Chapter Five

Analysis and Discussion of Results

The analysis was carried out using SAFE version 12.2. After completing the modeling steps, analysis was run to obtain result. The result was compared between both models, and the comparison was made to carry out which type of modeling gives a best result in term of constructing the bridge more economical and serviceable.

The analysis for studied structure has been carried out by applying HA alone (UDL+KEL) loading and HB loading in twice cases (case 2a & 2b).

(1) For HA alone: the edge knife load (KEL) applied perpendicular to notional lane in load case named HA alone 2, and the edge knife load (KEL) applied parallel to notional lane in load case named HA alone, but KEL is still has a length equal to the lane width. Combinations for ultimate (ULS C1 & ULS C3) and serviceability (SLS C1) states adopted regarding the two cases as follow:

❖ **Ultimate:**

1) ULS C1 = (1.05) Selfwieht + (1.75) Surfacing + (1.5) Walkway + (1.2) Railing + (1.5) HA alone.

2) ULS C3 = (1.05) Selfwieht + (1.75) Surfacing + (1.5) Walkway + (1.2) Railing + (1.5) HA alone2.

❖ **Serviceability:**

1) SLS C1 = (1) Selfwieht + (1) Surfacing + (1.2) Walkway + (1) Railing + (1.2) HA alone.

The results obtained from the computer analysis for ULS C1, ULS C2 and SLS C1 are shown in the Tables (5.1) and (5.3) below.

(2) For HB + HA loading:

Case (2a): The HB vehicle straddling two lanes (lane 1 & lane 2).

Lane 1: loaded with HB vehicle alone

Lane 2: loaded with HB vehicle alone

Lane 3: loaded with HA including the KEL

Case (2a) represented by HB vehicle positions 3, 6 and 9

Case (2b): The HB vehicle straddling two lanes (lane 1 & lane 2).

Lane 1: loaded with HB vehicle alone

Lane 2: loaded with HB vehicle + HA without KEL

Lane 3: loaded with HA including the KEL

Case (2b) represented by HB vehicle positions 1and 2

For HB cases the edge knife load (KEL) applied perpendicular to notional lane in load case named (HB + HA 2), and the edge knife load (KEL) applied parallel to notional lane in load case named (HB + HA), but KEL is still has a length equal to the lane width. Combinations for ultimate (ULS C2 & ULS C4) and serviceability (SLS C2) states adopted regarding the two cases as follow:

❖ **Ultimate:**

1) ULS C2 = (1.05) Selfwieht + (1.75) Surfacing + (1.5) Walkway + (1.2) Railing + (1.3) [HB+HA].
2) ULS C4 = (1.05) Selfwieht + (1.75) Surfacing + (1.5) Walkway + (1.2) Railing + (1.3) [HB+HA].

❖ **Serviceability:**

1) SLS C2 = (1) Selfwieht + (1) Surfacing + (1.2) Walkway + (1) Railing + (1.1) [HB+HA].

The results obtained from the computer analyses for ULS C1, ULS C2, ULS C3, ULS C4, SLS C1 and SLS C2 are shown in Tables (5.2) and (5.4) below.

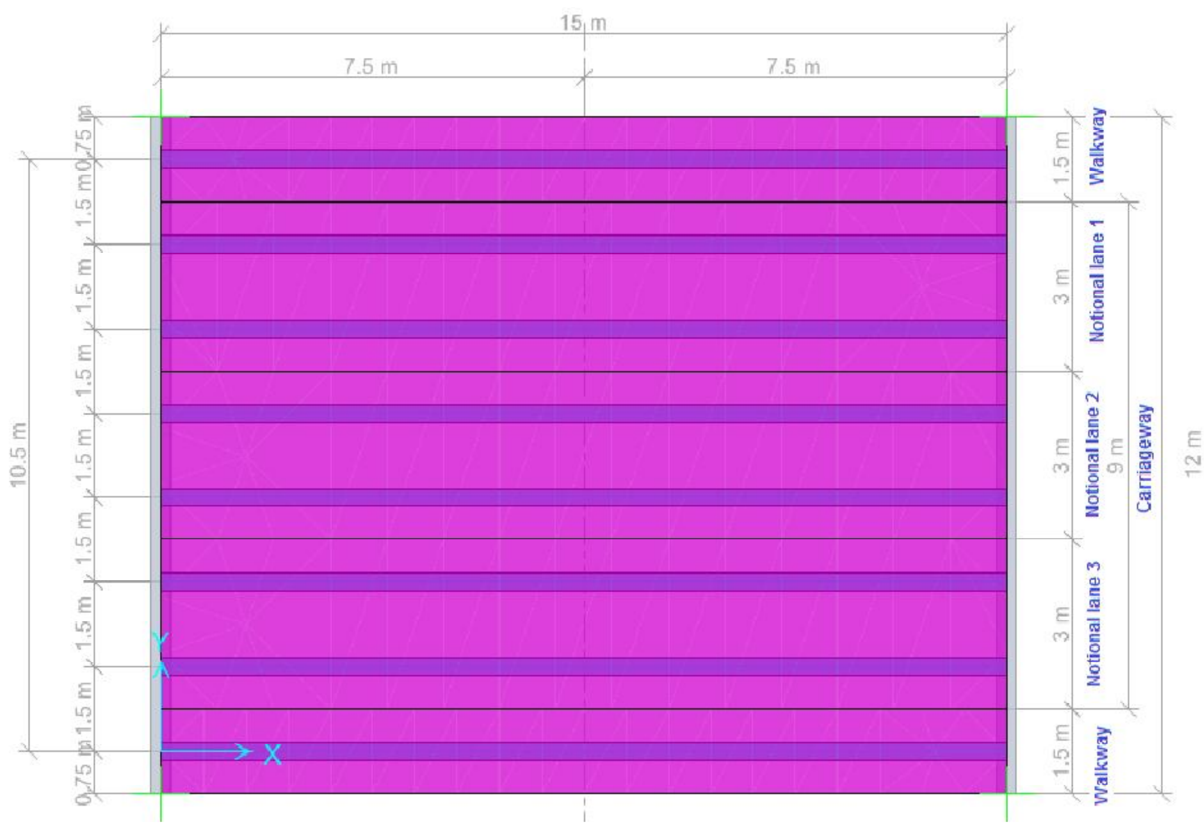

Fig. (5.1): Bridge Plan.

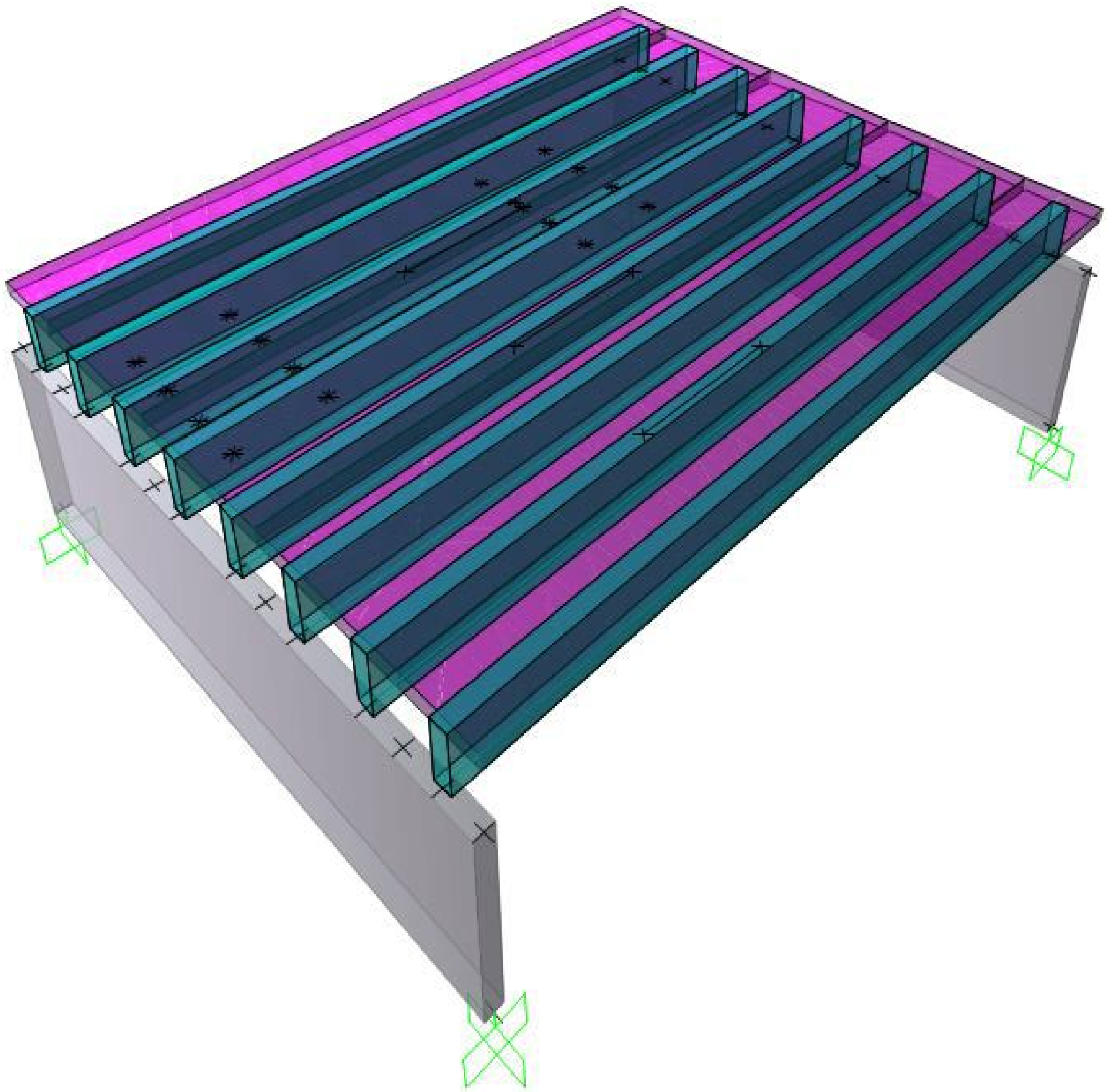

Fig. (5.2): Bridge superstructure 3D.

5.1 Load Pattern Values:

1. Surfacing Load

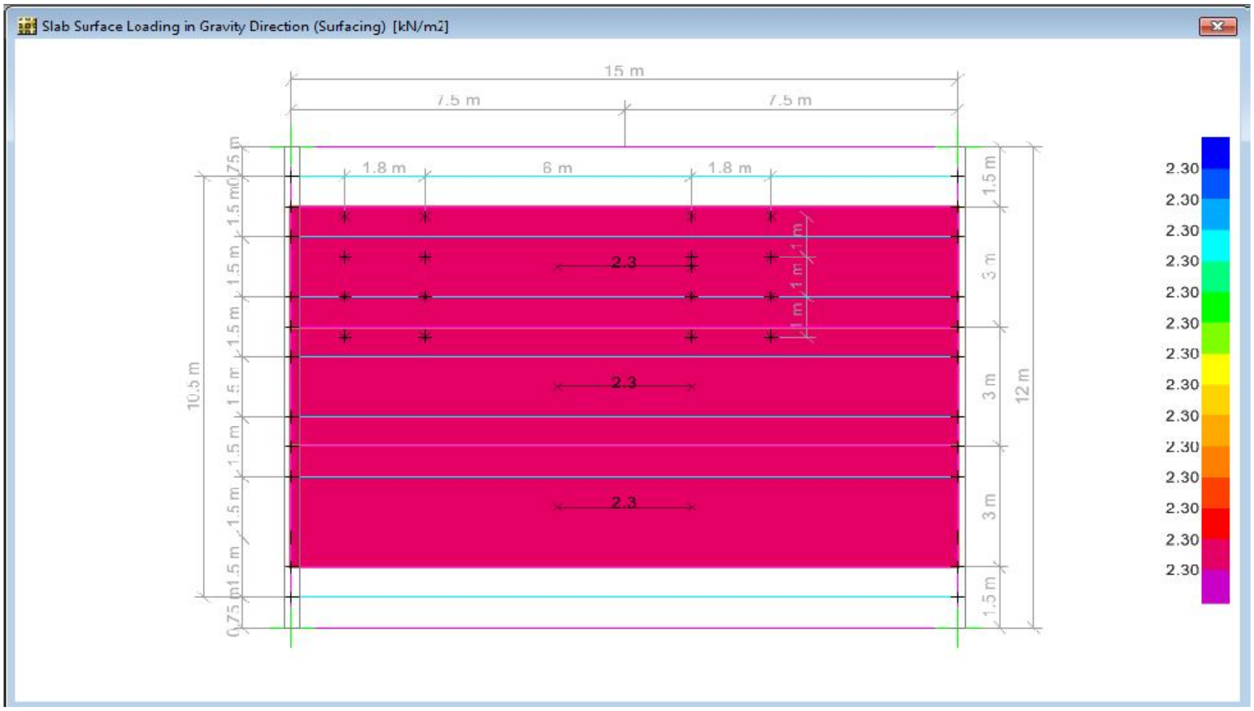

Fig. (5.3): Surfacing Load = 2.3 kN/m^2.

2. Walk way loading:

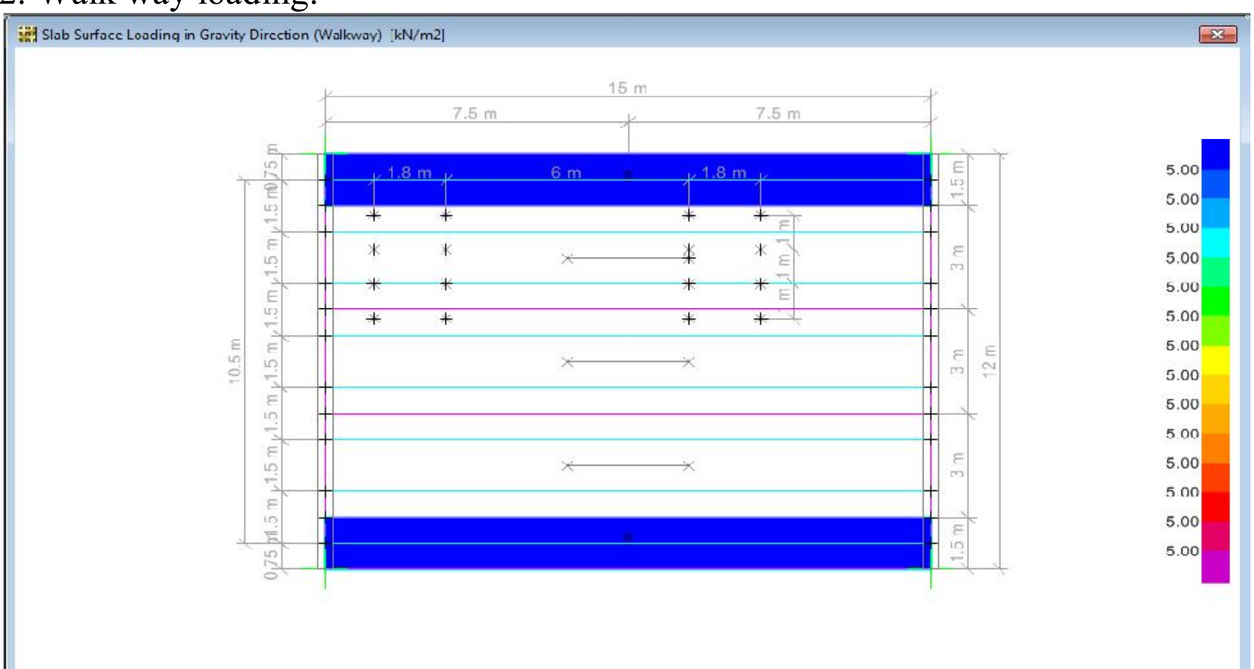

Fig. (5.4): Walkway Load = 5 kN/m^2.

3. Railing loading:

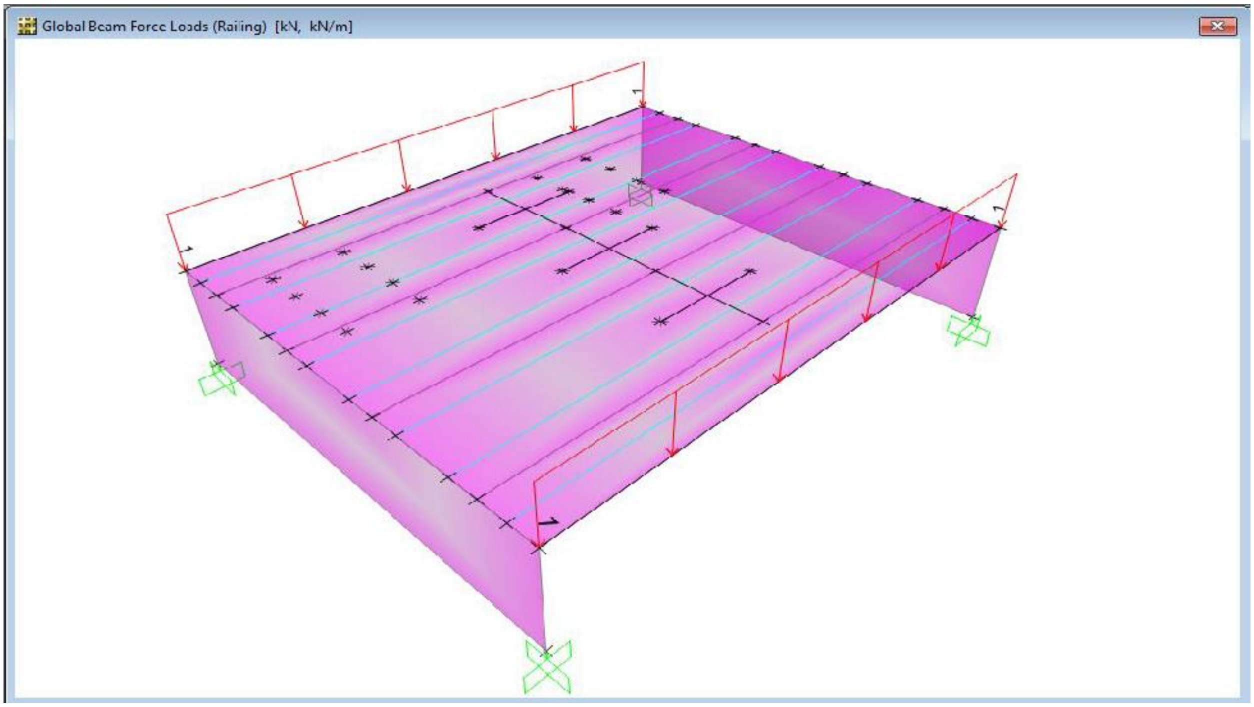

Fig. (5.5): Railing Load = 1 kN/m.

4. HA alone (UDL):

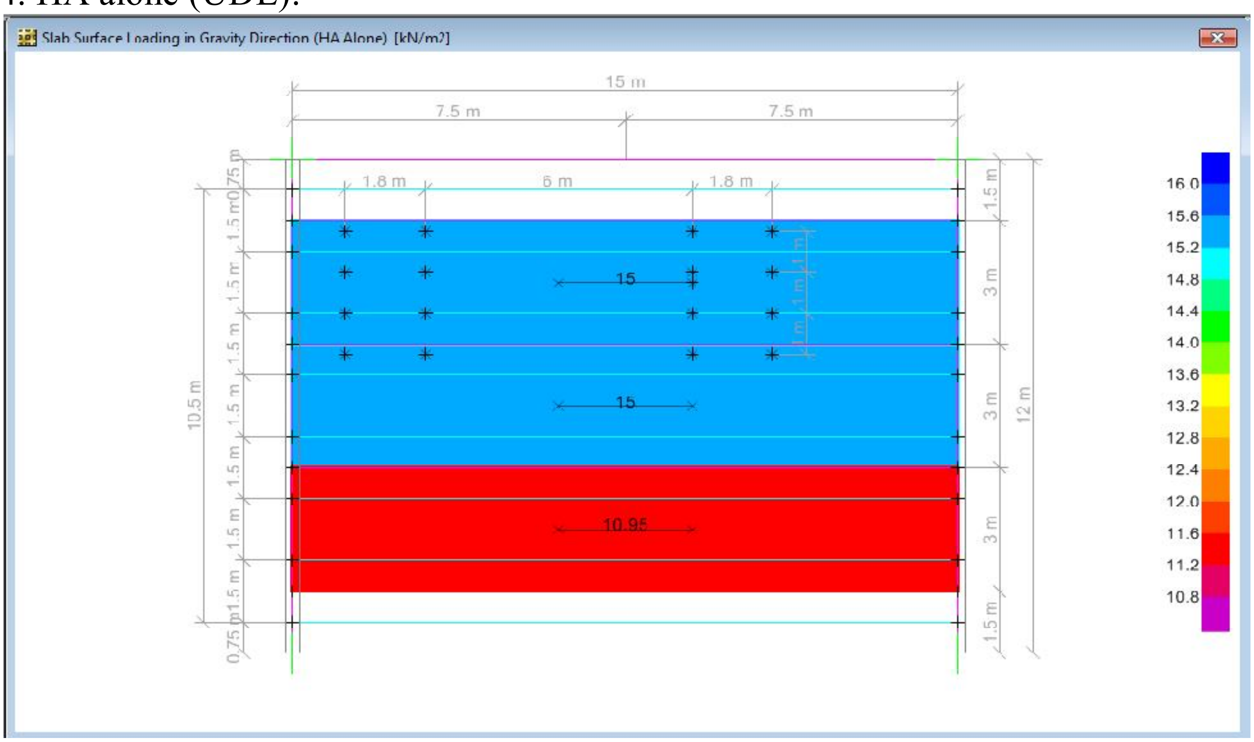

Fig. (5.6): HA Load (UDL).

5.1. HA alone (KEL): applied parallel to the bearing

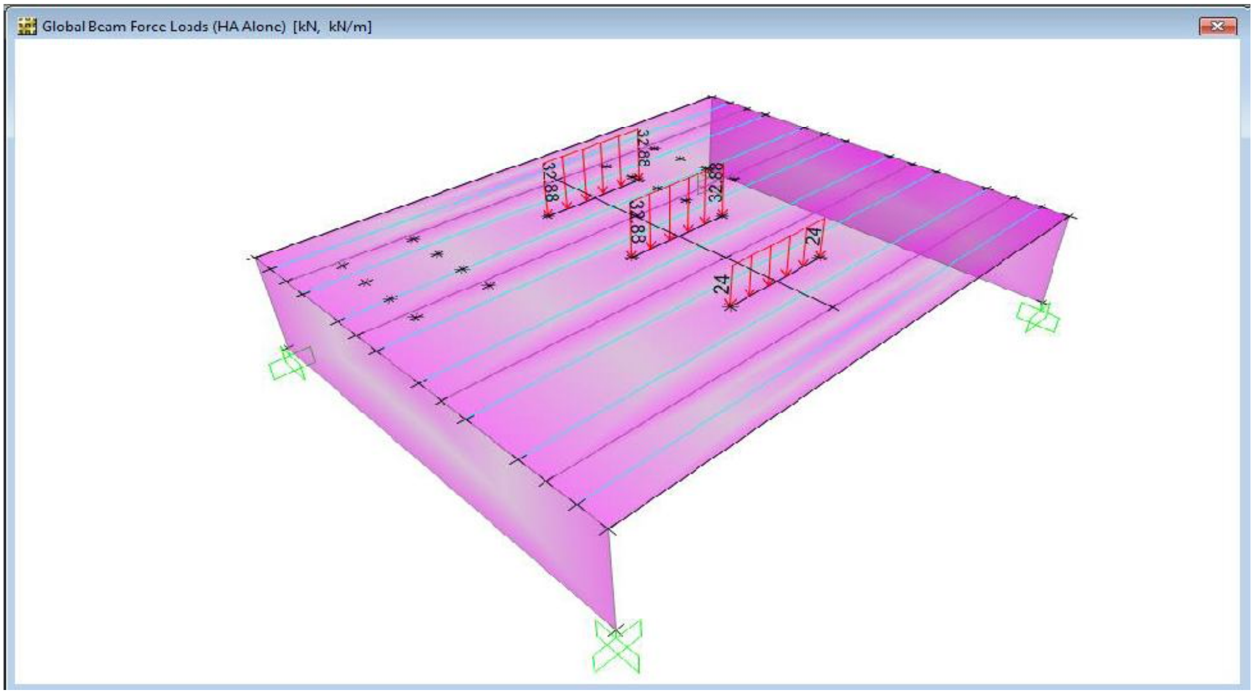

Fig. (5.7): HA Load (KEL) applied parallel to the bearing.

5.2. HA alone (KEL): applied perpendicular to notional lane.

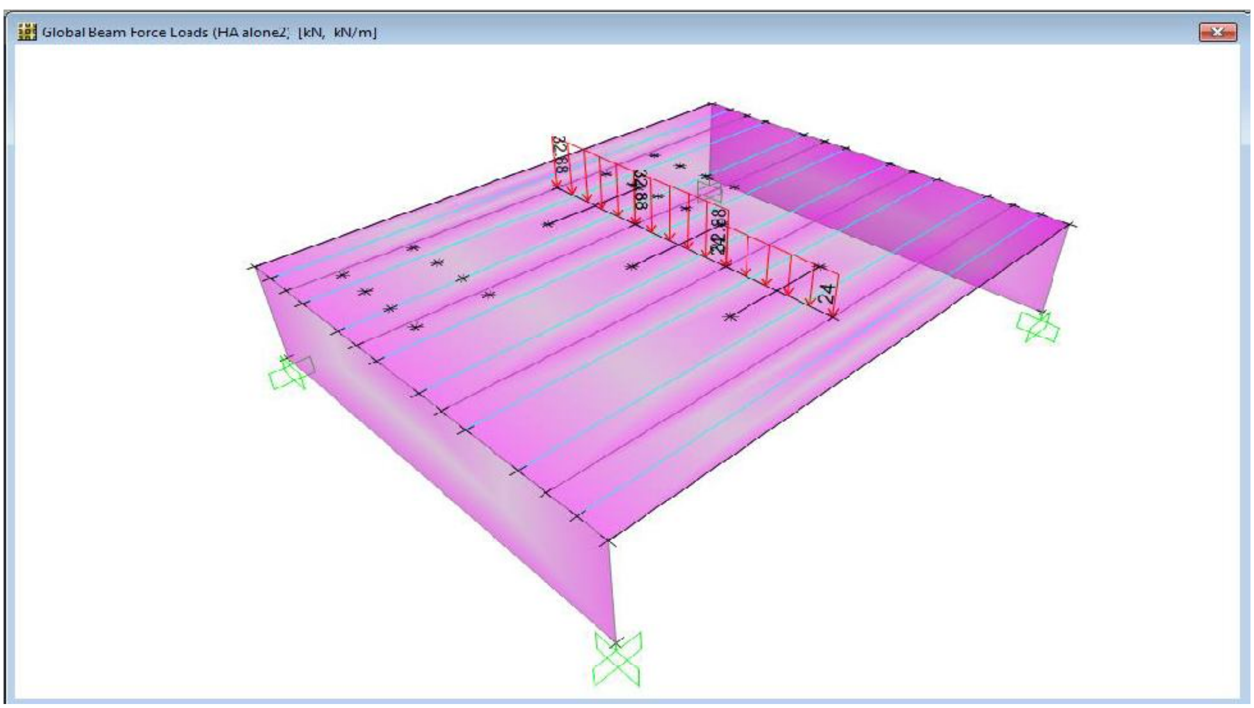

Fig. (5.8): HA Load (KEL) applied perpendicular to notional lane.

6. (HA + HB) loading: case (2b) straddling two lanes.

6.1. HA (UDL):

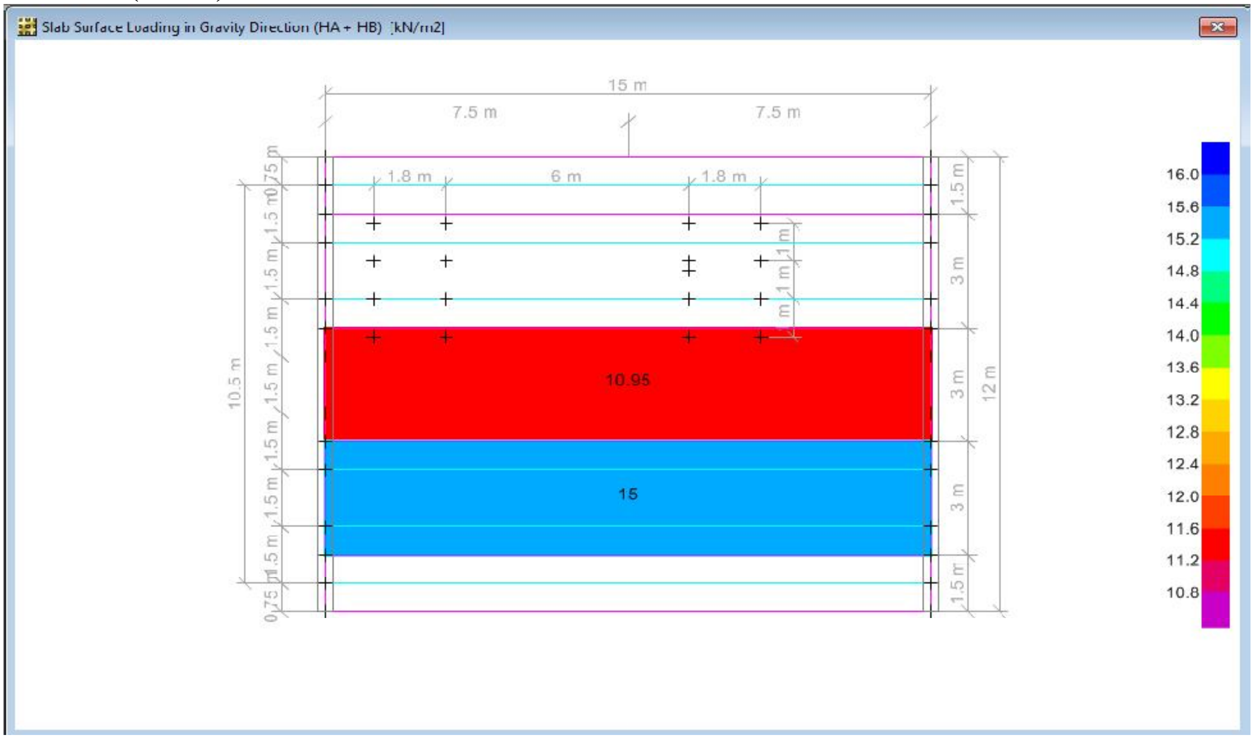

Fig. (5.9): HA+ HB Load (UDL).

6.2. HA (KEL): applied parallel to the bearing.

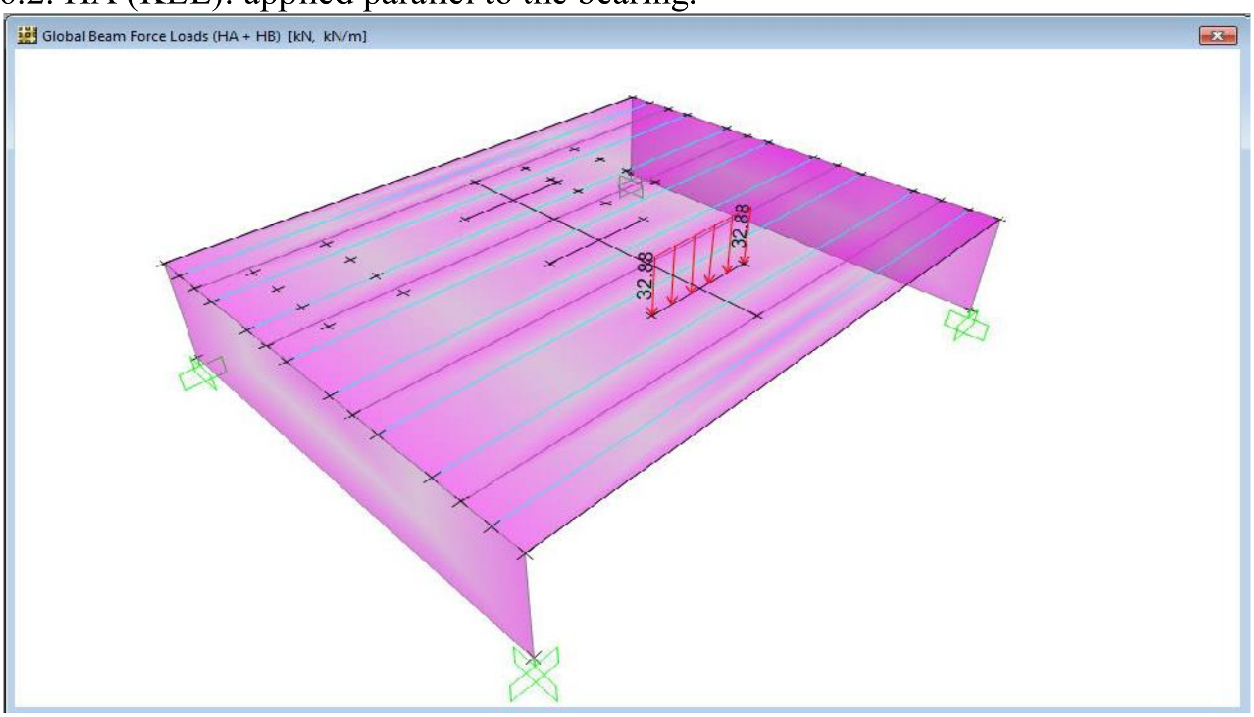

Fig. (5.10): HA+ HB Load plus (KEL).

6.3. HB Wheel loads:

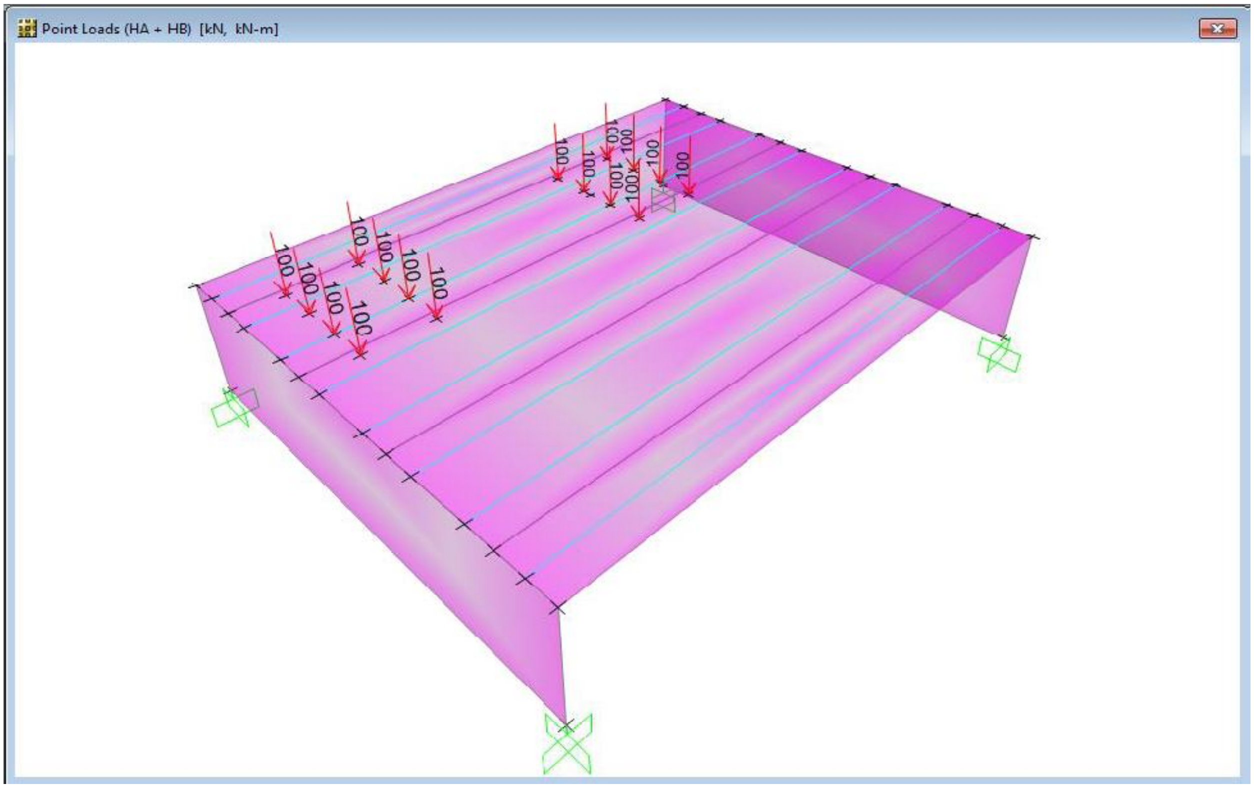

Fig. (5.11): HB Loading.

5.2 Analysis result for beam and shell and 3D solid element:

The analysis for beam and shell model was conducted to determine the, bending moment, Shear force, Torsion and Support reaction force. Result of analysis obtained from SAFE 12.2 by identifying which result and value to be shown.

The analysis was carried out in to position 1 and 2. Table (5.1) shows result of beam and shell model due to position 1 and Table (5.3) shows result of beam and shell model due to position 2.

The analysis for 3D solid model was performed to find out the analysis of moment, torsion, Shear force and support reaction as same as the previous model. Result of analysis obtained from SAFE by identifying which result and value to be shown.

The analysis was carried out in to position 1 and 2. Table (5.2) shows result of analysis of 3D solid element due to position 1 and Table (5.4) shows result due to position 2

5.2.1 Position (1):

HB loading case (2b): straddling two lanes.

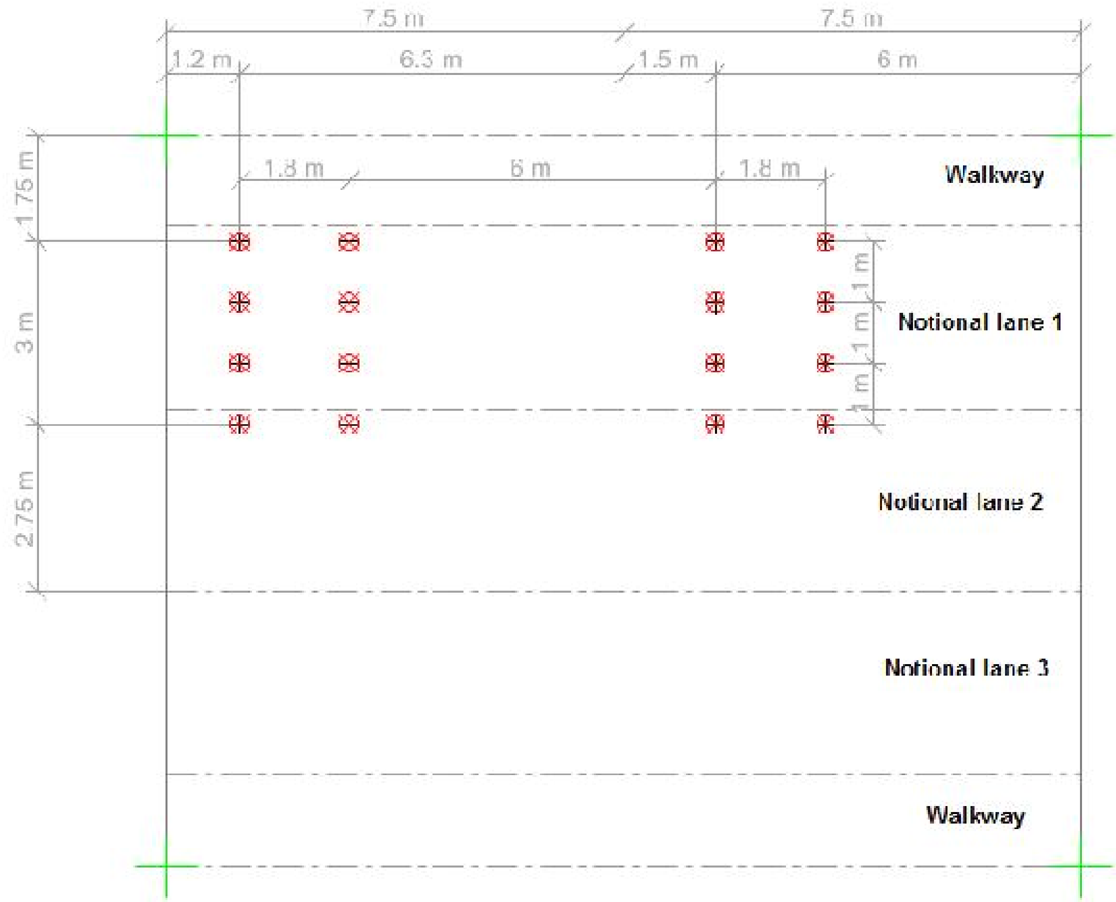

Fig. (5.12): HB vehicle Position (1).

Table (5.1): Analysis results due to HB vehicle position (1) beam and shell element.

Load Combination	SLAB		BEAM			Reaction Force
	M max (kN.m)	M min (kN.m)	M max (kN.m)	Shear max (kN)	Torsion E-13	KN
ULS C1	62.06	-45.4	1644	396.3	3.29	91.8
ULS C2	76.3	-71.4	1900.2	452.3	0.004	100.1
SLS C1	50.6	-34.6	1343.1	324.3	2.77	79.9
SLS C2	60.07	-59	1608.6	383.1	0.004	88.1
ULS C3	63.2	-42.2	1665.6	395.9	3.3	92.4
ULS C4	76.3	-71.5	1902.8	452.6	0.004	100.1

Table (5.2): Analysis results due to HB vehicle position (1) 3D Solid element.

Load Combination	SLAB		BEAM			Reaction Force
	M max (kN.m)	M min (kN.m)	M max (kN.m)	Shear max (kN)	Torsion E-13	KN
ULS C1	26.6	-53.3	594.4	379.8	-	65.6
ULS C2	35.6	-73.4	701.5	487.1	-	65.6
SLS C1	21.5	-45.3	484.2	310.4	-	62.4
SLS C2	30	-62.1	593.4	412.4	-	62.4
ULS C3	27.6	-53.4	615.1	379.7	-	65.6
ULS C4	35.6	-73.4	702.4	487.3	-	65.6

5.2.2 Position (2):

HB Loading case (2b): straddling two lanes.

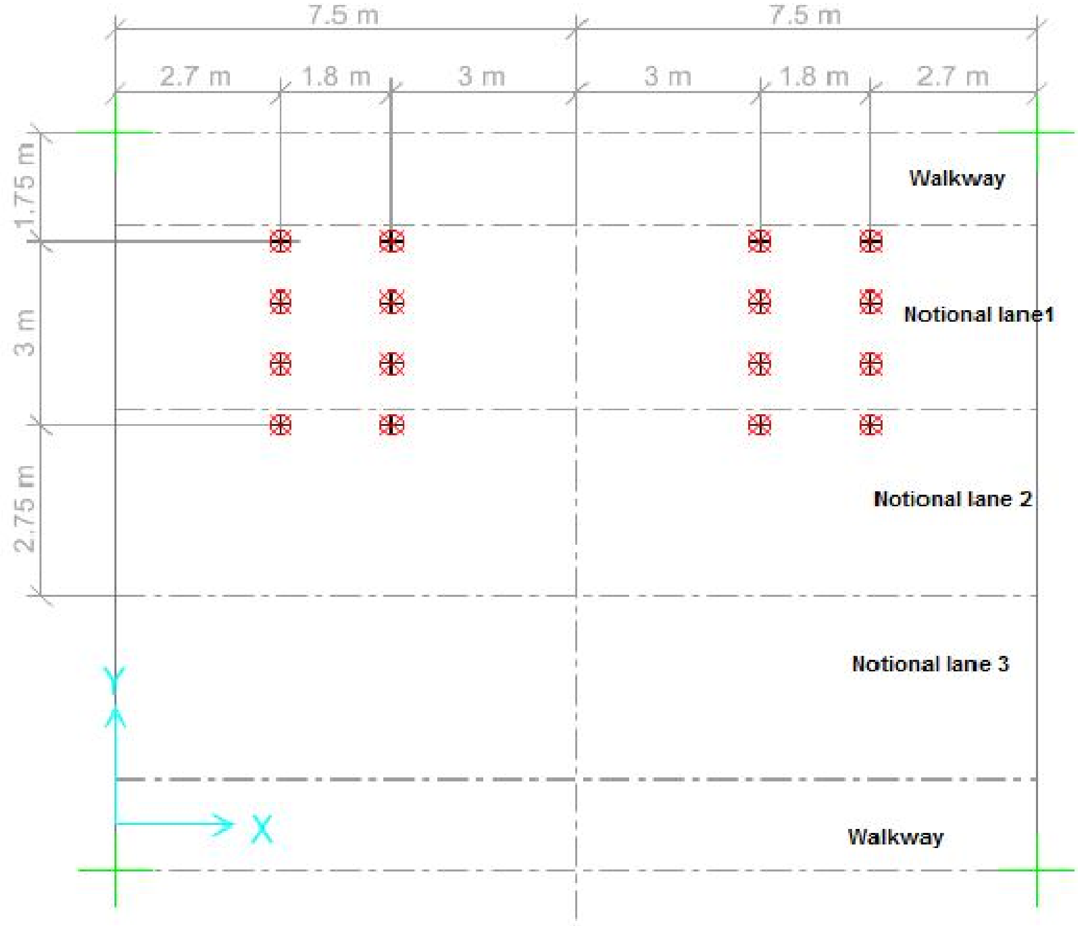

Fig. (5.13): HB vehicle Position (2)

Table (5.3): Analysis results due to HB vehicle position (2) beam and shell element.

Load Combination	**SLAB**		**BEAM**			**Reaction Force**
	M max (kN.m)	M min (kN.m)	M max (kN.m)	Shear max (kN)	Torsion E-13	KN
ULS C1	62.06	-45	1644	396.1	4.08	83.5
ULS C2	78.7	-73.9	1823.3	511.5	4.27	86
SLS C1	50.5	-34.2	1343.2	324.2	3.44	71.6
SLS C2	65.2	-61.2	1543.6	433.2	3.67	75
ULS C3	63.2	-42.8	1665.6	395.7	4.1	84
ULS C4	78.7	-74	1826	511.9	4.29	86

Table (5.4): Analysis results due to HB vehicle position (2) 3D Solid element.

Load Combination	SLAB		BEAM			Reaction Force
	M max (kN.m)	M min (kN.m)	M max (kN.m)	Shear max (kN)	Torsion E-13	KN
ULS C1	26.6	-53.3	594.4	379.8	-	65.6
ULS C2	29.9	-67.3	595.7	556.6	-	65.6
SLS C1	21.6	-45.3	484.2	310.4	-	62.4
SLS C2	25.2	-56.9	503.9	471.1	-	62.4
ULS C3	27.6	-53.4	615.1	379.7	-	65.6
ULS C4	29.9	-67.3	597.8	556.8	-	65.6

5.3 Comparison between beam and shell and 3D solid element:

In this subchapter, result from both models was compared to determine which model gives the most exceptional result based on analysis of shear force, support reaction, moment and torsion. The results were expected to give the bridge analysts idea of which models are best to be used when analyzing the bridge deck.

Although there are lots of model in analyzing the bridge deck, but for the study, only two models were analyzed. The point in formulate the comparison between two models are to determine which model gives the finest value that can be used for the design process.

Table (5.5): Slab moments:

Load Combination	Positive moment kN.m		Diff %	Negative moment kN.m		Diff %
	Beam and shell element	3D solid element		Beam and shell element	3D solid element	
ULS C1	62.06	26.6	57%	-45.4	-53.3	15%
ULS C2	76.3	35.6	53%	-71.4	-73.4	2%
SLS C1	50.6	21.9	57%	-34.6	-45.3	24%
SLS C2	60.07	30	50%	-59	-62.1	5%
ULS C3	63.2	27.6	56%	-42.2	-53.4	21%
ULS C4	76.3	35.6	53%	-71.5	-73.4	3%

Table (5.6): Beam major moments:

Load combination	Beam and shell element	3D Solid element	Diff %
ULS C1	1644	594.4	64%
ULS C2	1900.27	701.5	63%
SLS C1	1343.1	484.2	64%
SLS C2	1608.6	593.4	63%
ULS C3	1665.6	615.1	62%
ULS C4	1902.8	702.4	63%

Table (5.7): Beam major Shear Forces:

Load combination	Beam and shell element	3D Solid element	Diff %
ULS C1	396.3	379.8	4%
ULS C2	452.3	487.1	7%
SLS C1	324.3	310.4	4%
SLS C2	383.1	412.4	7%
ULS C3	395.5	379.7	4%
ULS C4	452.6	487.3	7%

Table (5.8): Beam Torsion moments:

Load combination	Beam and shell element	3D Solid element
ULS C1	3.29	-
ULS C2	0.004	-
SLS C1	2.77	-
SLS C2	0.004	-
ULS C3	3.3	-
ULS C4	0.004	-

Table (5.9): Reaction Force:

Load combination	**Beam and shell element**	**3D Solid element**	Diff %
ULS C1	91.8	65.6	29%
ULS C2	100.1	65.6	34%
SLS C1	79.9	62.4	22%
SLS C2	88.1	62.4	29%
ULS C3	92.4	65.6	29%
ULS C4	100.1	65.6	34%

5.4 Comparison between manual calculation and safe output data for edge beam:

Combination	Manual output	SAFE output	Diff %
ULS C1 Moment	1455	1644	11%
ULS C1 Shear force	388.1	396.1	2%

5.4 Discussion:

From the observation of the analysis we can see that the maximum value obtained from position one and ultimate limit state combination four [ULS C4].

For maximum slab moment beam and shell model gives greater values than 3D solid model, also for minimum moment beam and shell model gives lower values than 3d solid element.

For major beam moment we can see that 3D solid model gives minimum values compared with beam and shell model, for major shear force we can see that we have convergent values for two models and for torsion SAFE cannot give values for 3D solid model.

For Reaction force we find that beam and shell model gives a higher values compared with 3D solid model.