Behaviour of a full-scale bonded steel-concrete composite beam

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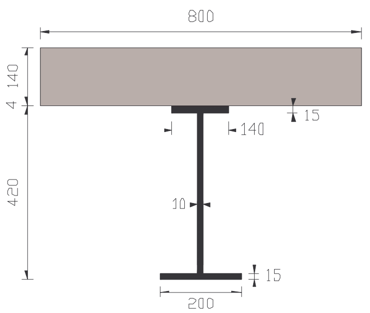
Introduction

The advantage of a steel-concrete composite beam is that the composite structure can combine high tensile strength of the steel and high compressive strength of the concrete. The steel-concrete composite structure is widely used in civil engineering. The connection between the steel beam and the concrete slab is currently ensured by metallic studs. The possibility of combining the steel beam and the concrete block by using the adhesive has been studied [1-3]. In present paper, we present the experimental work on the study of behaviour of a full-scale bonded steel-concrete composite beam.

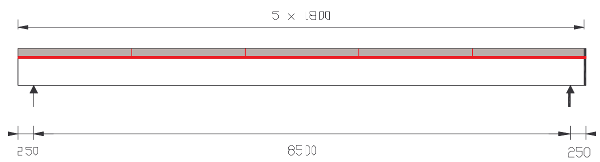
Experimental program

Geometry of test structure

The geometry of the bonded steel-concrete composite structure used in this work is shown in Fig.1. The composite beam with a length of 9000 mm and a height of 564 mm was tested under a three-point loading system (Fig.1.b). It consists of reinforced concrete slabs bonded on the surface of the steel beam of 420 mm high with an adhesive layer of 4 mm. The concrete slab is composed of five slabs joined by adhesive. Each slab has a length of 1800 mm and a cross section of 140 x 800 mm. The dimension of the steel beam and the concrete slab is shown in Fig.1.a.



1a. Beam section



1b.Composite structure dimension

Fig.1: Geometry of the test structure

Materials

The used adhesive is an epoxy adhesive with two components: resin and hardener. The compressive strength of the adhesive is approximately 55 MPa. Its flexural strength is 30 MPa. The measured modulus of elasticity is 12300 MPa. The tensile strength by shearing is 15 MPa and the Poisson's ratio 0.34. The value of compressive strength of the concrete is 70 MPa. Elastic modulus obtained by test is 36600 MPa. The type of the steel beam is S355.

Results and discussion

Failure of the composite beam The failure of the composite beam was produced by sudden rupture of the connection at the interface adhesive/steel, cracking of the concrete slab and pull of the concrete near the interface adhesive-concrete (Fig.2). The maximal deflexion situated at the bottom of the composite beam is important. The value obtained by test is 42 mm (Fig.3). This great deflexion is then to lead the cracking of the concrete slab. The ultimate force of the test composite beam is 402 kN.

2a. Failure of the interface adhesive/steel and concrete near the steel surface

2b.Cracking of the concrete slab

Fig.2. Failure modes of the composite beam

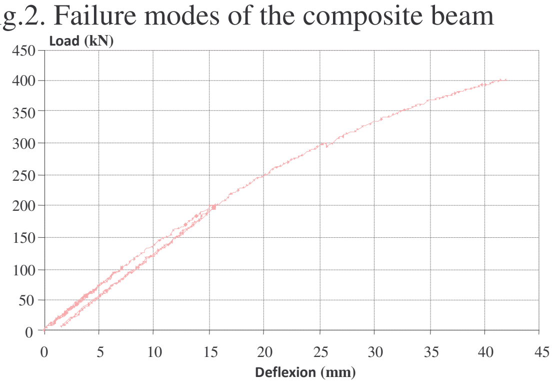


Fig.3. Deflexion at mid-span

Strain

Fig.4 illustrates the variation of strain in function of the heigth. These curves strain-height show that the bonded steel-concrete composite beam is assembled as an only element. The variation of the strain along the bean height is linear. The steel beam is not yielded. However, the position of the neutral axis is slightly moved to the upper surface of the composite beam.

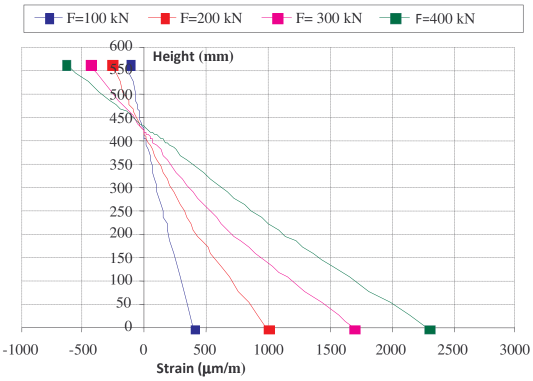


Fig.4: Strain distribution along the height of composite beam

Fig.5 shows the distribution of strain obtained by strain gauges stuck on the top of the steel beam according to the length for a given load. This figure shows clearly that the maximum strain under loading is situated at the center of the beam and the lowest is at the end. The strains in steel beam are positive, so the steel beam is in tensile. It can be seen that the strain value in the upper steel flange is low. The maximum value under the ultimate load is 310µm/m. In the other region, the strain is lower and near the support positions, the strain can be negligible.

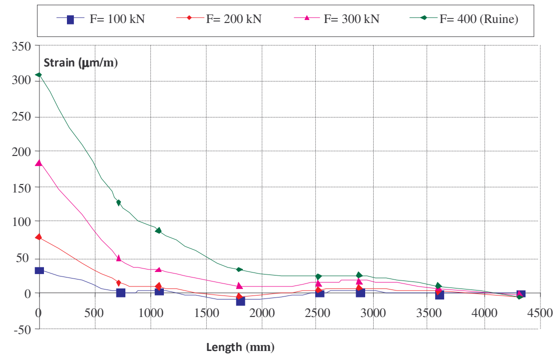


Fig.5: Distribution of strain under the upper steel flange along the beam length from the middle

Fig.6 shows the distribution of strain in the longitudinal reinforced steel of the concrete slab from the middle of the beam. These curves show also that the maximum strain is situated near the center and the value decreases towards the end of the beam

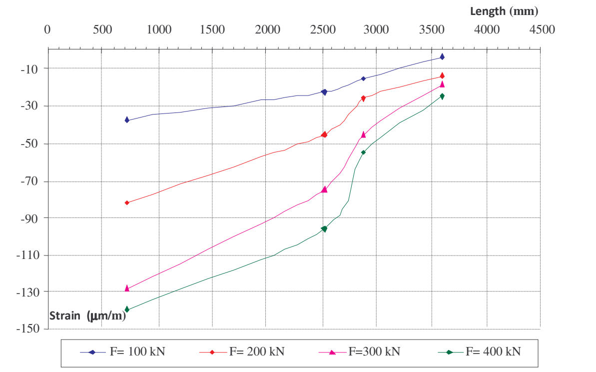


Fig.6: Distribution of strain of the reinforced steel along the beam length from the middle

Conclusion

By analysing the mechanical behaviour and the strain distribution in the different positions, the following conclusions can be obtained:

- The failure of the steel concrete composite is not appeared at the interface steel-concrete and the adhesive material. The bonded technical can be utilised to combine the steel and concrete materials.
- The full-scale bonded steel-concrete composite beam structure can be realized with several concrete slabs without modifying the general behaviour of the composite beam.
- Before the ruin of the composite beam, the great deflexion can be observed.
- The maximum stain is situated at the mid-span of the composite beam and the value decreases towards the beam end.

References:

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