressure per unit length of wall
W = Unit weight of soil
h = height from the base of the wall to the top surface of the soil.
Kp = Coefficient of static passive earth pressure.

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

A. The point of application of passive earth pressure due to earth fill shall be assumed to be at a point on the front face of the abutment at a height of h/3 above the level where stability is being tested.

B. The direction of passive earth pressure shall be assumed to be upwards and inclined atan angle δ to normal to front face of the abutment.

2. Earth pressure due to surcharge

Earth pressure due to surcharge on account of live load and dead loads (i.e. track, ballast etc.) shall be considered as equivalent to loads placed at formation level and extending up tothe front face of ballast wall.

3. Earth Pressure Due To Surcharge on Abutments

The horizontal active earth pressure P due to surcharge, dead and live loads per unit lengthon abutment will be worked out for the following two cases.

Case-1: When depth of the section h is less than(L-B). Case-2: When depth of the section h is more than (L-B). Where:

L = Length of the abutment

B = Width of uniform distribution of surcharge load at formation level; and h= Depth of the section below formation level.

Case-1: h ≤ (L-B)

The active earth pressure diagrams are as under: Whereas, S = Live load surcharge

per unit length V = Dead load surcharge per unit length P1=Force due to active earth pressure on 'abde'

P2 = Force due to active earth pressure on 'bcd. P1 = $\frac{(S+V)}{(B+h)}$ h×ka acting at h/2 from section under

$$\frac{(S+V)h^2\,ka}{2B(B+h)}$$

Consideration P2 = acting at 2h/3 from section underconsideration.

P1 = Force due to active earth pressure on 'abdefg'
P2 = Force due to active earth pressureon 'bcd'

P1= $\frac{(S+V)}{L}$ ka×h acting at h/2 from section under consideration

P2 =$\frac{(S+V)(L-B)^2 ka}{2BL}$ acting at $\left[h - \left(\frac{L-B}{3}\right)\right]$ from section underconsideration. Where,

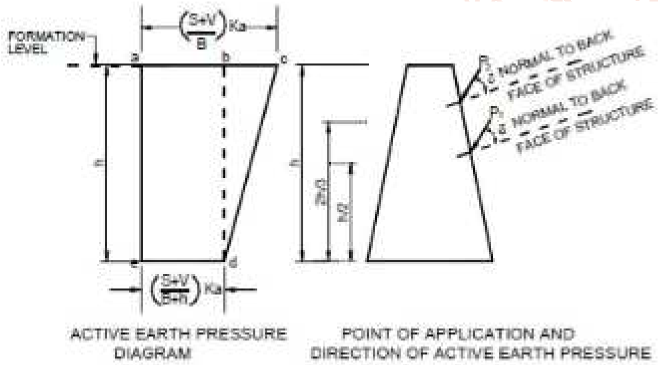
S = Live load surcharge for unit length.

V= Dead load surcharge for unit length.

h = Height of fill.

This is assumed to act at a height of h/2 from base of the section under consideration. Surcharge due to live load and dead load may be assumed to extend up to the front face of the ballast wall.

Case-1: h ≤ (L-B)



Case-2: h > (L-B)

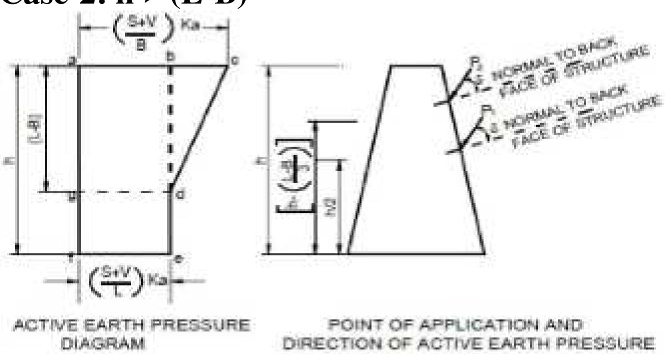


Figure 4.3 Different cases

Conclusions

From the literature review, it is concluded that the comparison to the years ago technology in construction world was quite developed. So we construct the tunnels and over-bridges using the box culverts very rapid and the cost of construction is less and there is less risk and pushing technology is widely used nowadays and gives very good results of work.

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

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