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ANALYSIS OF BUOYANCY SYSTEM FOR FLOATING BRIDGE AND DESIGN OF FLOATING BRIDGE

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Abstract –Large bodies of water with unusually deep bottoms can be crossed with floating bridges instead of traditional piers in certain situations.
As a potential method for preserving constant buoyancy,a system that makes use of compression and expansion of submerged air volume is offered. The breadth of factors that should be taken into account includes hydrodynamics and structural engineering. This research examines the buoyancy system and floating bridge design.
***Key Words*:**Floating Bridge,Buoyancy,Structural Engineering.

1.INTRODUCTION

Large bodies of water can be crossed using floating bridges at a lower cost than with traditional pier. Depending on design specifications ,the floating bridge of today is built out of steel, concrete, wood or a combination of material.

Throughout human history ,various kinds of floating bridge have been utilized. The majority of first bridges served as temporary structures for military operations .Permanent floating bridges have just lately been offered as an idea. One or more floating objects support a continuous upper deck on a floating bridge, allowing people to traverse over a body of water. The fundamental ideas sustain the stresses from self-weight and items passing by using the buoyancy of water.

New bridge designs are required when the limitations of conventional bridges are exceeded. Concepts and experience from the offshore industry are often relevant when designing new floating bridges especially considering design concepts for floating pontoon ; hence , this research will study one of these concepts .The platform concept in question employs a submerged air volume exposed to hydrostatic pressure. Varying pressure will compress or expand the air , to which the intention is to maintain constant buoyancy for the structure.

There are numerous extant sea bridges around the world today. This research is primarily concerned with an idea that could be used to pontoons for floating bridges The Nordhordland pontoon bridge is located in Salhus. The Bergsysund bridge is a curving pontoon bridge in northern Norway.

2. Concept for Maintaining Constant Buoyancy

The pontoon concept is based on the idea of maintaining a constant global vertical position, i.e., a constant distance to the seafloor regardless of the surface water level. This might alternatively be explained as maintaining a constant buoyant force independent of the structure's draught. The buoyancy force is proportional to the displaced fluid's density and volume. The balance of gravity determines a floating object's static equilibrium location

3. ARCHIMEDES PRINCIPLE

Mass of liquid displaced mass = density *volume

= ρ*V

Thrust = ρVg
V = length×breadth×depth
= $1267.2m^2$

Thrust = $1000\times9.81\times126=1236.06\times10^3$KN

Design of Deck Slab

1. Given Data

Size of slab=21m*12.5m

Depth of Slab=0.60m

Grade M25,Fe500,

Live Load=$5KN/mm^2$

2.Type of Slab

L_y/L_x=21/12.5=1.68 <2

Given Slab is Two Way Slab.

3.Overall Depth

Assume Clear Cover=30mm

D=d+0.03=0.63

4.Effective Span

L_y=21+0.6

L_x=12.5+0.6=13.1m

5.Calculation of Load

Dead Load = l×b×D×r=1*1*0.63*24=15.12KN/m

Live Load =5KN/m

Total Load = 15.12+5=20.12KN/m

Factored Load=1.5*Total load=1.5*20.12=30.18KN/m

6. Calculation of Moment

$M_{ux} = \alpha_x * W_u * L_x^2$

$M_{uy} = \alpha_y * W_u * L_y^2$

From IS 456 – 2000

$\alpha_x = 0.074$

$\alpha_y = 0.061$

$M_{ux} = 0.074 \times 30.18 \times (13.1)^2 = 383.26$ KNm

$M_{uy} = 0.061 \times 30.18 \times (21.6)^2 = 858.927$ KNm

7.Calculation of shear

$V_{ux} = 0.5\ W_u L_x = 0.5 \times 30.18 \times 13.1 = 197.679$ KN

$V_{uy} = 0.5\ W_u\ L_y = 0.5 \times 30.18 \times 21.6 = 325.944$ KN

8. Check for Depth

$M_u = 0.138$ Fck bd^2

d = 0.36 < 0.6 m

Hence Safe

9. Area of Reinforcement

Shorter Span

$M_{ux} = 0.87\ f_y A_{st}\ d\ \{ 1 – [\ (f_y\ a_{st}) / (f_{ck}\ bd)]\}$

$A_{st} = 1810.45\ mm^2$

Use 12mm dia bars

1. No. of Bars = (A_{st} / a_{st})= 1810.45 / (π/4 *12^2)

= 16 Bars

2.Spacing S_v = (A_{st} / a_{st}) * b= 70 mm

Minimum spacing is 300 mm

Longer Span

$M_{uy} = 0.87\ f_y A_{st}\ d\ \{ 1 – [\ (f_y\ a_{st}) / (f_{ck}\ bd)]\}$

$A_{st} = 1475.05\ mm^2$

Using 12mm Bars

1. No. of bars = (A_{st} / a_{st}) = (1475.05) / (π/4 *12^2)

= 14 Bars

2. Spacing S_v = (A_{st} / a_{st}) * b = 75 mm

10. Check For Shear τ_v

$\tau_v = V_{ux}/ bd = (197.679*10^3) / (1000*600) = 0.32\ N/mm^2$

$p_t = 100A_{st} / bd$

= (100 * 1810.45)/ (1000*600) = 0.301

$\tau_c = 0.38\ N/mm^2$

K=1

$K\ \tau_c = 0.38\ N/mm^2$

$\tau_{cmax} /2 = (3.1/2) = 1.55\ N/mm^2$

$\tau_v < K\ \tau_c < (\tau_{cmax} /2)$

$0.32\ N/mm^2 < 0.38\ N/mm^2 < 1.55\ N/mm^2$

Hence safe in shear reinforcement

11.Check for deflection

L/d = 25

$p_t = 0.301$

Modification factor = 1.2

d_{req} = 21000/(28*1.2)= 596.85 mm

$d_{req} < d_{prov}$

596.85 mm< 600mm

Hence safe in deflection.

DESIGN OF PANTOON TOP SLAB

1. Given Data

Size of Slab = 15m ×11m

Depth of Slab = 45 ×10^{-2} m

Grade M25 , Fe 500

2. Type of Slab

$L_y/L_x = 15/11 = 1.36 < 2$

The Given Slab is Two Way Slab

3. Overall Depth

Clear Cover = 30mm

D= d+0.03= 0.45+0.03 = 0.48m

4. Effective Span

L_y=15+0.45=15.45 m

L_x=11+0.45=11.45m

5. Calculation of Load

Dead Load (DL) = l*b*D*ɤ = 1×1×0.48×24= 10.08 KN/m

Dead Load (Deck Slab) =15.12KN/m

Total Load = 10.08+15.12= 25.2 KN/m

Factored Load = 1.5×25.2=37.8 KN/m

6. Calculation of Moment

$M_{ux} = \alpha_x * W_u * L_x^2$

$M_{uy} = \alpha_y * W_u * L_y^2$

From IS 456-2000

$\alpha_x = 0.093$

$\alpha_y = 0.055$

$M_{ux} = 0.093 \times 37.8 \times 11.45^2 = 460.877$ KNm

$M_{uy} = 0.055 \times 37.8 \times 15.45^2 = 496.26$ KNm

7. Calculation of Shear

$V_{ux} = 0.5\ W_u L_x = 0.5 \times 37.8 \times 11.45 = 216.405$ KN

$V_{uy} = 0.5\ W_u L_y = 0.5 \times 37.8 \times 15.45 = 290.005$ KN

8. Check for Depth

$M_u = 0.138$ Fck bd^2

D = 0.43m < 0.45m

9. Area of Reinforcement

For Shorter Span

$M_{ux} = 0.87\ f_y A_{st}\, d\ \{ 1 – [\ (f_y\ a_{st}) / (f_{ck}\ bd)]\}$

$A_{st} = 4084.45\ mm^2$

No. of Bars = $(A_{st} / a_{st}) = (1475.05) / (\pi/4 * 12^2)$

= 36 Bars

Spacing , $S_v = (A_{st} / a_{st}) * b = [(\pi/4 * 12^2)/2190.29]\times 1000 = 52$ mm

10. Check for shear

$\tau_v = V_{ux}/ bd = 216.405/(1000*450)= 0.4809\ N/mm^2$

$p_t = 100A_{st} /bd = (100 \times 4804.45)/ (1000\times450)=1.067$

$\tau_c = 0.38\ N/mm^2$

K=1

K τ_c =0.64 N/mm^2

$\tau_{cmax} /2 = (3.1/2) = 1.55\ N/mm^2$

τ_v< K τ_c <(τ_{cmax} /2)

0.48 N/mm^2<0.64N/mm^2<1.55 N/mm^2

Hence safe in shear reinforcement

11. Check for Deflection

L/d = 25

$p_t = 1.067$

Modification factor = 1

d_{req} = 15000/(28*1) = 535.71 mm

$d_{req} < d_{prov}$

535.71 mm< 450mm

Hence safe in deflection

DESIGN OF LONGER SHEAR WALL

1.Given data

Load= 1800KNm

Length of wall = 16m

Depth of wall = 5000m

Thickness of wall = 300m

2.Slenderness Ratio = 0.75 × 5000 = 3750mm

3.Minimum eccentricity (e_{min}) = 0.05t=0.05×300=15mm

4.Additional Eccentricity = $\frac{(\text{slenderness ratio})^2}{2500t}$

$= \frac{3750^2}{2500\times300}$

= 18.75 mm

5.Ultimate load carrying capacity per unit length

$P_w = 0.3\ f_{ck}[\ t\text{-}1.2\ e_{min}\ \text{-}2e_a] = 0.3\times20\times[300\text{-}1.2\times15\text{-}2\times18.75]$

= 6×[300-1.8-37.5]

= 1564.2 KN > 1800 KN

6.Minimum Reinforcement

$P_{hor} = \frac{20}{100}$% of total cross-sectional area

$P_{ver} = \frac{15}{100}$% of total cross-sectional area

A= 600mm^2

DESIGN OF SHORTER SHEAR WALL

1.Given data

Load =1080.2 KN

Length of wall = 12 m

Depth of wall = 5000m

Thickness of wall = 300m

2. slenderness ratio =0.75 × 5000 = 3750mm

3.Minimum eccentricity (e_{min}) = 0.05t=0.05×300=15mm

4.Additional Eccentricity = $\frac{(\text{slenderness ratio})^2}{2500t}$

$= \frac{3750^2}{2500\times300}$

= 18.75 mm

5.Ultimate load carrying capacity per unit length

P_w = 0.3 f_{ck}[t-1.2 e_{min} -2e_a]

= 0.3×20×[300-1.2×15-2×18.75] = 6×[300-1.8-37.5]

= 1564.2 KN > 1080.2 KN

6.Minimum Reinforcement

$P_{hor} = \frac{20}{100}$% of total cross-sectional area

$P_{ver} = \frac{15}{100}$% of total cross-sectional area

A= 600mm^2

DESIGN OF PONTOON BOTTOM SLAB

1.Given data

Size of slab =16m×12m

Grade M25,Fe500

2.Type of slab = $\frac{16}{12}$=1.33 <2

The slab is two way slab

3. Overall Depth ,

Clear cover= 50mm

D=d+0.05 = 1.65m

4.Effective span

L_y = 16+1.6=17.6m

L_x=12+1.6=13.6m

5. Load Calculations

Dead load =l*b*D*ɤ = 1×1×1.65×24 = 39.6 KN/m

DL and LL on Deck Slab = 20.12 KN/m

DL on top slab = 10.08 KN/m

DL on longer shear wall = 88.88 KN/m

DL on shorter shear wall = 88.88KN/m

Total Load =247.4KN/m

Factored Load = 1.5 × 247.4=371.1KN/m

6.Calculation of Moment

$M_{ux} = \alpha_x * W_u * L_x^2$

$M_{uy} = \alpha_y * W_u * L_y^2$

From IS 456-2000

α_x = 0.093

α_y = 0.055

M_{ux} = 0.093×371.1×13.6^2=6383.39KN/m

M_{uy} = 0.055×371.1×17.6^2=3775.13KN/m

7. Calculation Of Shear

V_{ux} = 0.5 $W_u L_x$ = 0.5 ×371.1×13.6= 2523.48KN

V_{uy} = 0.5 $W_u L_y$ = 0.5 ×371.1×17.6= 3265.6KN

8. Check for Depth

M_u = 0.138 Fck bd^2

D = 1360mm < 1600mm

Safe

9. Area of Reinforcement

<u>For Shorter Span</u>

$M_{ux} = 0.87 f_y A_{st} d \{ 1 - [(f_y a_{st}) / (f_{ck} bd)]\}$

A_{st} = 10512.41 mm^2

No. of Bars = (A_{st} / a_{st}) = (10512.41) / (π/4 *25^2)

= 21 Bars

Spacing , S_v = (A_{st} / a_{st}) * b = [(π/4 *25^2)/10512.41]×1000 =46 mm

<u>For longer span</u>

$M_{uy} = 0.87 f_y A_{st} d \{ 1 - [(f_y a_{st}) / (f_{ck} bd)]\}$

A_{st} = 5800 mm^2

No. of Bars = (A_{st} / a_{st}) = (5800) / (π/4 *25^2)

= 12 Bars

Spacing , $S_v = (A_{st} / a_{st}) * b = [(\pi/4 *25^2)/5800]\times1000 = 85$ mm

10. . Check for shear

$\tau_v = V_{ux}/ bd = 2523.48 /(1000*1600) = 0.85 N/mm^2$

$p_t = 100A_{st} /bd = (100 \times10512.41)/ (1000\times1600) = 0.657$

$\tau_c = 0.38 N/mm^2$

K=1

$K \tau_c = 0.92 N/mm^2$

$\tau_{cmax} /2 = (3.1/2) = 1.55 N/mm^2$

$\tau_v < K \tau_c < (\tau_{cmax} /2)$

$0.85 N/mm^2 < 0.92 N/mm^2 < 1.55 N/mm^2$

Safe in shear .

11. Check for Deflection

L/d = 25

$p_t = 0.66$

Modification factor = 1

d_{req} = 620mm <1600mm

$d_{req} < d_{prov}$

620mm< 1600mm

Hence safe in deflection.

CONCLUSION

The primary objective of this report is to study the new concept for buoyancy and reduction of vertical motion of floating bridge and design of floating bridge.

The loads acting on the floating bridge will be traffic load, wave load, environmental load ,buoyancy, hydrostatic water pressure, self weight of bridge.

The study findings showed it is evident that the floating bridges are not just a military device or folkloristic curiosity, but they also represent the economical solutions for crossing large sections of even deep water. The findings also suggested that the length of the floating bridges is not restricted by structural or technological problems.

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