International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 12 | Dec-2017 www.irjet.net p-ISSN: 2395-0072

DESIGN OF FLOATING BRIDGE CROSS OVER

M. Hari Sathish Kumar[1], E. Saravanan[2], S. Manikandan[3], S. Akash Kumar [4]

[1]Assistant Professor, Department of Civil Engineering, PERI Institute of Technology, Chennai 48.
[2,3,4]Student, Department of Civil Engineering, PERI Institute of Technology, Chennai 48

***

Abstract - Economy in construction is the ultimate need for today, so we go for suitable structures to fit the purpose. The bridge uses floats (floating concrete) to support a continuous or separate deck for vehicle and pedestrian travel. It is used in the area where there is not feasible to suspend a bridge from anchored piers and also the area which has large deep sea bed. Pier-less bridge are not new to this world. During the Cholas period for their invasion across rivers, they made use of trained elephants that swim on the surface, over which they transported all elements of battle by laying planks over elephants. This paper also includes floating bridges which are pier less and whose design has been modified to bear heavy weight and possible to connect large distance and it is used in the area having heavy population. These bridges are made of suitable concrete sections and are continuous in length so that they could connect island and mainland even over sea which eliminates the cost of pier and makes the bridges more economic.

Keywords- Cross-passage, tunnel linings, Flyover, Floating bridge, Concrete.

1. INTRODUCTION

Floating bridges were even built in olden ages with the help of boat like structures as supporting piers at regular intervals and decks were placed on it. Here the entire bridge transfers its load due to buoyancy.

There are basically two types of very large floating structures (VLFSs), namely the semi-submersible-type and the pontoon-type. Semi-submersible type floating structures are raised above the sea level using column tubes or ballast structural elements to minimize the effects of waves while maintaining a constant buoyancy force. Thus they can reduce the wave- induced motions and are therefore suitably deployed in high seas with large waves. In pontoon type bridges are placed on the surface of the water.

Floating bridges are cost-effective solutions for crossing large bodies of water with unusual depth and very soft bottom where conventional piers are impractical.As we propose to build a bridge across a natural drainage like rivers or some obstruction, we have to consider the height of piers constructed above the ground level as well as below the ground level as a part of foundation. When we lay piers for bridges crossing deeper rivers then the height of piers would be very large.

Even if the river bed is of soft bed rock then the depth up to which the piers have to be laid under the ground level as foundation is also so high. So as a whole it leads to a large excavation cost for drilling piles under water as well as constructing piers for such great heights.Even if we construct like this we must increase the dimensions of piers drastically to avoid buckling or go for many piers at shorter intervals to reduce the load over the piers.So in order to reduce the cost and make the bridge more economical we go for floating bridges now, which is made of concrete and it floats based on the principle of buoyancy.

A modern floating bridge may be constructed of wood, concrete, steel, or a combination of materials, depending on the design requirements. In our project we are using floating concrete to float the bridge structure. Figure1shows the floating concrete.

Fig. 1: Floating Concrete

United States, Canada, Norway, China and other Eastern countries have used this technologyto create wo0rks of great importance and have brought a strong innovation in the sector.The first longest pontoon bridge in the world (Figure2) is located in North America andsupport a large amount of heavy traffic also in extreme climatic conditions. In Norway we highlight the original combination of a floating bridge with a submerged tunnel.

In the Maldives an original floating bridge brilliantly reconciles the need forconnection between two islands with landscape and environmental requirements. A conventional design would implicate several big foundations at the seabed which are not only costly and complex to build but also have a very negativeimpact on any life at the bottom of the ocean.Finally, the enlargement hypothesis of a pontoon bridge in China provesthe vitality of this type of structure in a rapidly growing country.

3. ARCHIMEDES PRINCIPLE

Apparent Weight-Weight of Object in axis-Thrust force Equation
Mass of Liquid Displaced
Mass = Density*Volume
= $\rho*V$
Weight of the Liquid Displaced
w = m*g
m = $\rho*V$
w = $\rho*V$
From Archimedes
Apparent Loss of Weight = Weight of Water Displace
Thus The Thrust Force is
Thrust = $\rho*V*g$
V = length*breadth*depth
Length = 16m
Breadth = 12m
Depth = 7.6m
V = 16 * 12 *7.6
= $1459.2m^3$
Thrust = 1000*9.81 * 145
= 9810 * 1459.2
W = $1431.75*10^3$ KN

The Dimensions of the pontoon can sustain $1431.75*10^3$ KN capacity of load.

4. DESIGN OF DECK SLAB

STEP 1

Given Data
Size of Slab = 22m*13.5m
Depth of Slab = 0.60m
Grade used M25, Fe500
Live Load = 5 KN/mm^2

STEP 2

Type of Slab
L_y/L_x = 22/13.5
= 1.62<2
The Given Slab is Two Way Slab

STEP3

Overall Depth
Assume Clear Cover is 30mm
D = d+ 0.03
= 0.6+0.03
= 0.63m

STEP 4

Effective Span
L_y = 22+0.6
= 22.6m
L_x = 13.5+0.6=14.1m

STEP 5

Load Calculation
Dead load = $l*b*D*\gamma$
= 1*1*0.63*24
= 15.12 KN/m
Live Load = 5 KN/m
Total Load = 15.12+5
= 20.12 KN/m
Factored Load = 1.5* Total Load
= 30.18 KN/m

STEP6

Moment Calculation
M_{ux} = $\alpha_x*W_u*L_x^2$
M_{uy} = $\alpha_y*W_u*L_y^2$
From IS 456-2000
α_x = 0.074
α_y = 0.061
M_{ux} = $0.074*30.18*(14.1)^2$
= 444.01 KNm
M_{uy} = $0.061*30.18*(14.1)^2$
= 366.01 KNm

STEP 7

Shear Calculation
V_{ux} = $0.5W_uL_x$
= 0.5*30.18*14.1
= 212.77 KN

V_{uy} = $0.5W_uL_y$
= 0.5*30.18*22.6
= 341.03 KN

STEP 8

M_u = 0.138 Fck bd^2
d = 0.36m < 0.6m
Hence Safe

STEP9

Area of Reinforcement
Shorter Span
M_{ux} = 0.87 f_yAst d {1-[($f_y$ast)/(fck b d)]}
Ast = 1810.45 mm^2
use 12 mm dia bars
1. No. of. bars = (Ast/ast)
= (1810.45)/($\pi/4 * 12^2$)
= 16 Nos
2. Spacing, S_v = (ast/Ast)*b
= [($\pi/4 * 12^2$)/1810.45]*1000
= 70 mm
Min Spacing is 300 mm
Use 16 Nos of 12mm Dia Bars Spaced at 300mm c/c

Longer Span

M_{uy} = 0.87 f_yAst d {1-[($f_y$ast)/(fck b d)]}
Ast = 1475.05 mm^2
use 12 mm dia bars
1. No.of.bars = (Ast/ast)
= (1475.05)/($\pi/4 * 12^2$)
= 14 Nos
2. Spacing, S_v = (ast/Ast)*b
= [($\pi/4 * 12^2$)/1475.05]*1000
= 75 mm
Min Spacing is 300 mm
Use 14Nos of 12mm Dia Bars Spaced at 300mm c/c

STEP 10

Check for Shear

τ_v = V_{ux}/bd
= $(212.77*10^3)/(1000*600)$
= 0.35 N/mm^2
p_t = 100 Ast/bd
= (100*1810.45)/(1000*600)
= 0.301
τ_c = 0.38 N/mm^2
K=1
K τ_c = 0.38 N/mm^2
$\tau_{c\,max}/2$ = (3.1/2) = 1.55 N/mm^2
$\tau_v < K\tau_c < \tau_{c\,max}/2$
0.35 N/mm^2 < 0.38 N/mm^2 < 1.55 N/mm^2
Hence Safe In Shear Reinforcement

STEP 11

Check for Deflection
L/d = 25
p_t = 0.307
f_s = 290 N/mm^2
Modification factor = 1.2
d required = span/(B.V*M.F)
= 22000/(28*1.2)
= 573 mm

$d_{required} < d_{provided}$
572 mm < 600 mm
Hence Safe In Deflection

5 DESIGN OF PANTOON TOP SLAB

STEP 1

Given Data
Size of Slab = 16m*12m
Depth of Slab = 0.45m
Grade used M25,Fe500

STEP 2

Type of Slab
L_y/L_x = 16/12
= 1.33 <2
The Given Slab is Two Way Slab

STEP 3

Overall Depth
Assume Clear Cover is 30mm
D = d+ 0.03
= 0.45+0.03
= 0.48m

STEP 4

Effective Span
L_y = 16+0.45
= 16.45m
L_x = 12+0.45
= 12.45m

STEP 5

Load Calculation
Dead load = l*b*D*ɤ
= 1*1*0.48*24
= 10.08 KN/m
Another Dead load of Deck Slab= 20.2 KN/mm
Total Load = 10.08+20.2
= 30.28 KN/m
Factored Load = 1.5* Total Load
= 45.42 KN/m

STEP 6

Moment Calculation
M_{ux} = α_x*W_u*L_x^2
M_{uy} = α_y*W_u*L_y^2
From IS 456-2000
α_x = 0.093
α_y = 0.055
M_{ux} = 0.093*45.42*$(12.45)^2$
= 654.73KNm
M_{uy} = 0.055*45.42*$(12.45)^2$
= 387.21KNm

STEP 7

Shear Calculation
V_{ux} = $0.5W_uL_x$
= 0.5*45.42*12.45
= 282.74 KN
V_{uy} = $0.5W_uL_y$
= 0.5*45.42*16.45
= 373.58 KN

STEP 8

Check For Depth
M_u = 0.138 Fck bd^2
D = 0.43m < 0.45m
Hence Safe

Step 9

Area of Reinforcement
1.Shorter Span
M_{ux} = 0.87 f_yAst d {1-[($f_y$ast)/(fck b d)]}
Ast = 4084.45 mm^2
use 12 mm dia bars
1. No. of. bars = (Ast/ast)
= (4084.45)/($\pi/4 * 12^2$)
= 36 Nos
2. Spacing,S_v = (ast/Ast)*b
= [($\pi/4 * 12^2$)/4804.45]*1000
= 45 mm
Min Spacing is 300 mm
Use 36 Nos of 12mm Dia Bars Spaced at 300mm c/c
2.Longer Span
M_{uy} = 0.87 f_yAst d {1-[($f_y$ast)/(f_{ck} b d)]}
Ast = 2190.29 mm^2
use 12 mm dia bars
1. No.of.bars = (Ast/ast)
= (2190.29)/($\pi/4 * 12^2$)
= 20 Nos
2.Spacing,S_v = (ast/Ast)*b
= [($\pi/4 * 12^2$)/2190.29]*1000
= 52 mm
Min Spacing is 300 mm
Use 20Nos of 12mm Dia Bars Spaced at 300mm c/c

STEP 10

Check forShear
τ_v = V_{ux}/bd
= (282.74*10³)/(1000*450)
= 0.62 N/mm^2
p_t = 100 Ast/bd
= (100*4804.45)/(1000*450)
= 1.06
τ_c = 0.64 N/mm^2
K = 1
K τ_c = 0.64 n/mm^2
τ_c max/2 = (3.1/2)
= 1.55 N/mm^2
τ_v<Kτ_c<τ_c max/2
0.62 N/mm^2< 0.64 N/mm^2< 1.55 N/mm^2
Hence Safe In Shear Reinforcement

STEP 11

Check for Deflection
L/d = 25
p_t = 1.06
f_s = 240 N/mm^2
Modification factor = 1.0
$d_{required}$ = span/(B.V *M.F)
= 16000/(28*1.0)
= 437 mm

$d_{required}$<$d_{provided}$
437 mm < 450 mm
Hence Safe In Deflection

6. Design of longer shear wall

Step 1
Given Data
Load = 1812 KNm
Length of wall = 16m
Depth of wall = 5550m
Thickness of wall = 320m

Step 2
Slenderness ratio
H_e = 0.75*5550
= 4162.5mm
λ = 13

Step 3
Minimum eccentricity
e_{min} = 0.05 t
= 0.05*320
= 16mm

Step 4
Additional Eccentricity
e_a $= \frac{He^2}{2500t}$
= 21.65mm

Step 5
Ultimate load carrying capacity per unit length
P_w = $0.3 f_{ck}[t-1.2 e_{min}-2e_a]$
= 0.3*20[320-1.2*16-2*21.65]
= 1545 KN > 1812 KN

Step 6
Minimum reinforcement
P_h = 0.20% of total c/s area
P_v = 0.15% of total c/s area
A_n = 640mm^2

As the thickness is more than 150mm the steel has to be palce in two layers of 320mm^2/m

Spacing = 122.7≅150mm

Provide 10 mm dia bars at 150mm spacing.

7. Design of shorter shear wall

Step 1

Given Data
Load = 1087.2 KNm
Length of wall = 12m
Depth of wall = 5550m
Thickness of wall = 320m

Step 2
Slenderness ratio
H_e = 0.75*5550
= 4162.5mm
λ = 13

Step 3
Minimum eccentricity
e_{min} = 0.05 t
= 0.05*320
= 16mm

Step 4
Additional Eccentricity
e_a = $\frac{He^2}{2500t}$
= 21.65mm

Step 5
Ultimate load carrying capacity per unit length
P_w = $0.3 f_{ck}[t-1.2 e_{min}-2e_a]$
= 0.3*20[320-1.2*16-2*21.65]
= 1545 KN > 1087.2 KN

Step 6
Minimum reinforcement
P_h = 0.20% of total c/s area
P_v = 0.15% of total c/s area
A_n = 640mm^2

As the thickness is more than 150mm the steel has to be palce in two layers of 320mm^2/m

Spacing = 122.7≅150mm

Provide 10 mm dia bars at 150mm spacing.

7. Design of pontoon Bottom slab

STEP 1

Given Data
Size of Slab = 16m*12m
Depth of Slab = 1.6m
Grade used M25,Fe500

STEP 2

Type of Slab
L_y/L_x = 16/12
= 1.33 < 2

The Given Slab is Two Way Slab

STEP 3

Overall Depth
Assume Clear Cover is 50mm
D = d+ 0.05
= 1.6+0.05
= 1.65m

STEP 4

Effective Span
L_y = 16+1.6
= 17.6m
L_x = 12+1.6
= 13.6m

STEP 5

Load Calculation
Dead load on Bottom Slab= l*b*D*γ
= 1*1*1.65*24
= 39.6 KN/m
Dead load & Live load on Deck Slab
= 20.12 KN/m
Dead load on Top Slab = 10.08 KN/m
Dead load on Longer Shear wall
= 88.8 KN/m
Dead load on shorter shear wall
= 88.8 KN/m
Total Load = 247.4 KN/m
Factored Load = 1.5* Total Load
= 371.1 KN/m

STEP 6

Moment Calculation
M_{ux} = $\alpha_x * W_u * L_x^2$
M_{uy} = $\alpha_y * W_u * L_y^2$
From IS 456-2000
α_x = 0.093
α_y = 0.055
M_{ux} = $0.093*371.1*(13.6)^2$
= 6383.39KNm
M_{uy} = $0.055*371.1*(13.6)^2$
= 3775.13KNm

STEP 7

Shear Calculation
V_{ux} = $0.5W_uL_x$
= 0.5*371.1*13.6
= 2523.48 KN
V_{uy} = $0.5W_uL_y$
= 0.5*371.1*17.6
= 3265.68 KN

STEP 8

Check For Depth
M_u = $0.138\ F_{ck}\ bd^2$
d = 1360.24m < 1600m
Hence Safe

Step 9

Area of Reinforcement

1.Shorter Span
M_{ux} = 0.87 f_yAst d {1-[($f_y$ast)/(f_{ck} b d)]}
Ast = 10567.41 mm^2
use 25 mm dia bars
1. No.of.bars = (Ast/ast)
= $(10567.41)/(\pi/4 * 25^2)$
= 22 Nos
2. Spacing, S_v = (ast/Ast)*b
= $[(\pi/4 * 25^2)/10567.41]*1000$
= 46.45 mm

Min Spacing is 300 mm
Use 22 Nos of 25mm Dia Bars Spaced at 300mm c/c

2.Longer Span
M_{uy} = 0.87 f_yAst d {1-[($f_y$ast)/(f_{ck} b d)]}
Ast = 5852.13 mm^2
use 25 mm dia bars
1. No.of.bars = (Ast/ast)
= $(5852.13)/(\pi/4 * 25^2)$
= 12 Nos
2. Spacing,S_v = (ast/Ast)*b
= $[(\pi/4 * 25^2)/5852.13]*1000$
= 83.88 mm

Min Spacing is 300 mm
Use 12 Nos of 25mm Dia Bars Spaced at 300mm c/c

STEP 10

Check For Shear
τ_V = V_{ux}/bd
= (2523.48*10^3)/(1000*1600)
= 0.85 N/mm^2
pt = 100 Ast/bd
= (100*10567.41)/(1000*1600)
= 0.66
τ_C = 0.92 N/mm^2
K = 1

K τ_C = 0.92 n/mm^2
τ_C max/2 = (3.1/2)
= 1.55 N/mm^2
$\tau_V < K\tau_C < \tau_C$ max/2
0.85 N/mm^2 < 0.92 N/mm^2 < 1.55 N/mm^2
Hence Safe In Shear Reinforcement

STEP 11

Check For Deflection
L/d = 25
Pt = 0.66
fs = 290 N/mm^2
Modification factor = 1.0
d required = 628.57mm < 1600 mm
d required < d provided
437 mm < 450 mm
Hence Safe In Deflection

8. CONCLUSION

According to the above, it should be evident that the pontoon bridges are not just a folkloristic curiosity or a military device, but they represent an effective andeconomical solution for crossing large stretches of even deep water (lakes, rivers,).

The length of these bridges is not limited by structural or technological problems (such as e.g. for suspension or cable-stayed bridges) and some of them
lengthen over than 3000 m (Hobart Bridge).Although pontoon and floating bridges are particularly suitable for use in deepwater, where it would be difficult to build traditional foundations, nevertheless their use generally requires low tidal ranges, small wave motion and moderate currents.

Consider, for example, the semi-submersible pillars, currently used for offshore platforms in deep water, or the buoyant foundations tied to sea bottom by means of high strength tendons, used as support for wind power generation towers.

These devices would reduce the impact of waves and current on the pontoons and would avoid the lowering (however small) of floating supports for moving loads.

REFERENCES

[1.] The structure is designed with the reference from the book "DESIGN OF REINFORCEDCONCRETE ELEMENTS" by "KRISHNA RAJU" and "LIMIT STATE METHOD" by "B.C PUNMIA".

[2.] The coefficient values are taken from the code book "IS 456-2000".

[3.] The live load is taken from the code book "IS 875 PART 2" according to the building.

[4.] The shear wall is designed with the reference of code book "IS 3370-PART-4".