

Analysis and design of composite slab by varying different parameters

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Abstract. Composite deck slabs are in demand because of its faster, lighter and economical construction work. Composite slab consists of cold formed deck profiled sheet and concrete either lightweight or normal. Investigation of shear behaviour of the composite slab is very complex. Shear bond strength depends on the various parameter such as a shape of sheeting, a thickness of the sheet, type of embossment and its frequency of use, shear stiffener or intermediate stiffener, type of load, an arrangement of load, length of shear span, the thickness of concrete and support friction etc. In present study finite element analysis is carried out with ABAQUS 6.13, a simply supported composite slab is considered for the investigation of the shear bond behaviour of the composite slab by considering variation in three different parameters, the shape of a sheet, thickness of sheet and shear span. Different shear spans of two different shape of cold formed deck profiled sheet i.e. with intermediate stiffeners and without intermediate stiffeners are considered with two different thicknesses (0.8 mm and 1.2 mm) for simulation. In present work, simulation of models has done for static loading with 20 mm mesh size is considered.

1. Introduction

Cold formed deck profiled steel sheets are widely used for constructing composite slab. Cold formed deck profiled sheet performs two functions: it acts as the formwork during construction and as tension reinforcement in composite slab. In case of continuous slab, for taking care of shrinkage, temperature effect and a negative bending moment at support the only additional steel that needs to be provided is reinforcing steel.



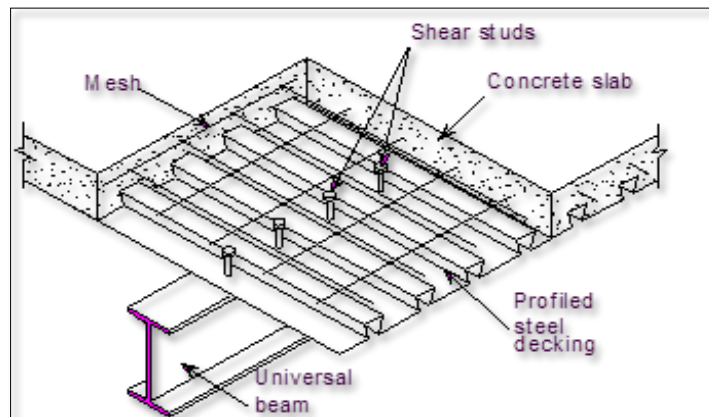


Figure 1. Details of composite slab.

This kind of flooring system results in faster construction, lighter floors and rational use of construction materials. This system is well accepted by the construction industry due to the many advantages over other types of floor systems (Andrade 2004; Makelainen and Sum 1999). There are some important advantages such as simple handling, light in weight, transportation and handling is easy and convenient. Some of the disadvantages of this system are: it needs proper binding in between cold formed deck profiled sheet and concrete. The cold formed steel deck profiled sheet is galvanized steel it required anticorrosive coating on the exposed side. Effect of ponding should also be taken during design. Composite slab means the cold formed deck profiled sheet and concrete to act compositely and there is a provision of interlocking between these two by some mechanical means. This can be provided by some shear transferring device like intermediate stiffeners, embossments and shear connectors etc. A typical example of the composite slab has been shown in figure 1. The shear bond connection in composite slab between the concrete and the cold formed deck profiled sheet is a highly nonlinear problem as far as material, boundary conditions and geometrical shapes are concerned. Resistance to shear bond in the composite slab is provided by profiled sheet, intermediate stiffeners, embossments and end anchorage. Resistance to vertical separation and the horizontal slip is provided by the suitable shape of cold formed deck profiled sheet. When composite slab undergoes loading firstly load transferred to concrete if the load exceeds the tensile strength of concrete cracks will form. Mechanical interlock between concrete and cold formed deck profiled sheet is due to intermediate stiffeners and embossments provided in the profiled sheet which holds concrete and cold formed deck profiled sheet together. When critical loading is achieved will lead to shear bond failure. Different failures in the composite slab are shown in figure 2(a) and (b).

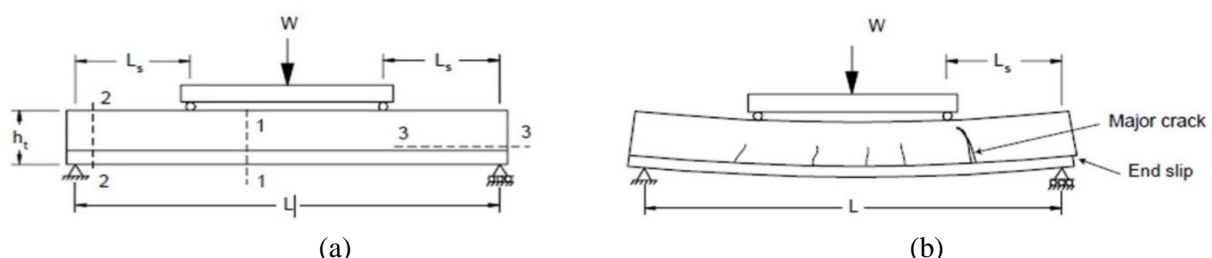


Figure 2. Different modes of failure in composite slab (R. P. Johnson 2004).

2. Structural Modelling

Finite element model is created with concrete and cold formed deck profiled sheet both are defined as a solid element. Figure 3, 4 and 5 show the model of concrete and cold formed deck profiled sheet in ABAQUS 6.13. The dimensions of the structure are 790 x 3000 mm and height of 105 mm with an

effective depth of 77.5 mm. The cold formed deck profiled sheet has a height of 55 mm and thickness of 0.8 mm and 1.2 mm respectively. In ABAQUS 6.13, the material properties of steel and concrete can be characterized as a homogeneous material. The boundary conditions are hinged ($U_1=U_2=U_3=0$) provided at one end and roller ($U_1=U_2=0$) on another end. As mentioned two parts (concrete and cold formed deck profiled sheet) are created to make the finite element model of composite slab. Each of these two parts composed of a linear hexahedral element (C3D8R): an 8 noded brick element with 20 mm mesh size.

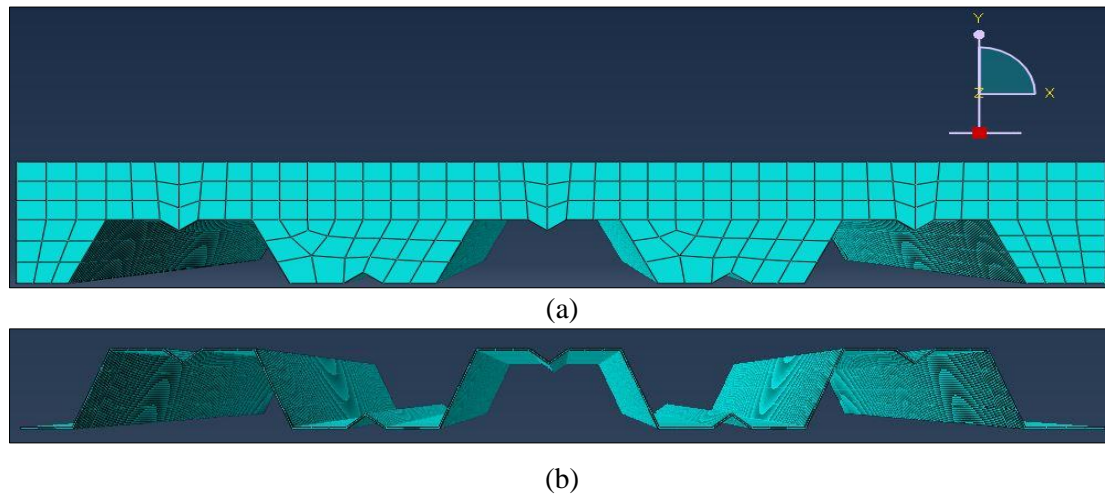


Figure 3. Model of concrete and deck profiled sheet with intermediate stiffener.

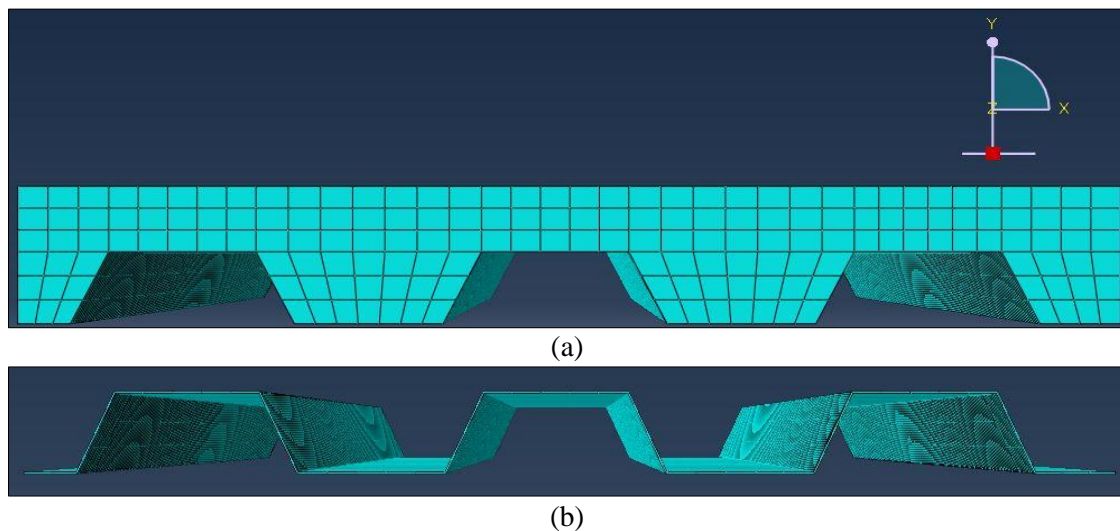


Figure 4. Model of concrete and deck profiled sheet without intermediate stiffener.

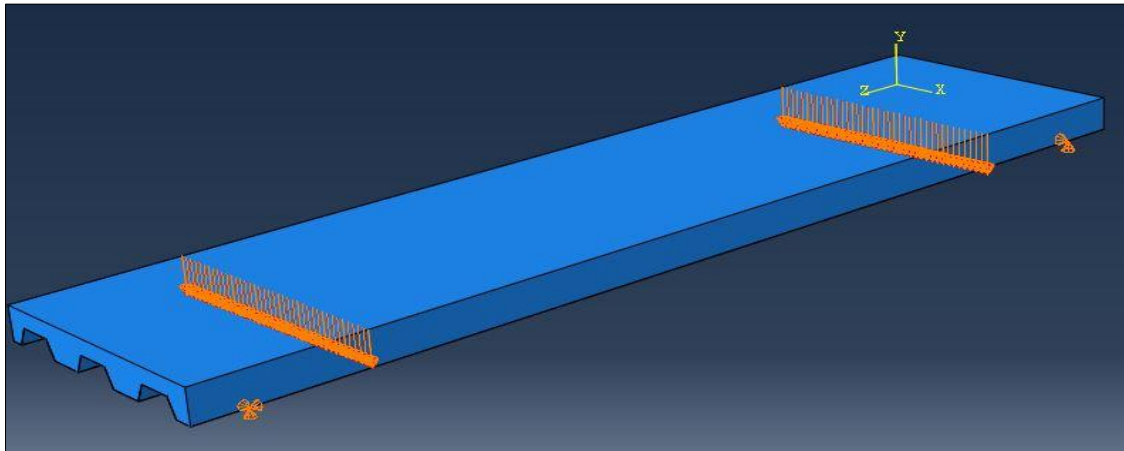


Figure 5. Assembly of composite slab with load and support condition in ABAQUS 6.13.

To produce a friction model that enables force resisting the relative tangential motion of the surfaces in the mechanical contact analysis, the tangential behaviour is specified. Friction formulation field between the contact surfaces is selected as a penalty to allow some relative motion of the surfaces, for a uniform friction coefficient of 0.3 the directionality of isotropic is chosen. The normal contact behaviour for the interface was also defined as a hard contact for pressure-over-closure. The surface-to-surface contact was utilized for interaction simulation. Table 1 and 2 show the properties of concrete and cold formed deck profiled sheet respectively.

Table 1. Properties of concrete.

(a)			
Concrete Damage Plasticity			
Dilation Angle	Eccentricity	σ_{bo}/σ_{co}	k
30	0.1	1.16	0.667

(b)	
Concrete Properties	Value
Density	2400 Kg/m ³
Young's Modulus	22365 N/mm ²
Grade of concrete	M20
Poisson's Ratio	0.2
Modelling Space	3D Deformable
Shape	Solid Homogenous

(c)	
Compressive Behaviour of concrete	
Stress (N/mm ²)	Strain
0	0
3.800	0.0001789
11.808	0.0006440
17.408	0.0011450
19.488	0.0015030
19.688	0.0017170
20.000	0.0017890
16.000	0.0050000
13.763	0.0060000

(d)	
Tensile Behaviour of concrete	
Yield stress (N/mm ²)	Cracking Strain
15	0
0	0.00137

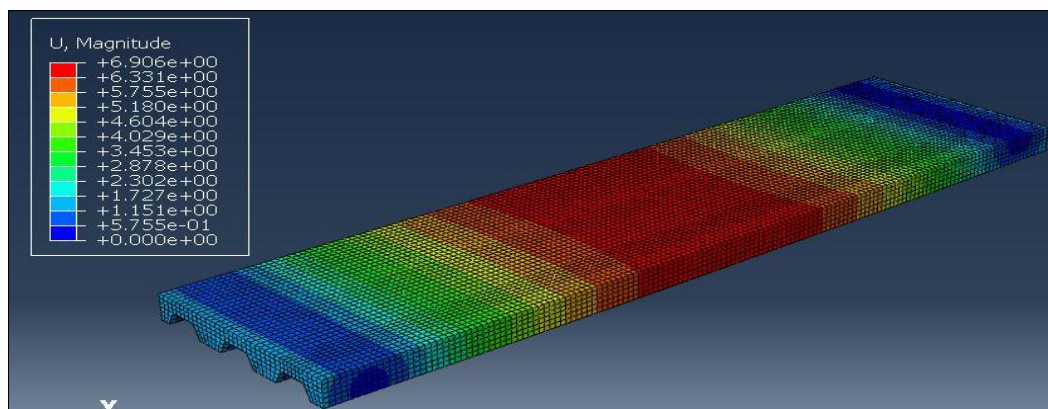
Table 2. Properties of steel.

(a)	
Steel Properties	Value
Density	7800 Kg/m ³
Young's Modulus	230000 N/mm ²
Yield Stress	230 N/mm ²
Poisson's Ratio	0.3
Modelling Space	3D Deformable
Shape	Solid Homogenous

(b)	
Plasticity	
Yield Stress (N/mm ²)	Plastic Strain
230	0
251.3	0.000685
232.9	0.008125
313.2	0.093084
251.6	0.210000

3. Results

Following are the results obtained from the simulation of 16 models in ABAQUS 6.13. Results are divided into 4 groups according to cold formed deck profiled sheet of 0.8 mm thickness with and without intermediate stiffener and 1.2 mm thickness with and without intermediate stiffeners as per different shear span (850 mm, 950 mm, 350 mm, and 380 mm) respectively. The variation pattern of deflection and S Mises for one of the models are shown in figure 6 and 7 respectively. In the similar way variation pattern for rest of the models are obtained.

**Figure 6.** Deflection variation pattern for 0.8 mm thickness model without intermediate stiffener

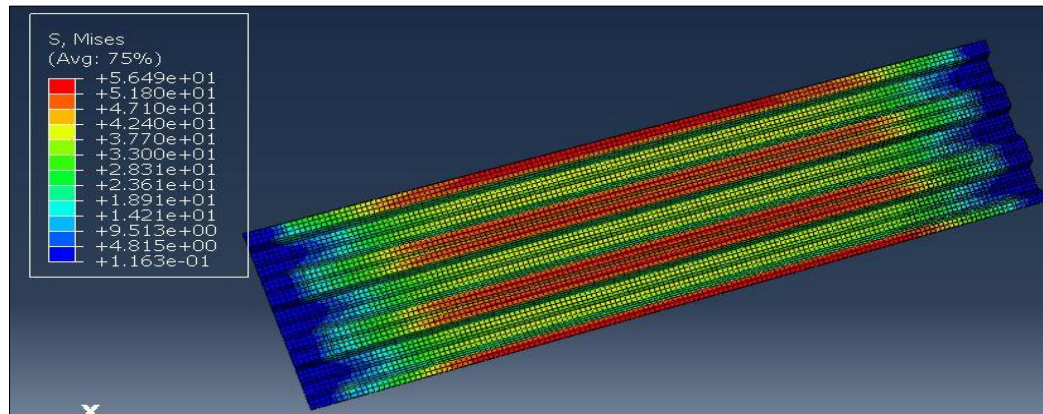


Figure 7. Stress (Mises) variation pattern for 0.8 mm thickness model without intermediate stiffener.

Table 3. Analytical result of 0.8 mm sheet thickness with intermediate stiffeners.

Shear Span (mm)	Load (kN)	S Mises	Deflection (mm)	Shear Force (kN)	Stress (Vu/bd) (N/mm ²)
850	22.934	59.72	6.68	9.1736	0.149834
950	27.317	79.07	8.56	10.9268	0.17847
350	52.738	62.07	7.03	21.0952	0.344552
380	47.871	60.42	6.91	19.1484	0.312755

Table 4. Analytical result of 0.8 mm sheet thickness without intermediate stiffeners.

Shear Span (mm)	Load (kN)	S Mises	Deflection (mm)	Shear Force (kN)	Stress (Vu/bd) (N/mm ²)
850	22.951	59.43	6.574	9.1804	0.149945
950	26.98	77.8	8.327	10.792	0.176268
350	52.744	61.59	6.861	21.0976	0.344591
380	47.88	59.82	6.906	19.152	0.312813

Table 5. Analytical result of 1.2 mm sheet thickness with intermediate stiffeners.

Shear Span (mm)	Load (kN)	S Mises	Deflection (mm)	Shear Force (kN)	Stress (Vu/bd) (N/mm ²)
850	22.612	57.53	6.517	9.0448	0.147731
950	26.92	75.94	8.322	10.768	0.175876
350	52.19	59.68	7.118	20.876	0.340972
380	47.36	56.49	6.77	18.944	0.309416

Table 6. Analytical result of 1.2 mm sheet thickness without intermediate stiffeners.

Shear Span (mm)	Load (kN)	S Mises	Deflection (mm)	Shear Force (kN)	Stress (Vu/bd) (N/mm ²)
850	22.632	55.48	6.285	9.0528	0.147861
950	26.978	73.77	8.067	10.7912	0.176255
350	52.21	58.79	6.916	20.884	0.341102
380	47.88	56.1	6.671	19.152	0.312813

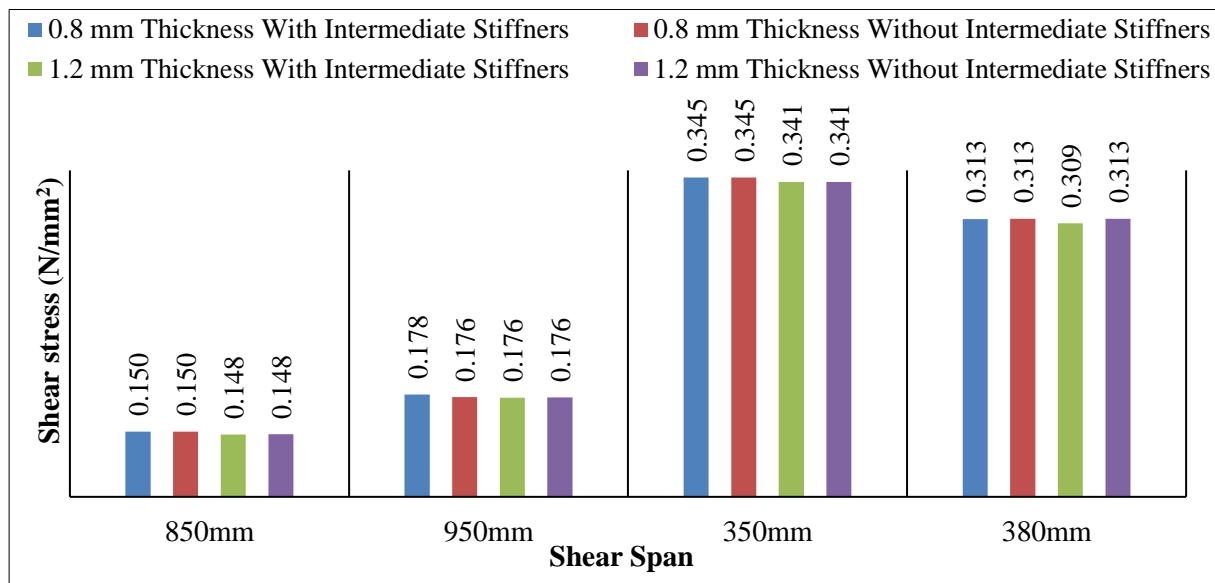


Figure 8. Comparison between shear stress with respect of shear span.

From the figure 8, it is clearly visible that the shear stress for the 350 mm shear span is maximum among all. The shear stress is maximum for the 0.8 mm thickness of cold formed deck profiled sheet with intermediate stiffener as 0.344552 N/mm².

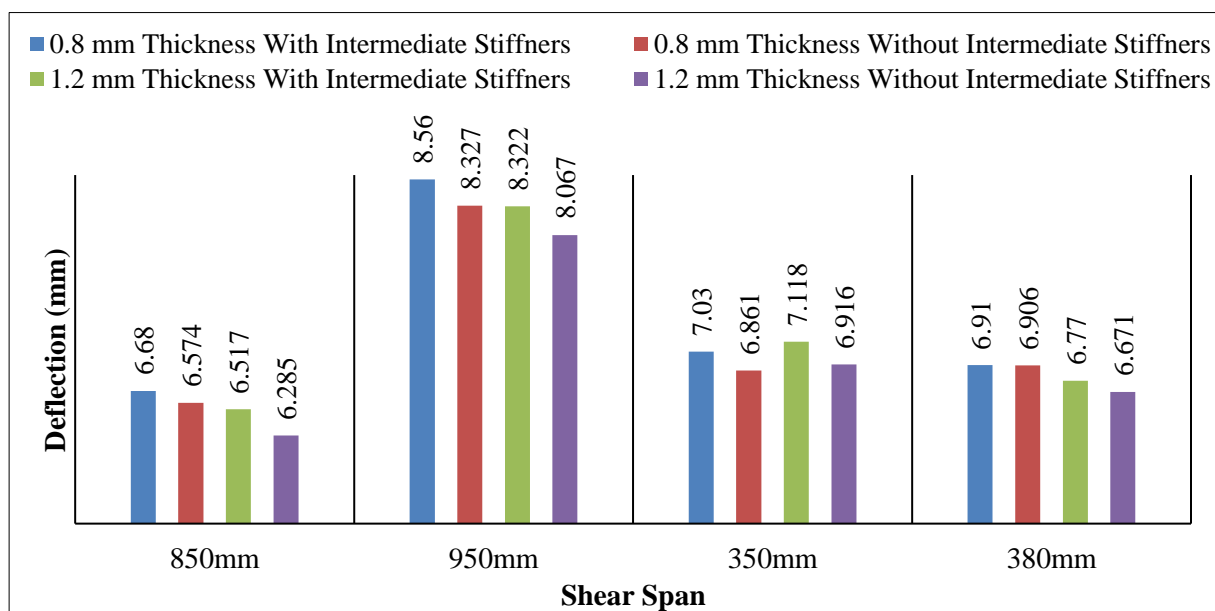


Figure 9. Comparison between deflections with respect of shear span.

From the figure 9, it is clearly visible that the deflection for the 1.2 mm thickness of cold formed deck profiled sheet without intermediate stiffener is best among all.

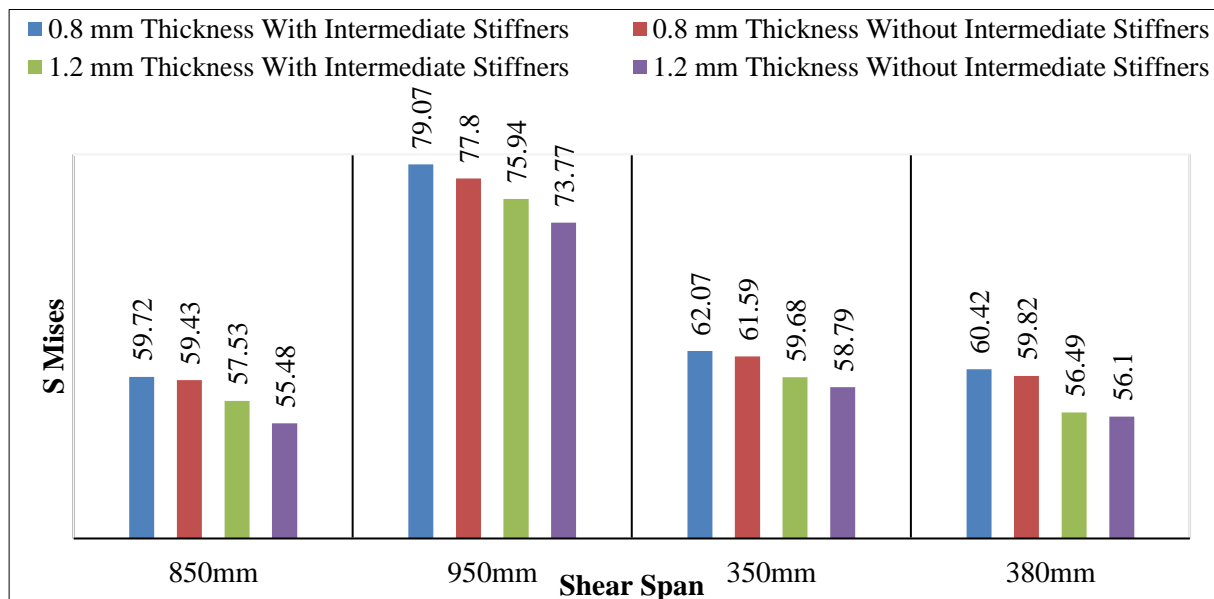


Figure 10. Comparison between Stresses (Mises) with respect of shear span.

From the figure 10, it is clearly visible that the S (Mises) for the 1.2 mm thickness of cold formed deck profiled sheet without intermediate stiffener is low among all.

4. Conclusion

From current study, it states that the shear bond capacity of composite slab increases with increase in thickness of cold formed deck profiled sheet as,

- Reduction in deflection of 2-5 %
- Reduction in stresses of 4-7 %.
- The change in shape of cold formed deck profiled sheet increases the stiffness of the composite slab.
- With intermediate stiffeners and without intermediate stiffeners there is a reduction in stresses upto 7%.
- Different shear spans are used to determine an accurate shear bond value of composite slab.

5. References

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