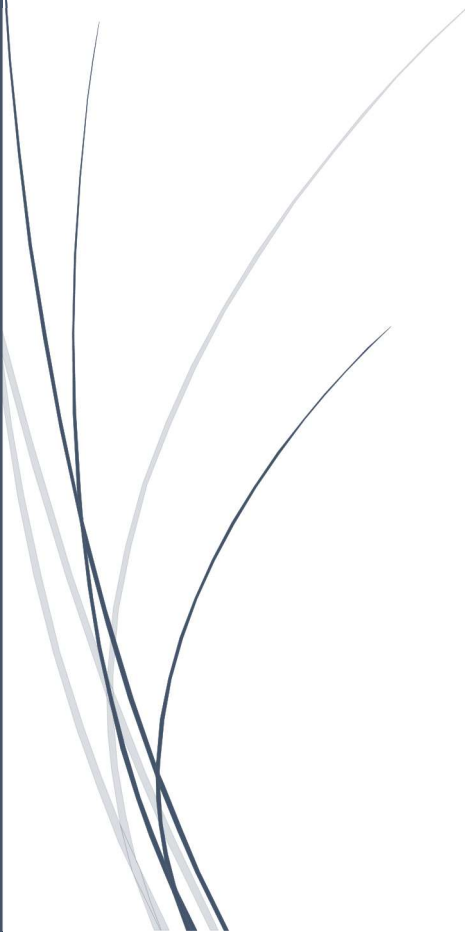


A dark blue vertical bar runs down the left side of the page. A blue arrow points to the right from this bar, containing the date 4/28/2023.

4/28/2023

Springfield Designs Ltd – Prince of Wales Dock Pedestrian Bridge

Structural Calculations

Several thin, curved lines in shades of blue and grey sweep upwards from the bottom left corner of the page.

Document Control

Richard Murray – Page 1-18

(Name – P.x-x)

Work Completed by Richard Murray
Highlighted **Yellow**

The density of the materials will be taken from Obinna.U (2020)

Bridge Component	Calculations (Dead load = Self Weight of Materials)	Result
Bridge Deck		
Section 1 – South Side	Bridge Deck construction is specified to be steel at 60m span. Width of bridge increases from 5.5m to 8.5m at widest point. Assumed width of 8m for calculation proves a factor of safety.	
	Width = 8m Span = 60m Thickness = 5cm Volume Calculation = $(8 \times 60) \times 0.05 = 24\text{m}^3$	
	Density of Steel is 78.50kn/m^3	
	Weight of Steel Deck = $78.50 \times 24 = 1884\text{kn/m}^3$	1884kn/m^3
	Proposed additional reinforcement along length of bridge in I beam * 3	
	Assumed dimensions of I Beam are; Area = 0.0244 60m Length Volume = $0.0244 \times 60 = 1.4654 \times 3 = 4.392\text{m}^3$	
	Density of Steel is 78.50kn/m^3	
	Weight of Steel I beam = $78.50 \times 4.392 = 344.772\text{kn/m}^3$	344.772kn/m^3
	Assumed Traverse I beam at each 'Cog'	

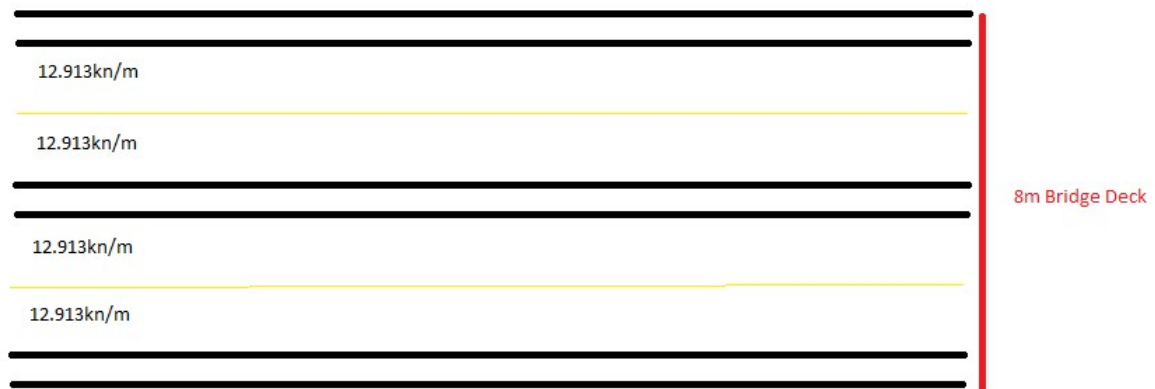
	Assumed dimensions of I Beam are; Area = 0.0244 8m Length Volume = $0.0244 \times 8 = 0.1952 \times 7 = 1.3664 \text{m}^3$	
	Density of Steel is 78.50kn/m^3	
	Weight of Steel I beam = $78.50 \times 1.3664 = 107.2624 \text{kn/m}^3$	107.2624kn/m^3
	Steel Poles/Beams will be located at each 4 points of cogs	
	0.031 Cross Sectional Area 60m length 4 Quantity	
	$(0.031 \times 60) \times 4 = 7.44 \text{m}^3$	
	Density of Steel is 78.50kn/m^3	
	Weight of Steel beam = $78.50 \times 7.44 = 584.04 \text{n/m}^3$	584.04n/m^3
	Perspex Windows	
	Circumference Area is assumed to be 26.763m as taken from plan at widest point	
	5m lengths	
	Total Number of windows = 11	
	Window Thickness 8mm	
	$((26.763 \times 5) \times 0.008) \times 11 = 11.7752 \text{m}^3$	
	Density of Perspex is 12kn/m^3	
	Weight of Perspex Windows = $12 \times 11.7752 =$ 141.30864kn/m^3	141.30864kn/m^3

	Steel Cog	
	Volume = 2.04 at widest point	
	12 Cogs	
	=12*2.04=24.48m ³	
	Density of Steel is 78.50kn/m ³	
	Weight of Steel I beam = 78.50*24.48=1921.68kn/m ³	1921.68kn/m ³
Total Weight of Section 1	Deck = 1884kn/m ³	
	Span Traversing I Beam = 344.772kn/m ³	
	Transverse I Beam = 107.2624kn/m ³	
	Steel Pole = 584.04n/m ³	
	Perspex Window = 141.30864kn/m ³	
	Steel Cog = 1921.68kn/m ³	
	Total Weight = 3,099.06304kn/m ³	3,099.06304kn/m ³
	Length of Bridge= 60m	
	UDL Calculation = 3,099.6304/60=51.651kn/ m ³	51.651kn/ m ³

Estimated Load Transitions would be as below;

$$51.651/8=6.456\text{kn/m}$$

2m of load would be experienced by the Spanning Beam due to 3 beams as shown in the below diagram.



As such the UDL for the central Beam would be $(12.913 \times 2) = 25.826 \text{ kn/m}$, the UDL for the 2 beams on the outside edge would be 12.913 kn/m

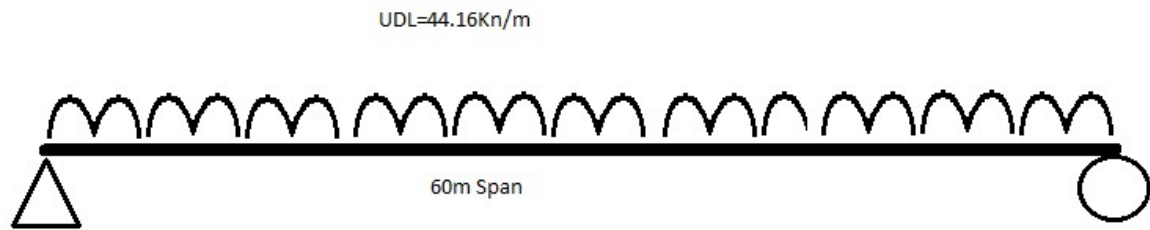
The live load as indicated by Concrete Development Group (No date) is 5 kn/m

As such from the above 2 sets of calculations will be required, 1 set for the central beam and another for the outside beam.

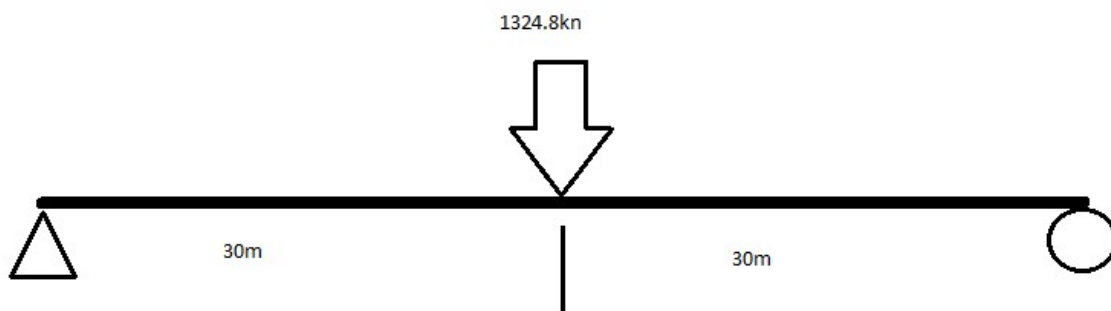
Central Beam Ultimate Limit Load

$$(1.4gk) + (1.6qk) = (1.4 \times 25.826) + (1.6 \times 5) = (36.1564) + (8) = 44.1564 = 44.16 \text{ kn/m}$$

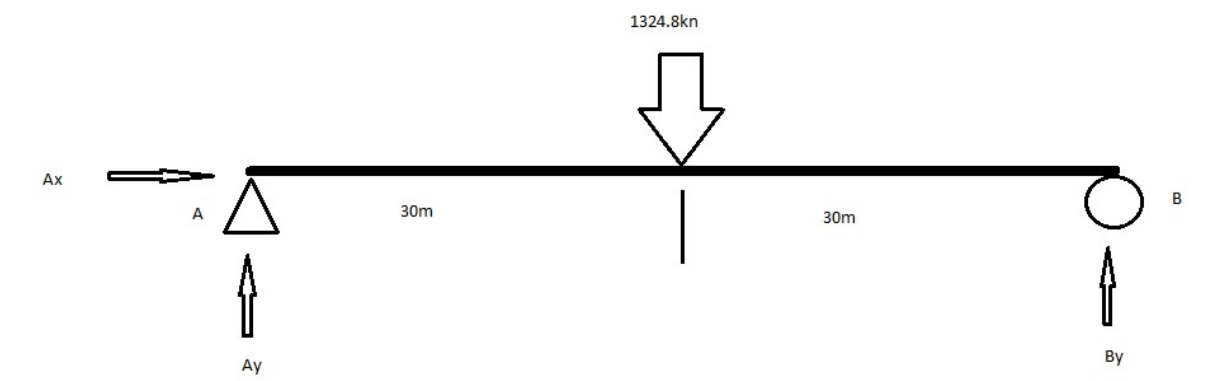
From the above the free body diagram will be as below



Converting the above into a point load;



As the beam is supported by each side the beam is Simply Supported. As such the resultant reactions can be calculated utilising the Equilibrium Equation



$$\sum f_x = 0 \quad a_x = 0$$

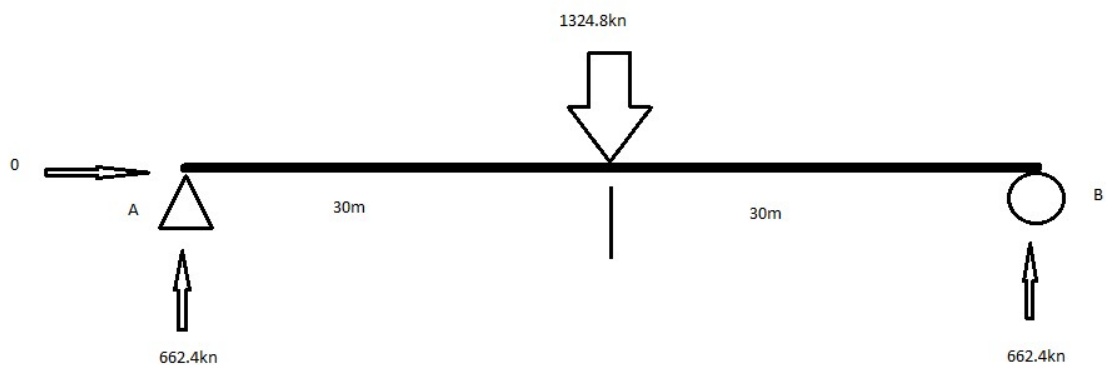
$$\sum f_y = 0 \quad A_y + B_y - 1324.8kn = 0 \quad A_y + B_y = 1324.4$$

$$\sum_{@A} M = 0 \quad B_y(60) - (1324.4 * 30) = 0 \quad B_y = \frac{-39732}{60} \quad B_y = -662.2 \quad B_y = 662.2$$

$$\sum f_y = 0 \quad A_y + B_y = 1324.8 \quad A_y + 662.2 = 1324.8 \text{ kn} \quad A_y = 662.6$$

Note – Due to the load being directly in the middle, the above difference is due to a rounding error within the equation.

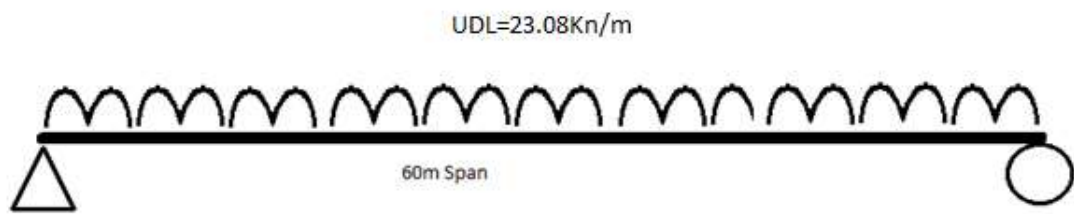
As such the loads will be taken as directly equal = 662.4kn



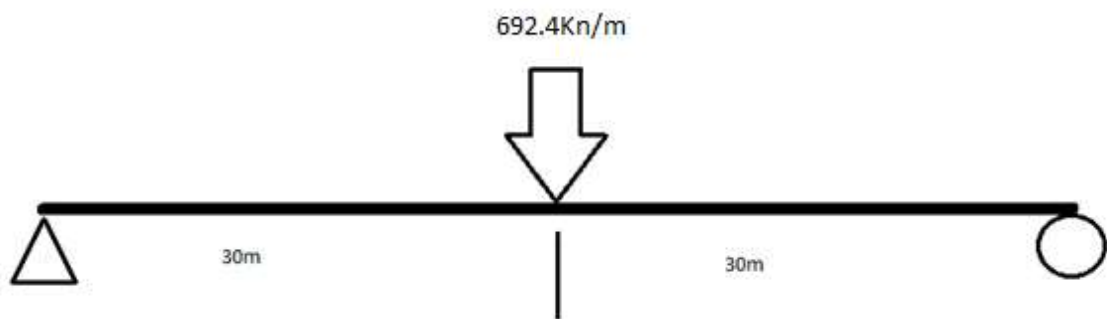
Side Beam Load

$$(1.4gk) + (1.6qk) = (1.4 * 12.913) + (1.6 * 5) = (18.0782) + (8) = 23.0782 = 23.08 \text{ kn/m}$$

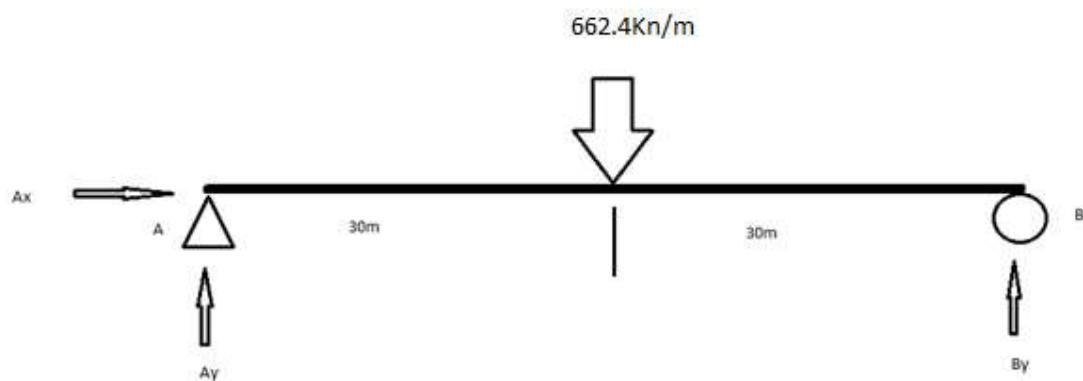
From the above the free body diagram will be as below



Converting the above into a point load;



As the beam is supported by each side the beam is Simply Supported. As such the resultant reactions can be calculated utilising the Equilibrium Equation

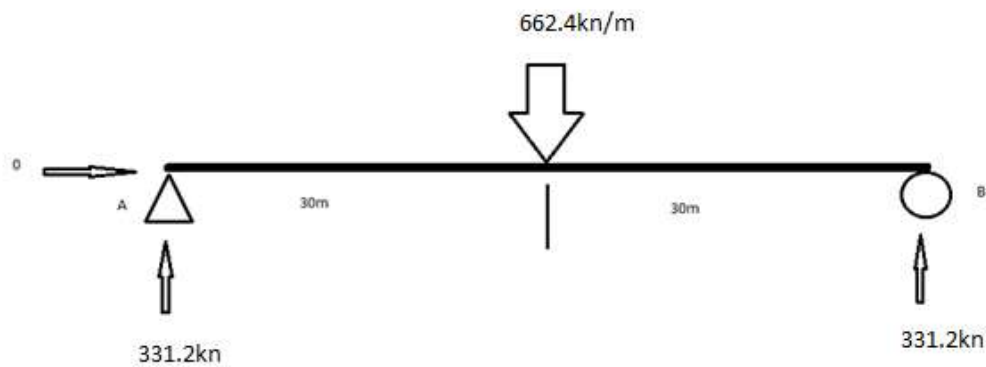


$$\sum f_x = 0 \quad a_x = 0$$

$$\sum f_y = 0 \quad Ay + By - 624.4kn = 0 \quad Ay + By = 662.4kn$$

$$\sum_{@A} M = 0 \quad B_y(60) - (662.4 * 30) = 0 \quad B_y = \frac{-19872}{60} \quad B_y = 331.2$$

$$\sum f_y = 0 \quad A_y + B_y = 662.4 \quad A_y + 331.2 = 662.4 \text{ kn} \quad A_y = 331.2 \text{ kn}$$



Note – As Section 3 is identical to Section 1. The above equations can also be taken for Section 3 of the bridge.

Central Span

The density of the materials will be taken from Obinna.U (2020)

Bridge Component	Calculations (Dead load = Self Weight of Materials)	Result
Bridge Deck		
Central Section	Bridge Deck construction is specified to be steel at 30m span. Width of bridge is 8m at widest point. This will be utilised in below calculations	
	Width = 8m Span = 30m Thickness = 5cm Volume Calculation = $(8 \times 30) \times 0.05 = 12\text{m}^3$	
	Density of Steel is 78.50kn/m^3	
	Weight of Steel Deck = $78.50 \times 24 = 942\text{kn/m}^3$	942kn/m^3
	Proposed additional reinforcement along length of bridge in I beam * 3	
	Assumed dimensions of I Beam are; Area = 0.0244 60m Length Volume = $0.0244 \times 30 = 0.732 \times 3 = 2.196\text{m}^3$	
	Density of Steel is 78.50kn/m^3	
	Weight of Steel I beam = $78.50 \times 2.196 = 172.386\text{kn/m}^3$	172.386kn/m^3
	Assumed Traverse I beam at each 'Cog'	

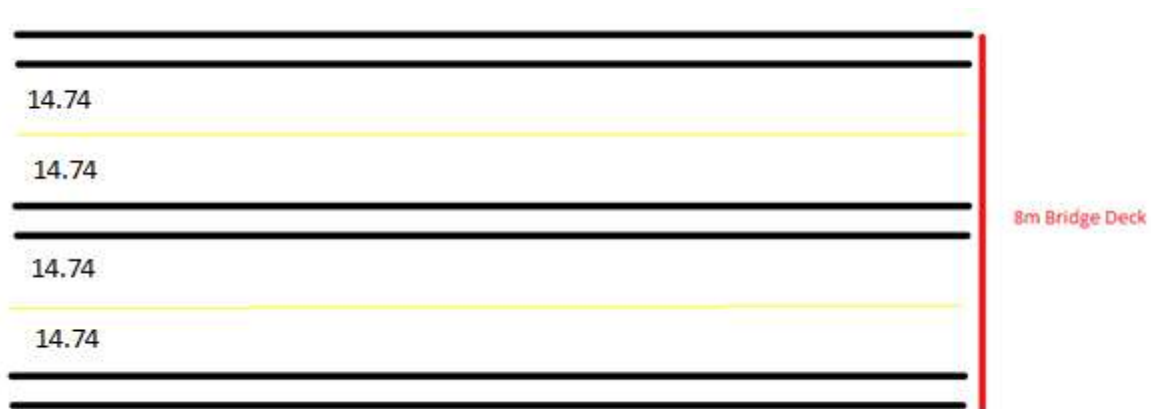
	Assumed dimensions of I Beam are; Area = 0.0244 8m Length Volume = $0.0244 \times 8 = 0.1952 \times 7 = 1.3664 \text{m}^3$	
	Density of Steel is 78.50kn/m^3	
	Weight of Steel I beam = $78.50 \times 1.3664 = 107.2624 \text{kn/m}^3$	107.2624kn/m^3
	Steel Poles/Beams will be located at each 4 points of cogs	
	0.031 Cross Sectional Area 30m length 4 Quantity	
	$(0.031 \times 30) \times 4 = 3.72 \text{m}^3$	
	Density of Steel is 78.50kn/m^3	
	Weight of Steel beam = $78.50 \times 3.72 = 292.02 \text{kn/m}^3$	292.02kn/m^3
	Perspex Windows	
	Circumference Area is assumed to be 26.763m as taken from plan at widest point	
	5m lengths	
	Total Number of windows = 6	
	Window Thickness 8mm	
	$((26.763 \times 5) \times 0.008) \times 6 = 6.42312 \text{m}^3$	
	Density of Perspex is 12kn/m^3	
	Weight of Perspex Windows = $12 \times 6.42312 =$ $77.07744 \text{kn/m}^3 = 77.077 \text{Kn/ m}^3$	77.077Kn/ m^3

	Steel Cog	
	Volume = 2.04 at widest point	
	7 Cogs	
	$= 7 * 2.04 = 14.28 \text{m}^3$	
	Density of Steel is 78.50kn/m^3	
	Weight of Steel I beam = $78.50 * 14.28 = 1120.98 \text{kn/m}^3$	1120.98kn/m^3
Total Weight of Central Section	Deck = 942kn/m^3	
	Span Traversing I Beam = 172.386kn/m^3	
	Transverse I Beam = 107.2624kn/m^3	
	Steel Pole = 292.02n/m^3	
	Perspex Window = 77.077kn/m^3	
	Steel Cog = 1120.98kn/m^3	
	Total Weight = 1769.7254kn/m^3	1769.73kn/m^3
	Length of Bridge = 30m	
	UDL Calculation = $1769.73 / 30 = 58.991 \text{kn/m}^3$	58.991kn/m^3

Estimated Load Transitions would be as below;

$$58.991 / 8 = 7.373875 = 7.37 \text{kn/m}$$

2m of load would be experienced by the Spanning Beam due to 3 beams as shown in the below diagram.



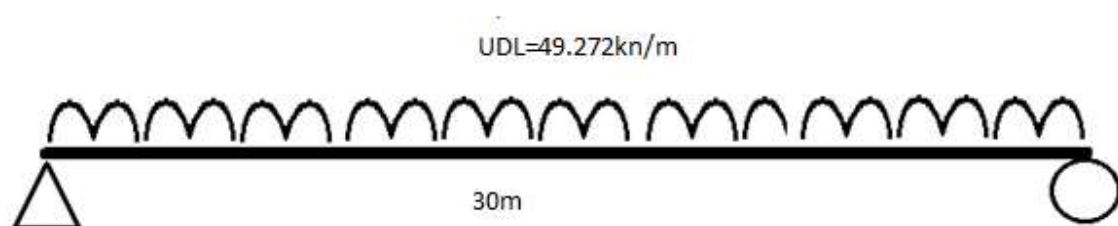
As such the UDL for the central Beam would be $(14.74 \times 2) = 29.48 \text{ kn/m}$, the UDL for the 2 beams on the outside edge would be 14.74 kn/m

The live load as indicated by Concrete Development Group (No date) Is 5 kn/m

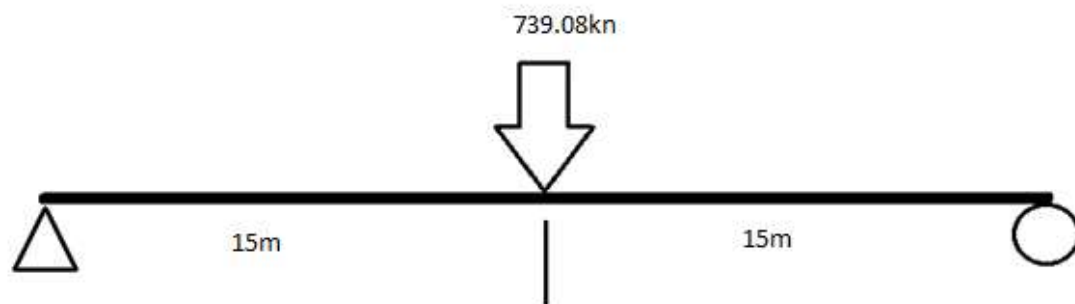
Central Beam Ultimate Limit Load

$$(1.4gk) + (1.6qk) = (1.4 \times 29.48) + (1.6 \times 5) = (41.272) + (8) = 49.272 = 49.272 \text{ kn/m}$$

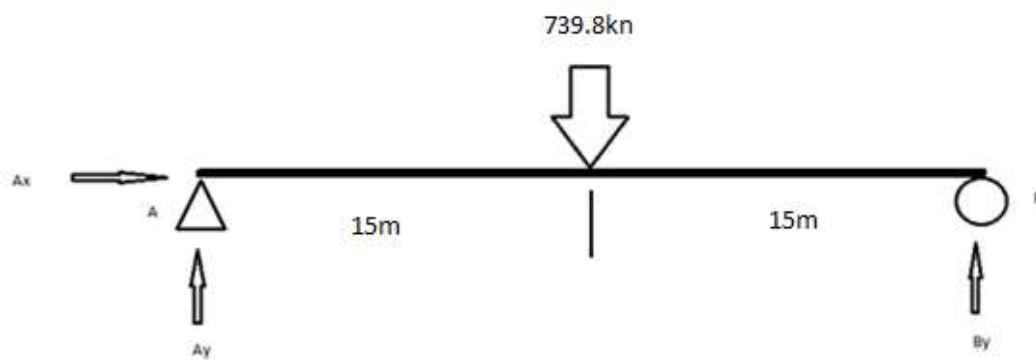
From the above the free body diagram will be as below



Converting the above into a point load;



As the beam is supported by each side the beam is Simply Supported. As such the resultant reactions can be calculated utilising the Equilibrium Equation

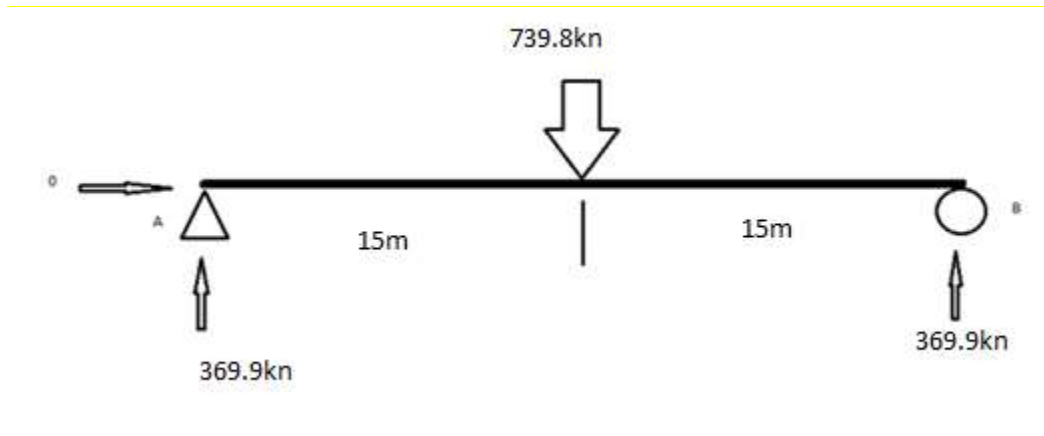


$$\sum f_x = 0 \quad A_x = 0$$

$$\sum f_y = 0 \quad A_y + B_y - 739.8kn = 0 \quad A_y + B_y = 739.8kn$$

$$\sum_{@A} M = 0 \quad B_y(30) - (739.8 * 15) = 0 \quad B_y = \frac{-11097}{30} \quad B_y - 369.9 \quad B_y = 369.9$$

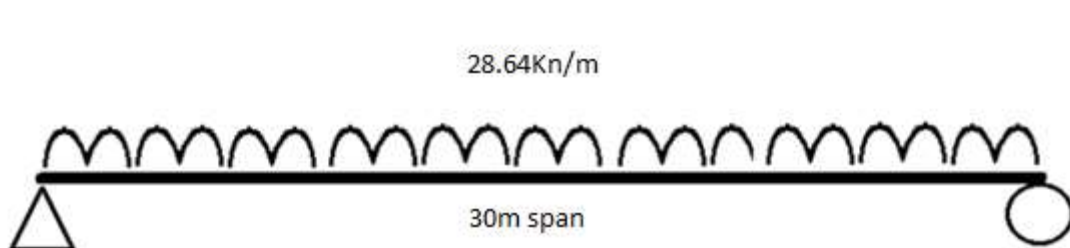
$$\sum f_y = 0 \quad A_y + B_y = 739.8 \quad A_y + 369.9 = 662.4kn \quad A_y = 369.9kn$$



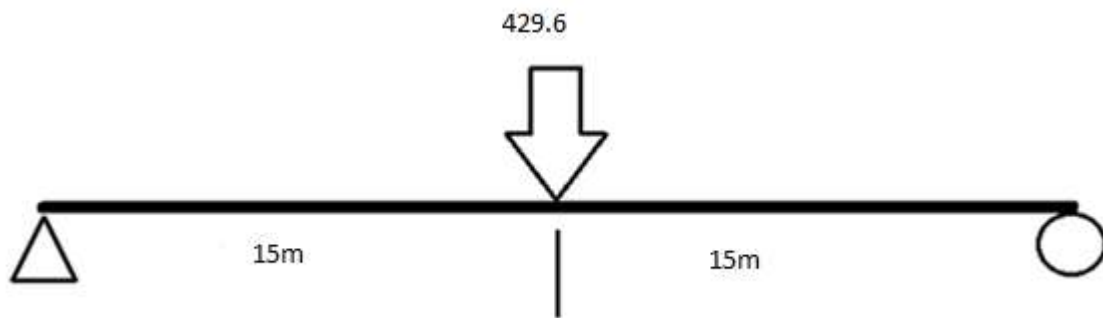
Side Beam Load

$$(1.4gk) + (1.6qk) = (1.4 * 14.74) + (1.6 * 5) = (20.636) + (8) = 28.636 = 28.64kn/m$$

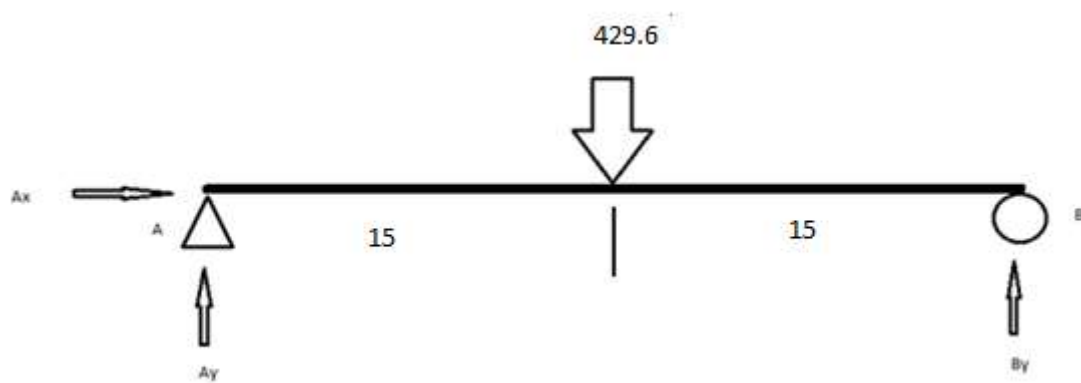
From the above the free body diagram will be as below



Converting the above into a point load;



As the beam is supported by each side the beam is Simply Supported. As such the resultant reactions can be calculated utilising the Equilibrium Equation

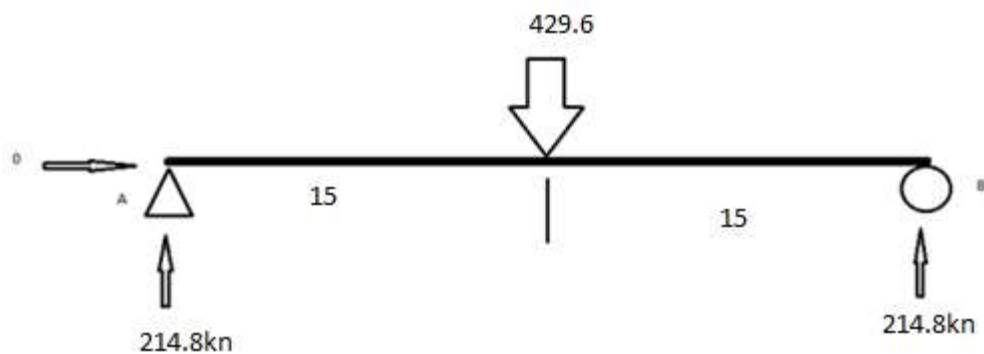


$$\sum f_x = 0 \quad A_x = 0$$

$$\sum f_y = 0 \quad A_y + B_y - 429.6 \text{ kn} = 0 \quad A_y + B_y = 429.6 \text{ kn}$$

$$\sum_{@A} M = 0 \quad By(30) - (429.6 * 15) = 0 \quad By = \frac{-6444}{30} \quad By - 214.8 \quad By = 214.8$$

$$\sum f_y = 0 \quad Ay + By = 429.6 \quad Ay + 214.8 = 429.6kn \quad Ay = 214.8kn$$



In conclusion each of the dock walls will need to be able to support 1324.6kn of weight, while the central ports will need to take 2064.4Kn. The vertical Lifting device will need to be rated to be able to support a total weight of 739.8kn each side.

Reference List

Obinna.U (2020) *Unit Weight of Construction Materials*. (Available at;

<https://structville.com/2020/12/unit-weight-of-construction-materials.html>) (Accessed 28/4/2023)

Concrete Development Group (No date) *Footbridges*. (Available at;

<https://www.cbdg.org.uk/footbridges.asp#:~:text=Design%20loading%20and%20vibration,is%20typically%205kN%2Fm2>) (Accessed 28/4/2023)