Journal of Contemporary Issues in Business and Government Vol. 26, No. 03, 2020
https://cibgp.com/

P-ISSN: 2204-1990; E-ISSN: 1323-6903
DOI: 10.47750/cibg.2020.26.03.004

Experimental and theoretical studies of sandwich beams made of steel, concrete, and steel have shown interesting results.

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Abstract:

Steel plates are subjected to axial and shear stresses to test theories of full and partial contact. Stud connections and frictional forces between steel plates and concrete at both the supports and load sites are included in the partial interaction research. Based on the partial interaction theory, the results of DSC beam testing are compared to the theoretical predictions. According to the findings, a theoretical approach may be used confidently to analyse fundamentally supported DSC beams of any shape. Various building techniques are described by terminology like "sandwich beams," "double skin composite structure," and "shear connections."

INTRODUCTION

There are two concrete layers sandwiched between two steel plates and welded shear connections in a DSC structure. Even though its construction is equal to that of double-reinforced concrete components, a more flexible connection allows for greater displacement. This structure has much more benefits than any other.

Many steel–concrete composite structures include steel as a core component. Steel plate, concrete, and reinforcing steel were used in its construction. With steel and concrete, shear connections are often used. Steel-concrete composite shear connectors are mechanically linked.

Steel-concrete contact has an effect on shear flow and strain distribution. Modifications in stiffness, strength, and failure mode are all linked one to the other. All, some, or none of the above interactions between steel and concrete are possible (Veljkovic, 1996; Oehlers et al., 2000). In certain cases, structural performance may be impacted by assumptions. Partial interactions may help enhance forecasts of behaviour. Due to shear connection deformation and interface slippage under applied stresses, steel–concrete composite components typically meet partial-interaction (Johnson, 1994; Dogan, 1997; Roberts and Dogan, 1998; Oehlers and Bradford, 1999; Jeong et al., 2005; Ranzi et al., 2006; Oehlers and Bradford, 1999). Quéiroza, Ranzi, and Bradford (all in 2007), as well as Jeong (in 2008), have all made reference to Gara et al.

For Christians, 2010 is a special year (Sousa Jnr. and colleagues, 2010). Due to its modest size, slippage in steel-concrete composite systems may go unnoticed (that is, full interaction). When shear connections are not necessary, stiffness connections may be reduced or the number of connections reduced. Slides may have a significant impact on a system's stiffness in certain circumstances (that is, partial interaction). In order for a composite beam to move and deform, it must have strong connections. A push-shear test may be used to measure the stiffness of shear joints.

According to Newmark et alfindings, .'s (1951). Concrete and steel T-beams' deflection may be determined analytically. One school of thought argued that the two places were only tangentially linked. A second-order differential equation can describe the link between longitudinal forces transmitted from the concrete slab and the applied bending moment. Yam was the first to adopt the approach that would subsequently be developed by Newmark et al.

Studies of the shear connection behaviour of non-linear materials were carried out by Yam (1968) and by Chapman (1970). (1968, 1971). (1981). The ultimate flexural strength of composite beams was obtained by solving non-linear differential equations repeatedly.

Newmark's calculations were used to refine and update Johnson (1975, 1981). For short-span composite constructions, these equations were utilised to examine the loss of contact.

Partially contact composite beams, according to Roberts, may be analysed in a new approach (1985). Layer displacements are used to model the equilibrium and compatibility equations in this method. Differential equations derived from FDEs, as well as their derivatives, may be solved

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simultaneously. This method was created by Al-Amery and Roberts by combining non-linear material and shear connection behaviour (1990). Nonlinear differential equations may be solved using finite difference techniques. According to Wright and others, it is a kind of composite beam with two layers. sandwiched between another layer. Comparing Dogan's experiments with the basic idea on DSCs.

Dogan made changes to Oduyemi's design (1991). (1997). The partial interaction study has taken into account the frictional forces between concrete and steel. The outside supports and load zones of the buildings were determined to be made of steel plates (Dogan et al. 1997; Dogan et al. 2010). Is it possible that Dogan's theoretical assumptions are not reflected in the actual results? (1997). Steel plates and studs are subjected to tensile and shear stresses. The axial strains in DSC beams were studied by Dogan (1997).

Governing differential equations

Full interaction

Assumptions at every level of the DSC beam interaction analysis are used to make predictions. Steel and concrete are both very long-lasting materials. Tensile stress testing on linearly elastic materials. This weight can't be supported any longer due to the failure of the strain. Concrete and steel are held together by a shear force. The least amount of slippage may be achieved by finding the ideal combination of stiffness and plane. Throughout the problem, all of the pieces are at the same height. This is taken into consideration when attempting to determine the amount of stress. Figure 1 depicts the bent parts. In Figure 1b, steel and concrete plates and slabs depict the anticipated situation. With the help of axial forces, steel plates may be perfectly welded together.

$$F_{sc} = \rho_1 M \tag{1}$$

$$F_{st} = \rho_2 M \tag{2}$$

In Figure 1a, Fsc is the compression force in a steel compression plate, and Fst is the tension force in a steel tension plate.

$$\rho_1 = \frac{E_{sc} A_{sc}}{\Sigma EI (1 + \alpha)} \left(d_{cu} + \frac{t_{sc}}{2} \right) \tag{3}$$

$$\rho_2 = \frac{E_{st} A_{st}}{\Sigma EI (1 + \alpha)} \left(d_c - d_{cu} + \frac{t_{st}}{2} \right) \tag{4}$$

When the steel plate is in tension, its Young's modulus is Est, while when steel plate is compressed, its Young's modulus is Asc. These variables are used to calculate a number that stands for the stiffness of the steel plate in compression, which in turn is used to calculate the depth of the concrete section that is uncracked. Finally, the uncracked depth of the concrete section is used to calculate the value of dcu (Dogan, 1997, 2010).

There are two factors that determine the axial force change in the steel plates: qsc and qst per unit length (Figure 2a).

$$q_{sc} = -\frac{dF_{sc}}{dx} \tag{5}$$

$$q_{st} = -\frac{dF_{st}}{dx} \tag{6}$$

Interaction that is just partial

According to Oduyemi (1991), a partial interaction approach is one that takes into account the influence of other people. The durability and abrasion resistance of concrete Steel plates distribute and sustain the weight. The following rules of thumb may be used to simplify the process of conducting partial interactions.

Because of their comparable linear properties, steel and concrete may simply be compared.

Elastic materials, small deflections, and shear are all examples of elasticity (a).

Concrete and steel plates are held together by shear connections, which minimise material deformation.

It covers the whole beam, in other words. lonesome in the woods Smeared connections are made between different places using connectors (e) There must be an equal strain distribution on each layer to establish a linear connection. All the layers are curved in the same way. buckling is eliminated since the deflection

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in each layer is equal. if the layers split, exposure to the elements Material cracking occurs when it is exposed to tensile strain, making it ineffective in supporting the load. Since the form and material properties of the beam are directly related, my neutral axis depth stays constant. Steel plates with axial strains have been solved by engineers. in order to enable for communication

$$F_{SC} = A_1 \cosh\sqrt{m_1}\,x + A_2 \sinh\sqrt{m_1}\,x + A_3 \cosh\sqrt{m_2}\,x + A_4 \sinh\sqrt{m_2}\,x + g_1 M + g_2 D^2 M \qquad (7)$$

$$F_{st} = A_1 g_3 \cosh\sqrt{m_1}\,x + A_2 g_3 \sinh\sqrt{m_1}\,x + A_3 g_4 \cosh\sqrt{m_2}\,x + A_4 g_4 \sinh\sqrt{m_2}\,x + g_5 M + g_6 D^2 M \qquad (8)$$

The beam's material and section properties are described by coefficients m1, m2, and g1 to g6, while constants A1 through A4 are provided by boundary conditions (Dogan, 1997; Roberts and Dogan, 1998; Roberts and Dogan, 1998; Roberts and Dogan, 1998; Roberts and Dogan 2010). qsc and qst are two forms of shear forces. The partial interaction equations 5 and 6 are identical.

Material attributes and assumptions

Numerous assumptions are used in the whole and partial interaction analysis because of the complexity of DSC beams. The mechanism was originally claimed to be sped up. The gap between the symmetrical loads must be decreased to zero in order to find solutions for a basic supported beam. Various One of the properties being studied is shear stiffness. Friction between the steel plates results in the formation of a concrete infill. Figures 1–3 show the beam's reflection of the user's force. This means that just half of the beam has to be taken into account. In general, the coefficient of friction between beams was around 0.25. Scientific and practical breakthroughs came together. The results of the experiment. Studs obstructing the investigation stymied the investigation. The axial tensile force of the supports was modelled using a tension steel plate based on test findings. Assumed geometry is used for comparing the geometry of complete and partial beams. A rough approximation of the object's size is provided by b=200mm and L=1400mm. A 150 mm-deep concrete core is encased in a steel plate.

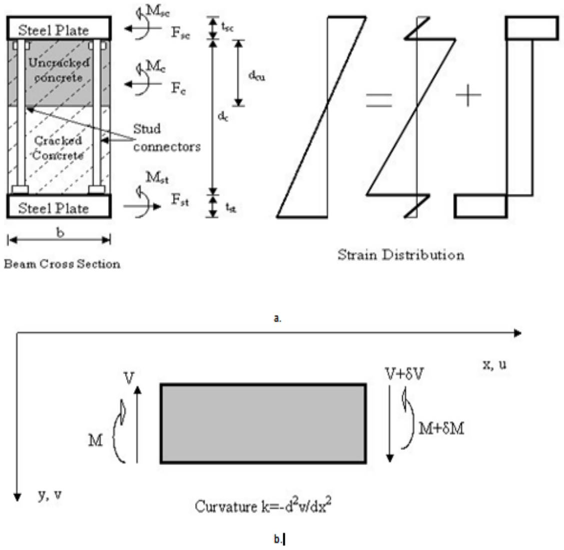


Figure 1. a. Internal forces and strain distribution over the depth of a DSC section for full interaction. b. The assumed positive sign conventions for displacements u and v in x and y directions.

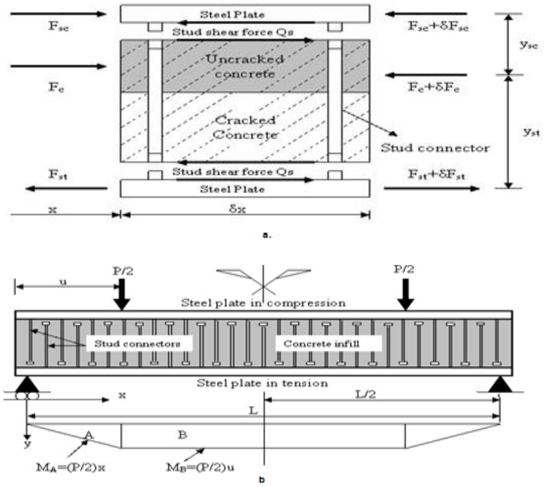
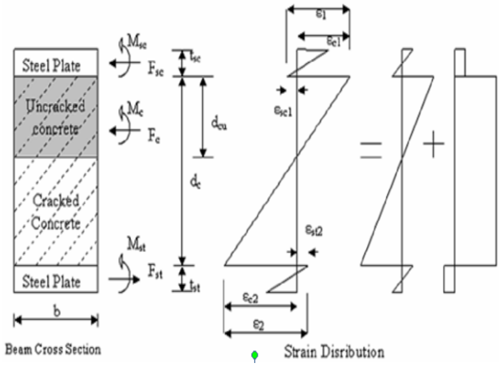


Figure 2. a. Interface shearing forces of a DSC beam. b. Support, loading and bending moment diagram.



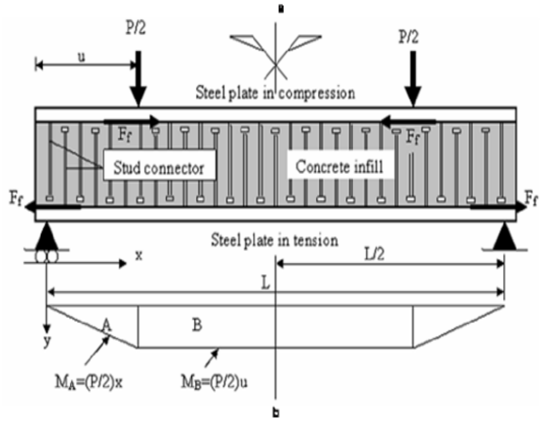


Figure 3 a. Internal forces and strain distribution over the depth of a DSC section for partial interaction.

b. Support, loading and frictional forces Ff at the supports and load points.

The stud spacing (st) is 200 millimetres, and the thickness (ts) is 8 millimetres on both plates. The Young's modulus of Es steel was evaluated at 210 kN/mm2. In the equation 67, the Young's modulus of concrete Ec is affected by changes in concrete compressive strength.

The compressive strength of a concrete cube in N/mm2 is given by Fcu, whereas the compressive strength in kN/mm2 is given by Ec. Ec ranged from 25.2 to 30.2 kN/mm2 in this experiment. The estimated concrete strength of the test beams was used to divide them into four distinct categories. There are four groups of Young's modulus (B1 and B2 with Ec = 25.2 kN/mm2, Group 2: B3 through B6 with Ec = 28.3 kN/mm2, Group 3: B7 and B8 with Ec = 27.1 kN/mm2, and Group 4: B9 and B10).

RESULTS

As DSC beams' behaviour is exceedingly complicated, many assumptions are made in whole and partial order to describe it.

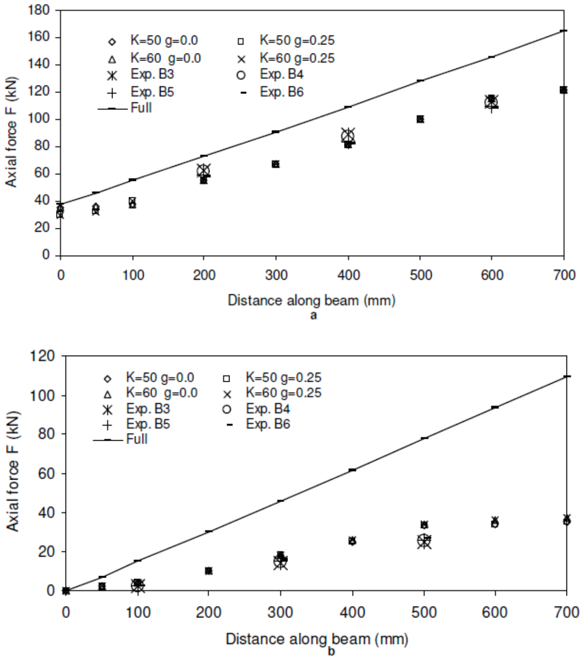


Figure 4. a. Comparison of experimental tension plate axial forces for the second group of beams B3-6

(P = 50 kN). b. Comparison of experimental compression plate axial forces for the second group of beams B3-6 (P = 50 kN)

Using interaction analysis, the system may be simplified. When comparing the theoretical findings with real results, the system geometry and material characteristics used were the same as those published by Dogan (1997).

Full and partial interaction models are studied here, with one neglecting friction between layers at the supports and the other including frictional forces. Test results at different applied loads are also compared. Axial forces in steel plates and shear forces in studs are studied, and the findings are presented here.

Axial pressures on steel plates

With and without frictional forces between the layers at the supports, Figures 4–6 illustrate axial forces in tension and compression steel plates along beams B3–10 with connection stiffness K = 50 and 60 kN/mm. These forces grow with increasing shear connection stiffness until they reach levels consistent with full interaction theory, which is when the shear connection stiffness approaches infinity.

Based on partial interaction theory, theoretical results are quite similar to experimental observations.

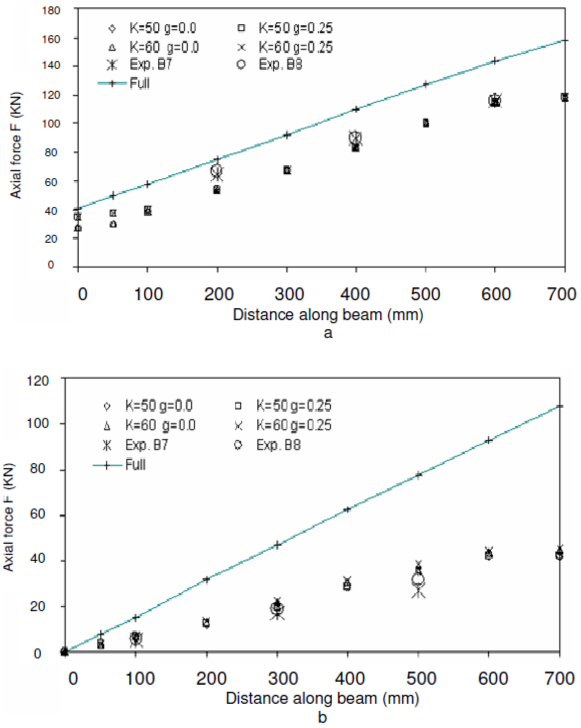
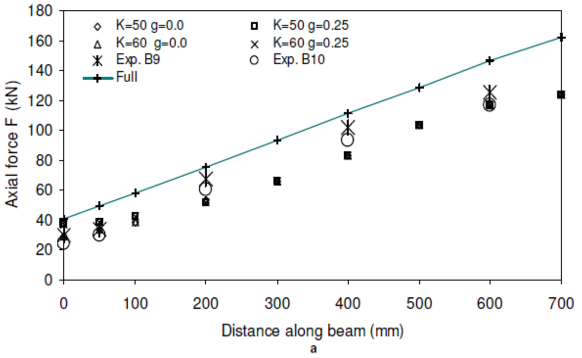


Figure 5. a. Comparison of experimental tension plate axial forces for the third group of beams B7-8 (P = 50 kN). b. Comparison of experimental compression plate axial forces for the third group of beams B7-8 (P = 50 kN).



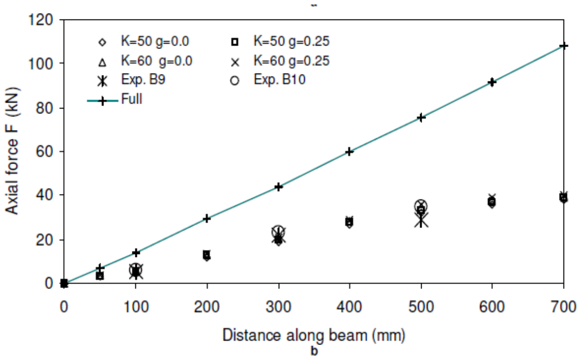


Figure 6. a. Comparison of experimental tension plate axial forces for the fourth group of beams B9-10 (P = 50 kN). b. Comparison of experimental compression plate axial forces for the fourth group of beams B9-10 (P = 50 kN).

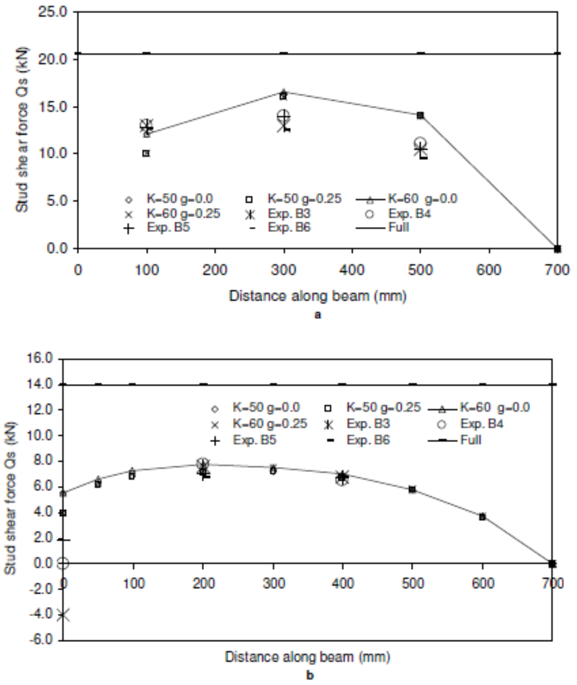


Figure 7. a. Comparison of experimental tension plate stud shear forces for the second group of beams B3-6 (P = 50 kN). b. Comparison of experimental compression plate stud shear forces for the second group of beams B3-6 (P = 50 kN). For both tension and compression plates, interaction theory predicts stronger axial forces.

Shear pressures in studs

Beam shear forces along beams B3–10 at the 50 kN load level are shown in Figures 7–9, theoretical and experimental, with or without frictional forces at the supports, for connection stiffness K = 50 or 60 kN/mm, with or without frictional forces at the supports. As the stiffness of the connection rises, the shear forces on the tension and compression plates are projected to increase. based solely on the notion of interactions Theoretical and experimental findings are in agreement.

CONCLUSIONS AND DISCUSSION

A mixture of complete and partial interaction analysis was used to compare actual data with theoretical predictions of DSC beam behaviour. The test beams were separated into four groups based on the differences in concrete cube strength and elastic modulus, and axial forces and stud shears were compared for each group.

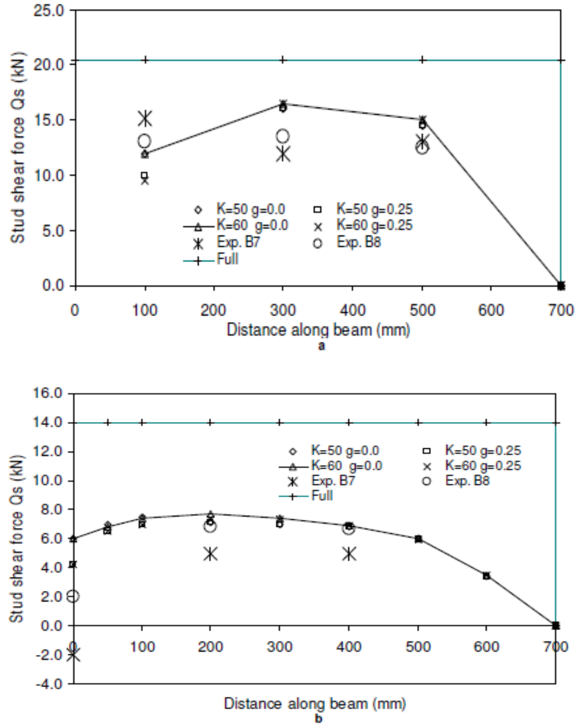


Figure 8. a. Comparison of experimental tension plate stud shear forces for the third group of beams B7-8 (P = 50 kN). b. Comparison of experimental tension plate stud shear forces for the third group of beams B7-8 (P = 50 kN). Forces are shown.

Because of concrete fracture depths and the distance between tension steel plates and concrete infill, the experimental findings differed from what was predicted. The distribution of shear forces at the end of the beam was disrupted due to local concrete cracking. As the fracture depth rose, the axial force in the steel plates reduced, causing a rise in the moment lever arm. Frictional pressures at and around the supports and studs of partially interacting beams have a considerable impact on their behaviour.

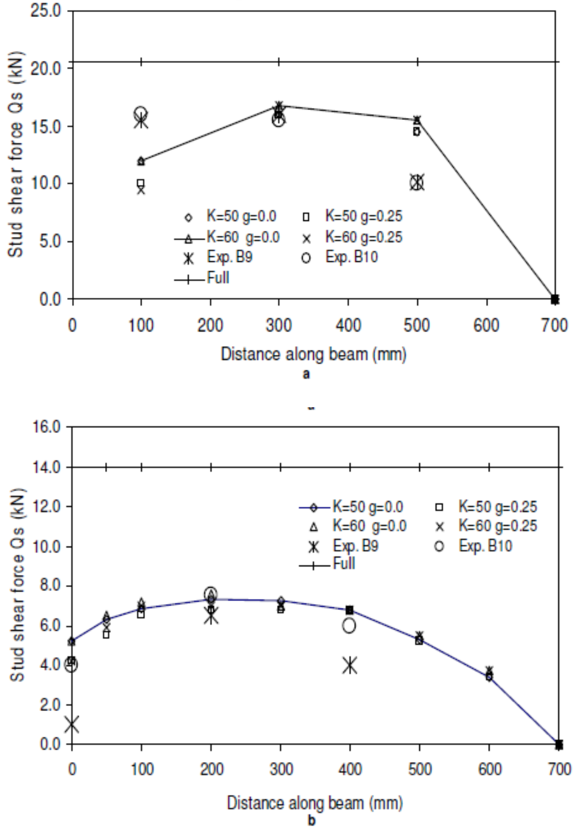


Figure 9. a. Comparison of experimental tension plate stud shear forces for the fourth group of beams B9-10 (P = 50 kN) b. Comparison of experimental compression plate stud shear forces for the fourth group of beams B9-10 (P = 50 kN).

The theoretical results based on partial interaction theory, assuming realistic material and shear connector properties and incorporating the influence of interface frictional forces, show satisfactory correlation with test result.

Subscripts

A	cross-section area of steel plate
c	concrete core
cu	uncracked concrete core
f	frictional force
p	partially interactive section
s	fully interactive section
sc	steel plates in compression
st	steel plates in tension

NOTATION

A	cross-section area
b	width of beam section
d	depth of concrete
e	strain difference at steel-concrete interface
E	Young's modulus
EA	axial rigidity
EI	flexural rigidity
F	axial force in steel plates
f	ultimate strength of concrete
g	coefficient of friction at steel-concrete interface
I	second moment of area
k	curvature
K	stiffness of shear connector
L	span of beam
M	bending moment
n	number of connectors across the beam
P	applied point load on beam
p	longitudinal pitch of connectors
q	shear force (shear flow) per unit length between concrete infill and steel plate
Q	shear force on one connector
s	stud spacing
t	thickness of steel plate
u	distance of point load from support
V	transverse shear force
x, y	co-ordinate axes
x	distance along beam from support
y	moment lever arm
v	deflection
α	composite stiffness factor
ε	strain

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