



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 6, June 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512



9940 572 462



6381 907 438



ijirset@gmail.com



www.ijirset.com

Arrangement of Connectors in the Simple Beam of Composite Steel-Concrete Pattern Subjected to Uniform Loads

Duong Viet Ha*, Nguyen Thu Trang

Faculty of Civil and Environment, Thai Nguyen University of Technology, Thai Nguyen, Vietnam

ABSTRACT: In the composite steel-concrete structures, they were found that creating detailed connectors to increase the bond strength between concrete and steel is very important and indispensable. In Eurocode 4 were calculated and detailed about layout of connectors with spacing equally along the length of the beam, and then the construction is easy, but not reasonable for bearing shear forces and economics. This paper presents a calculation and detailed layout for setting connectors reasonably in the simple beam of composite steel-concrete pattern subjected to uniform loads, suggesting that the proposal calculation herein will be economic efficiency savings than calculated in Eurocode 4.

KEYWORDS: Composite structures, simple beam, steel, concrete, connectors.

I. INTRODUCTION

In some parts of the construction, composite steel-concrete beams are parts that are most significant features of complex structures such as bearing capacity of large, delicate texture, hardness, good resistance to twisting and large deformation ability than plain structural steel or concrete reinforced beams. A composite steel-concrete beam is made from a hot-rolled steel beams or a welded-complex steel beam and combination with the reinforced concrete floor, they are interconnected by links (detailed connectors) to ensure the work simultaneously [1].

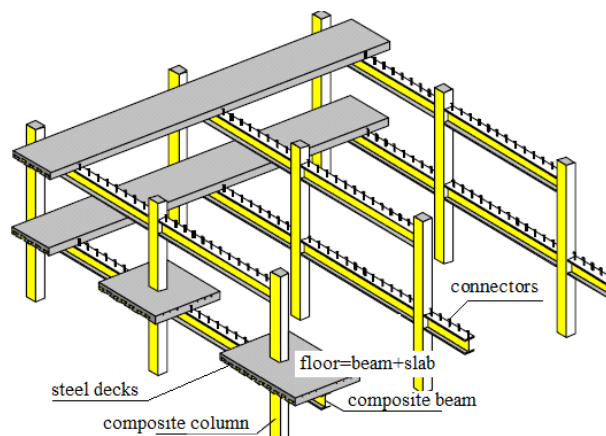


Fig. 1 Parts of the building using composite structures

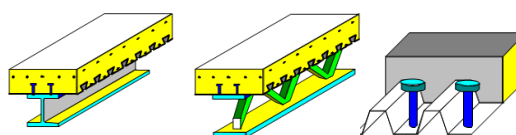


Fig. 2 Connectors in composite steel-concrete beams



Fig. 3 Some types of connectors

II. PROPOSED METHOD

A. Calculation and layout detailed connectors following Eurocode4

The connector number is calculated on the basis of plastic analysis and limit state.

Analyzing the work of beams

Surveying the work of a steel beam composite steel-concrete under the effect of gradually increasing loads:

When loads are small, steel beams and concrete reinforced slabs work linearly, the link between these two components subjected to very small shear stress, the along-axis slider is negligible. This period corresponds to the load conditions of normal use inside the positive momentum of the beam in practice.

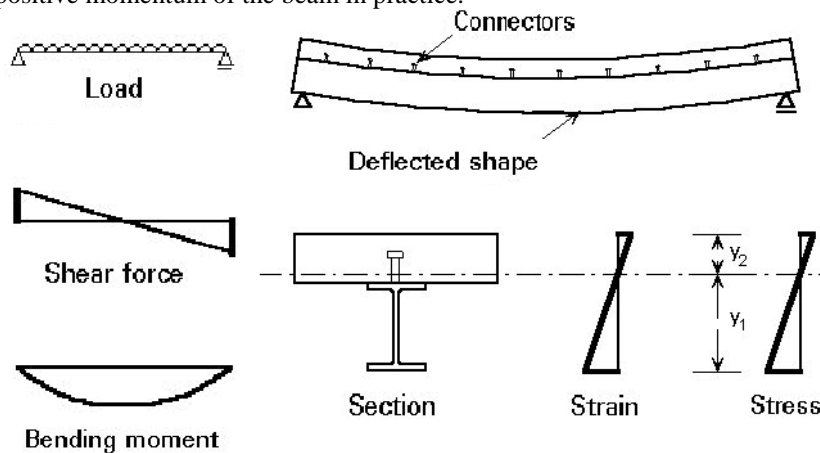


Fig. 4. Beam behavior at low load

Increased load is applied, the shear stress between the slab and steel beam effects for the shear connection and causes deformation, this deformation is called shear deformation and contributes to the overall beam. This period corresponds to the load conditions using in the composite beam incompletely (a smaller number of selected connectors less than needed).

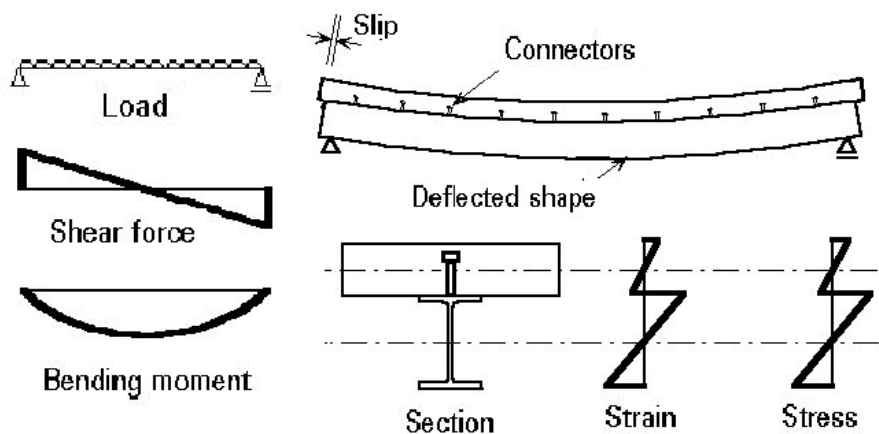


Fig. 5. Beam behavior at increasing load

Continue to increase the load to cause plastic deformation in one or several components of the beam: steel beams will become plasticity, concrete slab is going brittle state (rectangular stress 0,85fck) or connectors will be plastic.

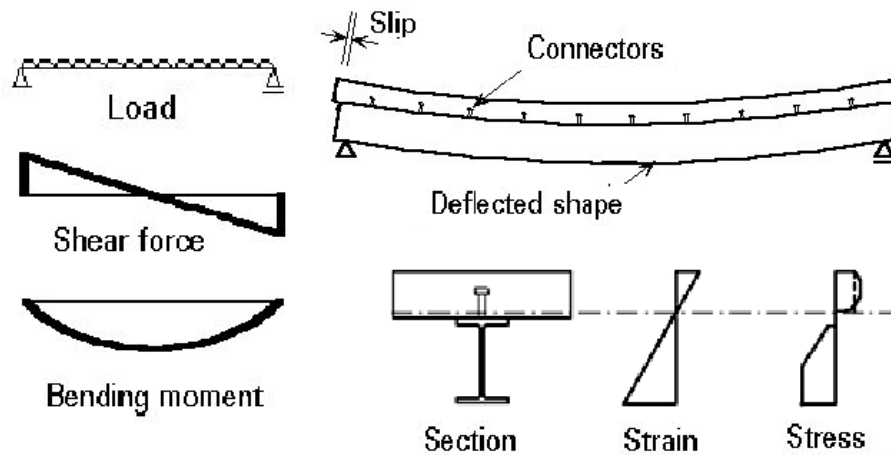


Fig. 6 Beam behavior at high loads

Shear forces applied to the connectors:

$$T = \frac{VS}{I} \quad (1)$$

When small loads, the forces cause the elastic deformation in the connectors, slip between concrete and steel beam is the largest at the top of the beam.

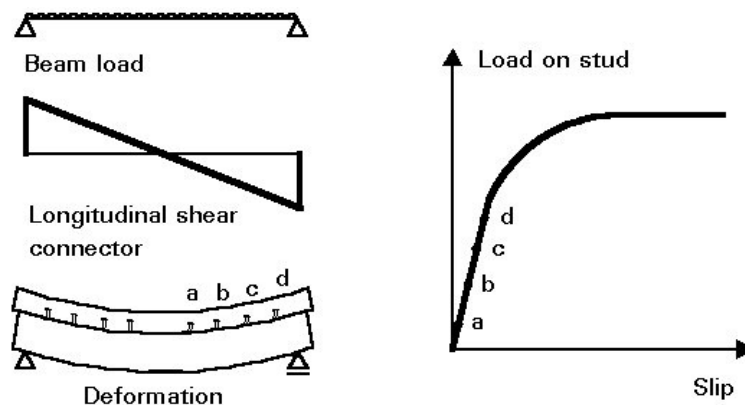


Fig. 7 Typical shear force and deflection

Increased load, the connectors at the top of the beam begin to plastic deformation

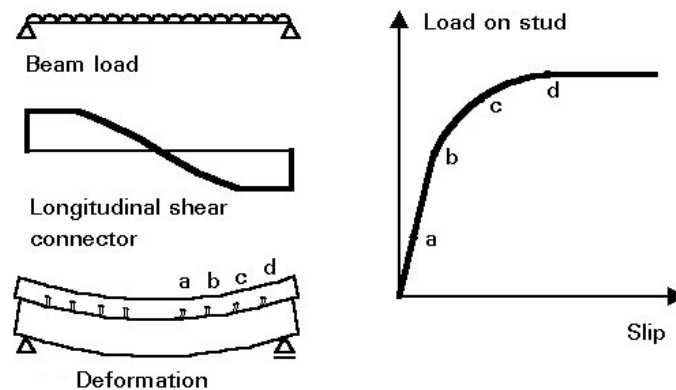


Fig. 8 The connectors at the top of the beam begin to plastic deformation

Continue to increase the loads, the inside successional connectors of the beam began plastic deformation, the collapse occurs when all the connectors reached endurance limit.

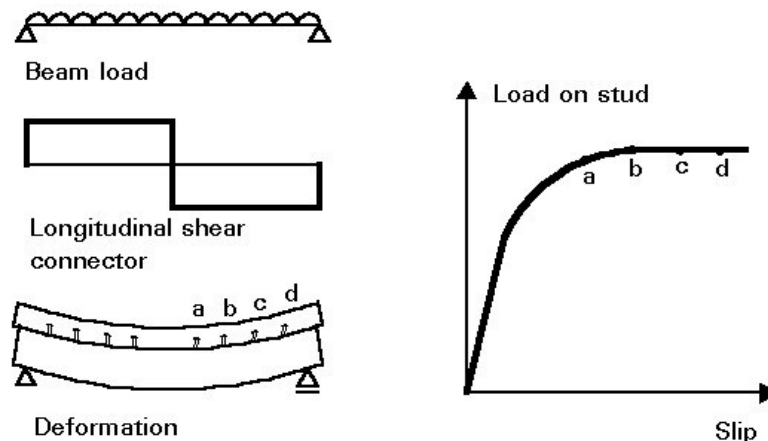


Fig. 9 All the connectors reached endurance limit.

Thus, we can see that the destruction of the conjugate beam is determined by three major destructive elements. If the beam is calculated to be destructive when steel reaches to plastic state, concrete has just reached the destructive deformation and all connectors have just been deformation that the model are considered ideal. However, due to the elastic interaction of three components to be very complex destructive so that beams should normally be calculated to undermine the status of the connection between steel and concrete beams (detailed connectors).

In determining the bearing capacity of the composite beam, the connectors are assumed that even when deformed they are still capable of vertical shear bearing, this analysis should be the strength of the beam is determined by shear forces of connectors. Connections are seen as plastic, so the re-distribution of the shear forces makes all the connections received strength PRd - is calculated by a connection, so placing equally spaced connectors with appropriating [3].

Force acting on the connector is

$$V_{lf} = \min \left(\frac{A_a f_{y.s.k}}{\gamma_s}; 0,85 \frac{b_{eff} h_c f_{ck}}{\gamma_c} \right) \quad (2)$$

Shear strength of the connector is

$$P_{Rd} = \min \left(0,8 f_u \frac{\pi d^2}{4} / \gamma_v; 0,29 \alpha d^2 \sqrt{f_{ck} E_{cm}} / \gamma_v \right) \quad (3)$$

Number of connectors:

$$N_f = \frac{V_{lf}}{P_{Rd}} \quad (4)$$

The connector layout: the connectors are arranged along the length of the beam with equal distances, then has advantages and disadvantages: Ease of construction; The whole connector arrangement on the beam are enough to arise shear forces when entire plastic strength of the beam is formed (link completely) - this is not economical because the connector number is too large. If you reduce the number of connectors down until resistance of beam's moment is limit (link not entirely), but the connectors are evenly spaced layout is not suitable for shear force diagrams in figure below.

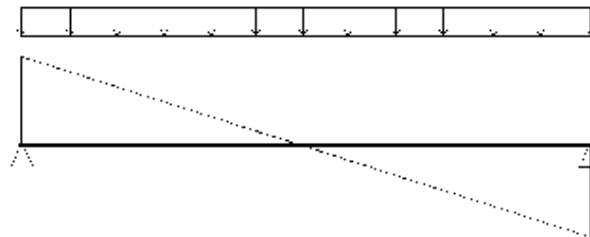


Fig.10 Shear force

B. Propose a calculation and layout to set connectors using the elastic shear force diagram

Although uniform layout of connectors in the composite beam was suitable for analysis of plastic work and convenient for construction, but did not fit the state under the bearing of actual shear forces on a composite steel-concrete beam.

With the assumption at the position of the large shear loads there will be connectors to bear larger loads, in which the beam is being undermined by the destruction of the connectors. Therefore, the arrangement of distance between the connectors is uneven that reflecting the distribution of shear forces at the interface between concrete and steel beam remains a general and consistent with the state's elastic work of a composite beam.

Because each connector has ductility so that the shear force diagram is a cosine curve, can be considered this approximate diagram to be linear.

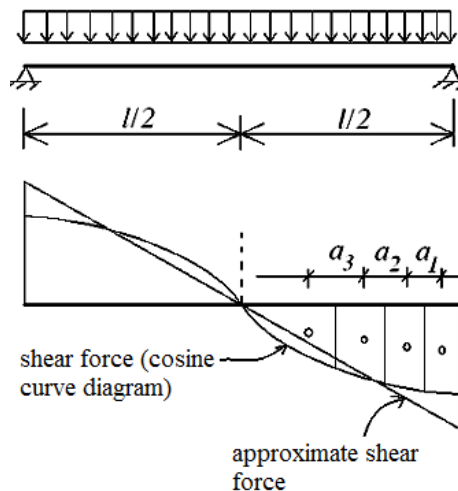


Fig.11 Arrange the connectors according to shear force chart

The shear force total acting on the half-beam is

$$T_{l/2} = \int_0^{l/2} \frac{V \cdot S}{I} dx = \frac{S}{I} \int_0^{l/2} V \cdot dx = \frac{S}{I} (M_{l/2} - M_0) = \frac{M_{\max} \cdot S}{I} \quad (5)$$

M_{\max} is taken by M_{PL} according Eurocode4 to ensure that it remains plastic-strength moment.

The elastic section modulus of the concrete area converted into steel area is

$$S = \frac{b_{eff}}{n} \cdot h_c \left(x_e - \frac{h_c}{2} \right) \quad (6)$$

The connector is placed at the centroid of n forms that area of each form is equal on the shear force diagrams, with n is the number of connector on the half-beams, is calculated using the formula:

$$n \geq \frac{T_{1/2}}{P_{Rd}} \quad (7)$$

where P_{Rd} – capacity of the shear force resistance of a detailed connector.

Finding the distance a_i may reference [2] or use Autocad software to catch the centroids of the quadrangles and then measure the distances between these centroids. However, the layout of connectors following this shear force diagrams, at the middle of the beam, where the gaps of connectors are the huge, do not meet the requirements of constitution in the beams, we need to allocate additional connectors that made up the distance between the connectors not exceeding 800mm and 6 times the thickness of the concrete slab.

ork in this paper is divided in two stages. 1) Text- Detection 2) Inpainting. Text detection is done by applying morphological open-close and close-open filters and combines the images. Thereafter, gradient is applied to detect the edges followed by thresholding and morphological dilation, erosion operation. Then, connected component labelling is performed to label each object separately. Finally, the set of selection criteria is applied to filter out non text regions. After text detection, text inpainting is accomplished by using exemplar based Inpainting algorithm.

III. EXAMPLE ILLUSTRATION AND COMPARISON OF RESULTS

Calculating connections of a simple beam under the shear force; Specifications of the beam: 10m span; steel IPE500 with cross-section area $A_s=11600\text{mm}^2$, $I_s=4,82.10^8 \text{ mm}^4$; the largest bending moment at the middle of the beam according to limit state 1 is $M_{pl}=830\text{kNm}$; the concrete slab is 120mm thick; Uniform distributed load $p=40\text{kN/m}$. Bolt shaped cap form with length $h = 100\text{mm}$, diameter $d=19\text{mm}$, link completely; The breaking strength of the connector steel is $f_u=450\text{N/mm}^2$; Safety factor $\gamma_v = 1,25$.

We will calculate and arrange connectors according to two methods “Eurocode 4” and “the elastic shear force diagram” below.

3.1 Calculation of connections following plastic state (Eurocode4):

a, Determine the shear force transmitted to the connector by

$$V_{lf} = \min(F_{s,max}, F_{c,max}) \quad (8)$$

Ignore the participation of reinforcement in the slab, and substituting eqn (2) gets

$$F_{s,max} = \frac{A_s f_{y.s.k}}{\gamma_s} = \frac{11600.235}{1,1} \cdot 10^{-3} = 2478,2\text{kN} \quad (9)$$

$$F_{c,max} = \frac{0,85 A_a f_{c.k}}{\gamma_c} = \frac{0,85 b_{eff} h_c f_{c.k}}{\gamma_c} = \frac{0,85.2500.120.25}{1,5} \cdot 10^{-3} = 4250\text{kN} \quad (10)$$

Then get

$$V_{lf} = 2478,2 \text{ kN} \quad (11)$$

b, Calculating strength of the connection subjected to the shear force is

$$P_{Rd} = \min(P_{Rd}^{(1)}, P_{Rd}^{(2)}) \quad (12)$$

From eqn (3) the shear strength of the connector is

$$P_{Rd}^{(1)} = 0,8 f_u \frac{\pi d^2}{4} / \gamma_v = 0,85.450. \frac{\pi 19^2}{4} / 1,25 = 81,7\text{kN} \quad (13)$$

The shear strength of the concrete slab

$$P_{Rd}^{(2)} = 0,29. \alpha. d^2 \sqrt{f_{ck}. E_{cm}} / \gamma_v = 0,29. \alpha. d^2 \sqrt{25.30500.10^{-3}} / 1,25 = 71,27\text{kN} \quad (14)$$

c, Calculate the complete connection

The minimum number of connectors from eqn (4) is

$$N_f = 2. \frac{V_{lf}}{P_{Rd}} = 2. \frac{2478,2}{71,27} = 69,54 \quad (15)$$

Get $N=2 \times 35=70$ connectors (type of caps at the top). Possess quatity of 35 arranged on the half-beam.

The connectors are equally spaced by an interval:

$$\frac{l}{N} = 143 \text{ mm} \quad (16)$$

3.2 Calculation of connections following the elastic shear force diagram

The elastic modulus ratio is

$$n = \frac{E_s}{E_c} = \frac{210000}{30500} = 6,89 \quad (17)$$

Then

$$\frac{b_{\text{eff}}}{n} = \frac{2500}{6,89} = 363 \quad (18)$$

Substituting eqn (6) get the elastic section modulus of the concrete area converted into steel area

$$S = \frac{b_{\text{eff}}}{n} \cdot h_c \cdot \left(x_e - \frac{h_c}{2} \right) = 363 \cdot 120 \cdot (125,2 - 60) = 2722500 \text{ mm}^3 \quad (19)$$

Moment of inertia of the equivalent cross-sectional area in the composite beam section is

$$I = 1,41 \cdot 10^9 \text{ mm}^4 \quad (20)$$

The shear force total acting on the half-beam from (5) is

$$T_{l/2} = \frac{M_{\text{max}} S}{I} = \frac{830000 \cdot 2722500}{1410000000} = 1602 \text{ kN} \quad (21)$$

The number of connectors on the half-beam is

$$N = \frac{T_{l/2}}{P_{\text{Rd}}} = \frac{1602}{71,27} = 22,5 \quad (22)$$

Get $N = 23$ connectors for the half-beam.

Degree of connection is

$$\eta = \frac{N}{N_f} = \frac{46}{70} = 0,66 > 0,4 \quad (23)$$

The beam are considered incomplete link.

Due to the distance between two connectors at the middle of the beam is $2a_{23}$ not satisfactory according to constitution in Eurocode4, should add one connector on the place of mid's beam (47 connectors).

Thus, the detailed layout of connectors under irregular intervals mentioned above is justified because the connectors bearing the same forces by matching the elastic shear force diagram.

IV. CONCLUSION

According to the analysis of plastic model, calculate the number of connectors (70 connectors) is larger than the calculation according to the elastic shear force diagram (46 connectors).

The number of connectors calculated according to the elastic shear force diagram is distributed unevenly and ensure greater than 40% connectors to be provisioned in Eurocode4 for beams not completely arranged. If connectors are arranged from the elastic shear force diagram and accordance with constitution in Eurocode4, need requirements to add some connectors at the middle of the beam. Autocad software can be used to determine distances between the connectors.

ACKNOWLEDGEMENTS

This work was supported by Thai Nguyen University of Technology, Vietnam.

REFERENCES

- [1] Pham Van Hoi, "Steel - concrete composite structure.", Science and Technics Publishing House, Ha Noi, 2006.
- [2] Doan Dinh Kien, Steel structures, Science and Technics Publishing House, Ha Noi, 2006.
- [3] Nguyen Van Dat, Doan Dinh Kien, Nguyen Quoc Thai, Dao Ba Thuc, "Wood texture ", University and Professional High School Publishing House, 1975.
- [4] EN 1994-1-1:2004. Eurocode 4: Design of composite steel and concrete structure. General rules and rules for buildings.



- [5] TCVN 5575:2012- Steel structures - Design standard.
- [6] R.P.Johnson, Composite structure of steel and concrete. Volume 1. Beams, slabs, columns and frames for buildings, Blackwell Scientific Publication, 1994.
- [7] Cosenza, E. and Zandonini, R, "Composite Construction", CRC Press LLC, 1999.
- [8] Edward G. Nawy, Concrete construction engineering handbook, CRC Press LLC, 1997.
- [9] J.M Aribert, A Albitar. Exemples de dimensionnement de poutres mixtes avec dalles coulées dans un bac collaborant et un faible degré de connexion – Rubrique Technique et Application, p. 73-88, Revue Construction Métallique n°2, 1990.
- [10] J.M Aribert. Exemples d'application de l'Eurocode 4 pour dimensionnement de la connexion de poutres mixtes: connexion complète, connexion partielle, connecteurs ductiles. Rubriques Technique et Application, p. 1-21, Revue Construction Métallique n°2, 1994.



**Impact Factor:
7.512**



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

📞 9940 572 462 📞 6381 907 438 ✉ ijirset@gmail.com



www.ijirset.com

Scan to save the contact details