Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 60 (1990)

Artikel: Study of the mechanical properties of composite beams

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DOI: https://doi.org/10.5169/seals-46491

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Study of the Mechanical Properties of Composite Beams

Etude des propriétés mécaniques de poutres mixtes

Studie der mechanischen Eigenschaften von Verbundträgern

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1. SUMMARY

Deformability is always a problem for the design of steel-concrete composite elements. In this study the variation of an ideal Modulus of Elasticity (E_i) for the composite beams is evaluated. The problem is approached by two different methods. Experimentally, by tests of large scale steel-concrete composite specimens and theoretically, by a method using a finite-element programm and the strain energy theory (SED).

2. INTRODUCTION

Since several factors affect the mechanical behaviour of steel-concrete composite beams, the variation of E_i is evaluated in terms of the magnitude of the applied load and the contribution of each section of the two materials as a percentage of the overall composite section. Additional factors taken into account in the study are the quality of the two materials, mainly of the concrete, and the types of loadings.
Determination of E_i would permit the calculation of the deformations and the description of the mechanical behaviour of such structural composite elements more accurately. As it is obvious, knowledge of the above conditions would lead to the better design of structures consisting of composite elements.

3. DESCRIPTION OF METHODS

In the experimental study the problem is faced by testing large scale specimens of composite steel-concrete beams with different kind of cross-section (Fig. 2). Typical flexible shear connectors are used to ensure the cooperation of the two materials. In a series of bending tests different types of loading are applied and diagrams of load versus deflection are drawn (Fig. 1). At the same time strain gages on steel and concrete surfaces are used to measure the deformations in each part of the composite cross-section.
From the experimental measurements the rigidity of the ideal cross-section (E_iI_i) is calculated as a function of the applied load P and the results are shown in diagrams E_iI_i versus P (Fig. 2). Also, from the different dimensions in the cross-section of the specimens and the different types of loading, diagrams giving the variation of E_iI_i in terms of the above factors are obtained.
The theoretical approach is achieved by simulating the composite beam as an element with a crack in the concrete. The idealization of the one half of the beam, divided into finite elements, along with the applied load is shown in Fig. 3. The crack propagation in the concrete is studied by applying SED [1] and the resulting variation of the deflection in terms of the bending moment is drawn in Fig. 4.

4. CONCLUSIONS

Considering that the damage of concrete is the main factor affecting the mechanical behaviour of the composite beam, the proposed theoretical model explains and verifies the experimental results. Therefore, the application of the above theoretical method into various types of beams would lead to the estimation of the variation of E_iI_i in terms of the factors affecting the mechanical behaviour of composite beams.

An additional advantage gained from the finite element program is the determination of the position taking by the neutral axis of the ideal cross-section during loading. In this procedure the moment of inertia of the ideal cross-section (I_i) is calculated and the diagrams giving the variation of E_iI_i could be transformed into corresponding diagrams showing the variation of the ideal Modulus of Elasticity (E_i).

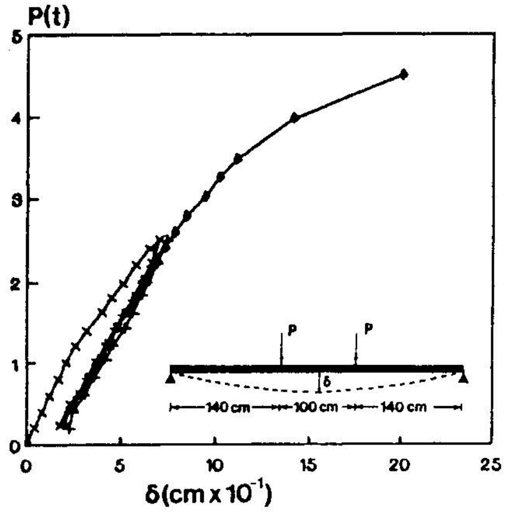

Fig. 1 Load versus deflection.

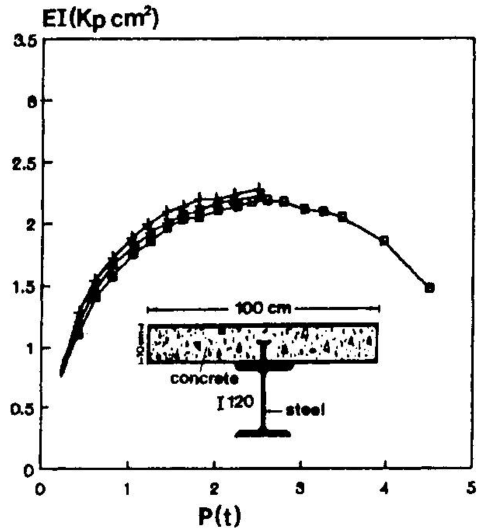

Fig. 2 Rigidity versus load.

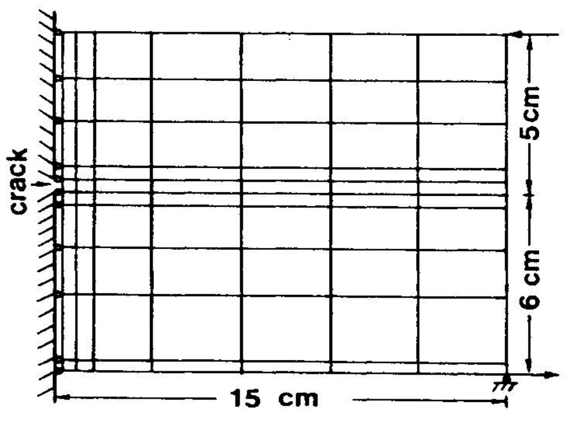

Fig. 3 Finite elements net.

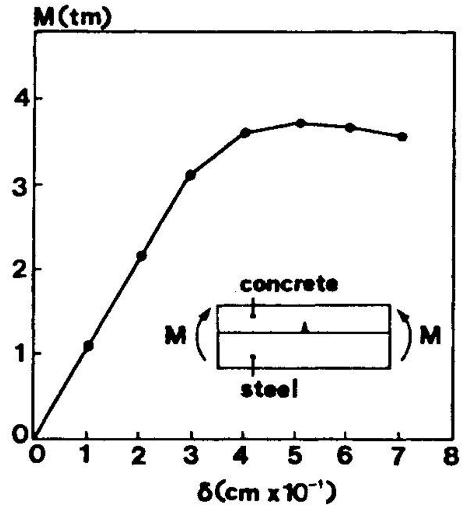

Fig. 4 Theoretical P-δ.

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