A Finite Element Modeling of Steel Concrete Beam Considering Double Composite Action

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Abstract- *A Steel Concrete composite construction has gained wide accepted an after native to pure steel or concrete action the use of composite structures is increasingly present in civil constructions works.The main function of these slabs are to allow for the joint behavior of the beam- slab. Comparing with the traditional single steel concrete composite containers beam.The mechanical properties in concrete crack. Formation of sectional plastic hinge are also invest gated. Shell element were used to model the concrete slab. It also has mixed formulation capacity for simulating deformation of nearly in compressions.The two material contacts also take in to account friction and connection between the parties. A dimensioned element solid 65 element is used to simulate to the concrete. A there is dimensional failure surface for concrete.Shell transfer co efficient for open crack was entered 0,s its recommended range is from 0.2 to 0.5 as presented by Razghiotal.The compression result from the analytical model to the experimental obtained result.The slip strain-beam length curves analyze the different performance of the double steal concrete.*

Keywords- Finite element modeling of steel and contact elements TARGE170 © CONTA173: Deign 2000

I. INTRODUCTION

Comparing with the traditional single steel-concrete composite continuous beam, its advantage is that effectively limits the crack width of the negative moment area, and also improves the stress state of section, so that it is suitable to the composite continuous beam with a larger span. The mechanical properties of the double composite beam obviously depend on their respective properties and interactions. In the negative applied bending moment area, the concrete slab cracks under tension and then the interface slip occurs between steel profile and concrete slab, with non-linear features, it makes great impact on the structure of the internal forces and deformation. Therefore, it is necessary to present a finite element model to study the mechanical properties of the double steel-concrete composite beam in negative moment regions. Although many experimental and theoretical studies for the traditional single steel-concrete composite beam have been done, few research studies have been found in references to the double steel-concrete composite continuous beam. Rozsas [1] investigated the plastic reserve of composite plate girder bridges due to the synergetic combination of the concrete and steel. The plastic design in the framework of the Eurocode through an existing elastically designed bridge is also introduced. Xu et al. [2] discussed the improvement of the local buckling strength of continuous double composite box girders by adding a concrete slab to the steel bottom flange.

II. DOUBLE STEEL CONCRETE COMPOSITE BEAM

Based on this investigation, a simplified analytical model through Ansys 11 software is developed in order to enables the prediction of the fracture behavior. Its results are compared with the previously available experimental investigated models introduced by Duan et al. [24]. The results demonstrate a better approximation for the failure criteria in both cases..

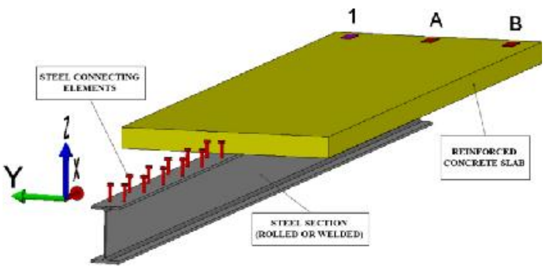


Fig. 1: Double Steel Concrete Composite Beam)

2.1 Types Of Composite Beams

Composite beams typically consist of steel “I” sections acting structurally with a concrete slab by means of shear connectors attached to the top flange of the steel section. The beams are generally designed to be simply supported, and an effective part of the slab is taken as acting as a part of the composite section on either side of the centreline of the section. It is possible a significant saving in steel weight and/or structural floor depth due to the composite action of the steel beam and the concrete slab which increases the stiffness of the beam and the load capacity.

2.1.1 Types Of Shear Connectors

There are quite different types of shear connectors, some welded and other nailed connectors. Welded connectors were commonly used in composite construction, but with the development of the use of thinner steel sheets, it has been necessary the use of nailed instead of welded. The choice of a specific type of connector is based on its ultimate resistance which depends not only on its own properties, also on the concrete grade used..

2.1.2 Headed Studs

The standard dimensions of headed studs are Ø 19 mm and a length of 125 mm. The behavior of the headed studs does not vary a lot when concrete properties are changed. Their load capacity is much lower than that of perfobondstrip and T-shape connectors, and it is always around the same value although fibre concrete, light weight concrete or higher strength concrete is used. Headed studs characteristic resistance is lower than that of perfobondstrip and T-shape connectors, and it depends on the number of studs used (see Figure 2.5)

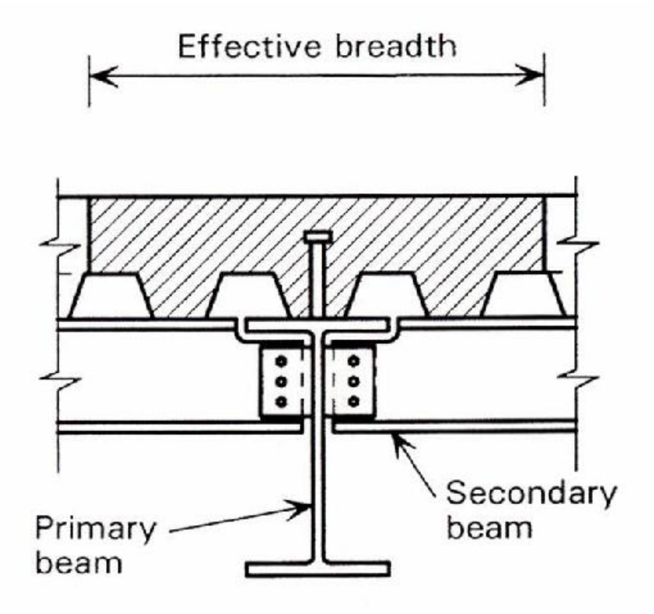


Fig. 2: Primary and secondary beams

III. FINITE ELEMENT PACKAGE WAS USED TO CARRY OUT THE MODEL

The modeling of the head studs shear connectors was done by the BEAM 188 elements, which allow for the configuration of the cross section, enable consideration of the nonlinearity of the material and include bending stresses. This element was indicated in Fig. 3a. SOLID185 is used for the modeling of the steel beam. It is defined by eight nodes having three degrees of freedom at each node, translations in the nodal x, y, and z directions. The element has plasticity, hyperelasticity, stress stiffening, creep, large deflection, and large strain capabilities.

IV. SOLID ELEMENT USED TO SIMULATOR TO THE CONCRETE

A three-dimensional failure surface for concrete is shown in Fig. 8. The most significant non-zero principal stresses are in the x and y directions respectively. Three failure surfaces are shown as the projections on the rxp - ryp plane. The mode of failure is the function of the sign of rzp (principal stress in Z direction). For example, if rxp and ryp, both are negative (compressive) and rzp is slightly positive (tensile), cracking would be predicted in a direction perpendicular to rzp. However, if rzp is zero or slightly negative, the material is considered as crushed. Implementation of the William and Warnke [26] material model in Ansys 11 requires different constants that must be defined. Shear behavior of SOLID65 element in Ansys 11 is controlled by two-shear transfer coefficient for open and closed cracks. These coefficients represent conditions at the crack allowing for the possibility of shear sliding across the crack face. A number of preliminary analysis were attempted in this study with various values for the shear transfer coefficients (for open and closed cracks) within the below indicated ranges, but Ansys convergence problems were encountered at the following entering values of the William and Warnke [26] constants:

1. Shear transfer coefficient for open crack was entered as 0.5. Its recommended range is from 0.2 to 0.5 as presented by Razaghi et al. [27].
2. Shear transfer coefficient for closed crack was entered as 1. Its recommended range is from 0.0 (for representing a smooth crack, i.e., complete loss of shear transfer), to 1 (for representing a rough crack, i.e., no loss of shear transfer),as suggested by Razaghi et al. [27].
3. Uniaxial tensile cracking stress which was based upon the modulus of rupture; and was entered as 4.70 Mpa.
4. Uniaxial crushing stress was based on the uniaxial unconfined compressive strength, and was entered as 47.0 Mpa, to turn on the crushing capability of the concrete element as discussed by Kachlakev and Miller [28].
5. Biaxial crushing stress
6. Ambient hydrostatic stress state for use with constant 7 and 8.

7. Biaxial crushing stress under the ambient hydrostatic stress state (constant 6).
8. Uniaxial crushing stress under the ambient hydrostatic stress state (constant 6).
9. Stiffness multiplier for cracked tensile condition.

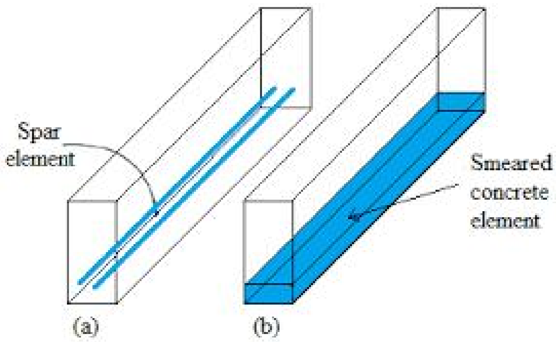


Fig. 3: Solid Element Used To Simulator To The Concrete

4.1 BASIS OF DESIGN OF COMPOSITE SLABS

4.1.1 Definition

Composite slabs construction comprises two different elements, steel decking or sheeting, and in-situ concrete. The steel decking is considered as the permanent formwork to the in-situ concrete.The most efficient use of composite slabs is for spans between 3 and 4 m, and the most common is 3m. The ability of the decking to support the construction loads, without the need for temporary propping, normally dictates these spans. If props are used, longer spans are possible. Also some of the deeper profiles can achieve spans of up to 4.5 m without propping during construction. The maximum span to depth ratio for the deck will normally be 60.

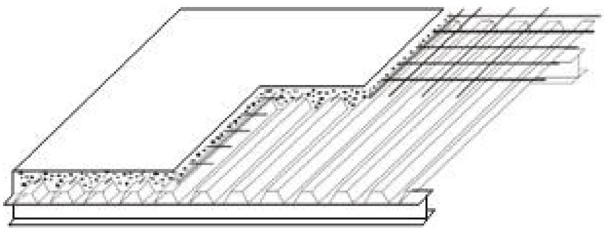


Fig.4.1 3-D shell Element configuration

The slab depths largely depend on fire insulation requirements and are usually between 100 and 200 mm. It depends on the time of fire resistant expected. To choose the concrete type it has to take into account that it affects the stiffness of the section and the strength of the shear connectors. Normal weight concrete (NWC) and light weight concrete (LWC) are both used. When the concrete has gained sufficient strength it acts as a composite slab with the tensile strength of the decking. A light mesh of reinforcement is placed in the concrete to reduce the severity of cracking and to increase the fire resistance. If the slab is unpropped during construction, the decking alone has to resist the self- weight and the construction loads. In this case subsequent loads are applied to the composite section. If the slab is propped during construction, all of the loads have to be resisted by the composite section. This can lead to a reduction in the imposed load that the slab can support, due to the increase of the shear in the interface between the concrete and the decking.

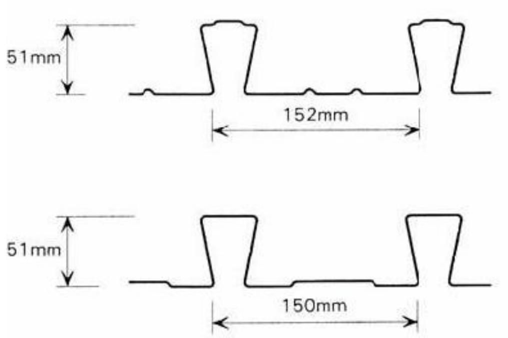


Fig. 4.2: Re-entrant profiled steel decking

4.2 COMPOSITE STAGE CONDITION

The most common mode of failure of the composite slab is due to the breakdown of shear bond. The ultimate moment resistance of composite slabs is determined by the breakdown of bond and mechanical interlock between the decking and the concrete, known as shear bond. Composite slabs are usually designed as simply supported members, and the slip between the decking and the concrete usually occurs before the plastic moment resistance of the composite section is reached. Eurocode 4 permits the design of composite slabs as continuous slabs by placing reinforcement in the negative moment region. There are two methods of design of composite slabs permitted by Eurocode 4. The traditionally used which is called “m” and “k” method, and an alternative method based on the principles of partial shear connection.The performance of a particular deck profiled in a composite slab can only be well assessed by test. Design by testing consists of two main parts with different purposes.The test is carried out in two states:A dynamic part to identify those cases where there is an inherently brittle bond between the concrete and the steel. (10,000 load cycles up to 1.5 times the working load).

Following the dynamic part, a static load is applied and increased until failure occurs.

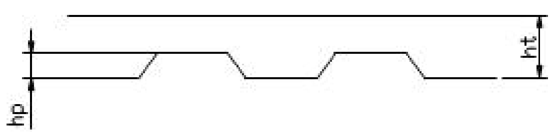


Fig.4.3. Composite slab cross section

Table 4.2 Fire resistance specifications for trapezoidal decking

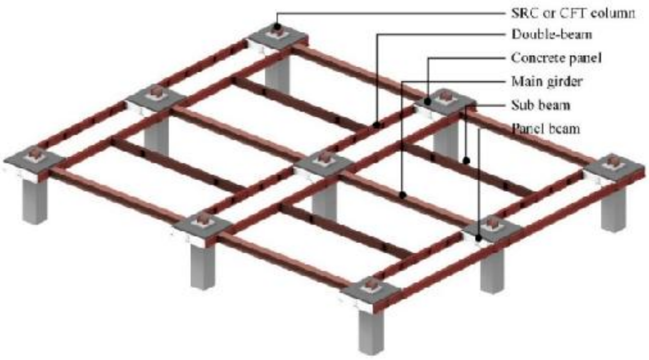
Maxim um (m)	Fire (hours)	Minimum dimensions			Mesh Size
		Deck thickne ss t (mm)	Slab thickness ht (mm)		
			NWC	LWC	
2.7	1	0.8	130	120	A142
3.0	1	0.9	130	120	A142
3.0	1 1/2	0.9	140	130	A142
3.0	2	0.9	155	140	A193
3.6	1	1.0	130	120	A193
3.6	1 1/2	1.2	140	130	A193
3.6	2	1.2	155	140	A252

Table 4.1 General rules for the slab: maximum span-to-depth ratios(*)

	NWC	LWC
Single spans	30	25
End spans	35	30
Internal spans	38	33

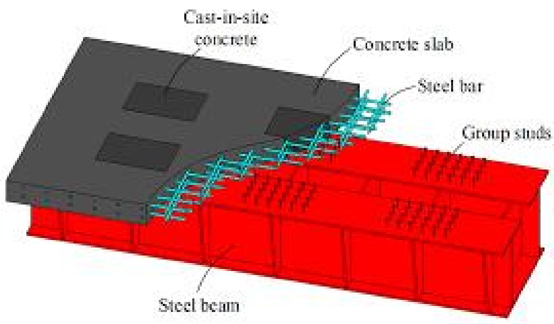
V. VALIDATION OF THE PERFORMANCE OF THE PROPOSED MODEL

Validation Of The Performance Of The Proposed Model The composite action the case study under consideration involves the influence of the removing the model.The load–deflection curves analyze the different performance of the double steel-concrete composite model with respect to the strength and deflection capacities. Figs. 9–11 illustrate the load–deflection curves obtained by both the proposed and experimental approaches for the models SCB1, SCB2



THE INFLUENCE OF REMAINING THE LOWER SLAB

The influence of the lower slab Double composite beam load carry out of the distributer area of the steel beam.The case study under consideration involves the influence of removing the lower slab on the mechanical and geometrical characteristics of the beam models at failure, such as the strength and the deflection capacity values. The study was conducted on three proposed models SB1, SCB2, and SCB3 respectively. Fig. 20 illustrates the effect of varying composite action on the fracture characteristics (strength and maximum deflection) of the proposed model.



VI. CONCLUSION

This paper investigates the behavior of the continuous steelconcrete composite beam taking into account the existence of the double composite action and the head stud shear connectors. Based on the finite element numerical study and the experimentally available results, the following main conclusions can be extrapolated:

1. A numerical proposed model based on the finite element theory can be used to examine the geometrical and mechanical characteristics in steel-concrete composite beam with double composite action, resulting in a good agreement when comparing to available full-scale test data.
2. The comparison of the strength capacity values obtained by the proposed and experimental models leads to a good agreeable between them.
3. An increase in the proposed interface steel-concrete slip values of approximately 38% compared to the experimentally available data was observed, leading to slightly non-agreeable results.
4. An increase in the proposed interface steel-concrete slip strain values of approximately 49% and 55% compared to the experimentally available data was observed for both the upper and the lower slabs respectively, leading to somewhat non-agreeing values between them.
5. Parametric studies were carried out to look at the impact of removing the lower slab, the effect of varying steel beam height and the lower slab length

and thickness, and the effect of changing the head studs arrangement and diameter.

6. The presence of the lower slab increases the proposed strength capacity values by an average amount 0.08% for all experienced composite models, leading to a minor effect on the strength capacity.
7. In comparison with the five suggested cases of steel beam height involved in the parametric study, it can be observed that the more increase the steel beam height is the bigger the ultimate load values are.
8. Moreover, this study showed that the smaller the lower slab length or thickness is the smaller the ultimate load values and the bigger the maximum deflection values are.
9. It can be noted that the change of the shape of the studs arrangement has no influence on the values of the ultimate load. In addition, the beam model including fully studs arrangement had a minimum value of the maximum deflection, whereas the case of the completely removed head studs had the maximum one.

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