International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 8 ǁ August 2022 ǁ PP. 135-138

Numerical Simulation to Investigate the Effect of Internal Connections on Displacement of Flexural Beams

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Abstract
In the current use of flexural beams, the use of composite beams in large structures brings better efficiency. Instead of using large beams, the beam cross-sections are divided into smaller sections that are suitable for production technology and have a reasonable cost, these beams will be connected in a suitable way so that they work as designed. When using composite beams, the moment of inertia and bending moment of the section are usually paid more attention, but in fact we see that the connection between the beams in the structure will significantly affect the ability of the beams. load bearing of the structure and cannot be ignored in the calculations. In this paper, we will simulate and illustrate the influence of the connection between beams in the structure for the case of three-point bending problem and consider the displacement of structure.
Keywords: *Displacement of flexural beams, Composite beams, Numerical simulation…*

Date of Submission: 26-07-2022 Date of acceptance: 09-08-2022

I. Introduction

Displacement of flexural beam is the displacement of the survey point on the beam when subjected to an external force, the value of the displacement depends on the material, moment of inertia of the section, loads and other dimensions of structure. Several methods have been developed to determine the displacement of flexural beams. In practice, to obtain a suitable flexural structure, composite cross-section beams have been used in many cases. For this type of problem, in addition to the factors affecting the displacement of the flexural beam as mentioned above, the interaction between the beams in the structure will also greatly affect the deflection of the beam.

The connection between beams in the structure can be mentioned as: fixed connection (bonded connection), soft connection or no connection. These connections differ mainly in the relative sliding between the two beams, the fixed connection allowing the beam to work as a double height girder, and the unconnected beam working as two independent beams.

II. Method of stress-strain analysis for composite beams

Many authors have proposed different methods for calculating beams of composite cross-sections subjected to bending, such as cross-sectional conversion method, homogenization method, finite element method..etc.

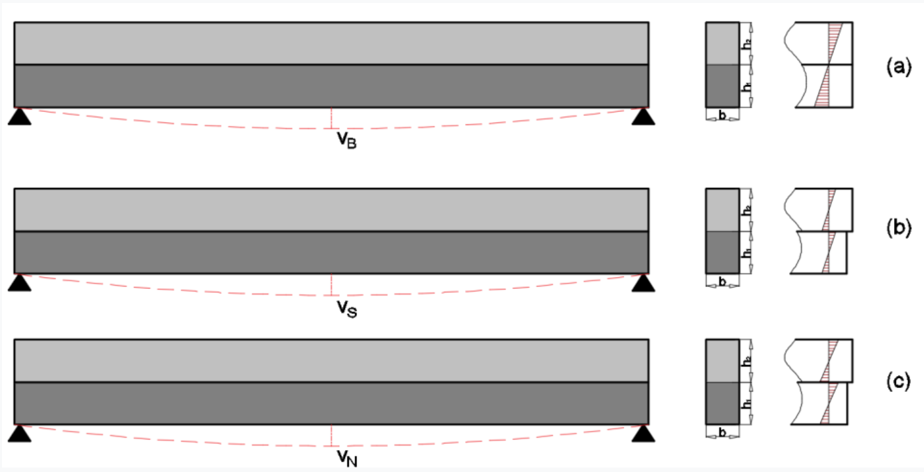

Fig 1. Some types of composite beam connections.

The value of the displacements: $V_N > V_S > V_B$

In there

V_B *is the maximum displacement of the rigidly coupled beams (Bonded – contact)*

V_S *is the maximum displacement of the soft connectionbeams (Sliding contact)*

V_N *is the maximum displacement of the double beam without contact*

The Calculations forflexural composite beams *(Figure 1)*shows that the rigid connection results in a beam equivalent to a single girder with a cross-section converted by the sum of the component sections. Therefore, the displacement of the beam is also minimal compared to other connection cases.

The homogenization approach is based on the idea that the properties of a heterogeneous medium can be determined by analyzing a small portion of it [1-3]. In other words, Representative Volume Element (RVE) is a sample for the entire area (*Fig2*). The finite element method (FEM) is a popular method for numerically solving differential equations arising in engineering and mathematical modeling [4]. The FEM is a general numerical method for solving partial differential equations in two or three space variables (i.e., some boundary value problems). To solve a problem, the FEM subdivides a large system into smaller, simpler parts that are called finite elements [5-7]. This is achieved by a particular space discretization in the space dimensions, which is implemented by the construction of a mesh of the object: the numerical domain for the solution, which has a finite number of points [8-10].

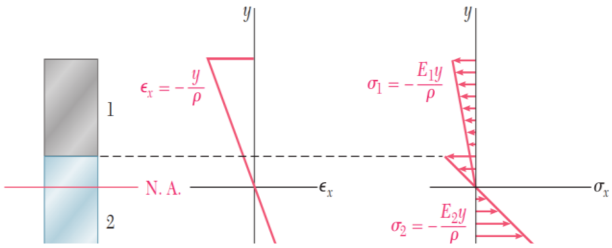

Fig 2. Strain and stress distribution in bar made of two materials

III. Numerical model of beams in bending load

To evaluate the influence of beam internal connections on the structural system, we build a model of three points bending model. The finite element method is used to determine the displacement.

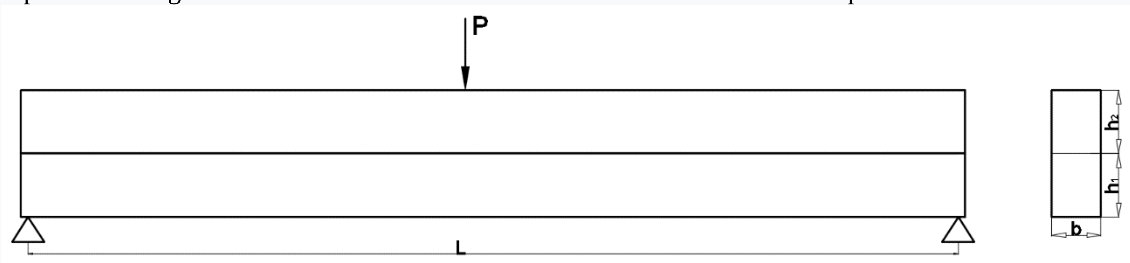

Fig 3. Three points bending composite beams.

Beams model has parameters and mechanical properties as in Table 1.

Table 1. The dimension and elastic module of beams

Beams	L (mm)	b (mm)	h (m)	E(GPa)
1	200	10	30	200
2	200	10	30	200

Model of three-points flexural beam with internal load concentrated at the center of the beam with P = 1000N. The problem model is built with different types of interactions between the two beams, including: Bonded, sliding, no sliding, separation, shrink, shrink fit.

IV. Result

The overall displacement of the beam in the direction of the applied load is shown in the figure for each specific connection condition.The result of comparing the maximum displacement value will give us a basis to evaluate the influence of internal connections on the displacement of the beam.

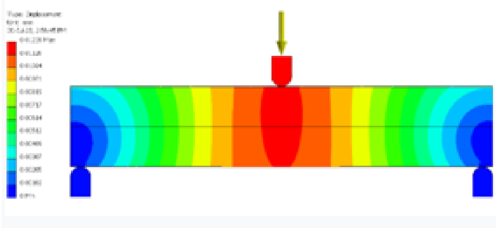

Fig 4. Displacement of beamswith bonded contact

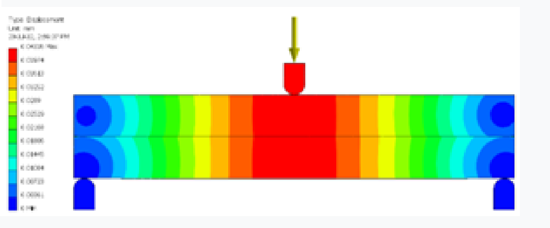

Fig 5. Displacement of beamswith separation contact

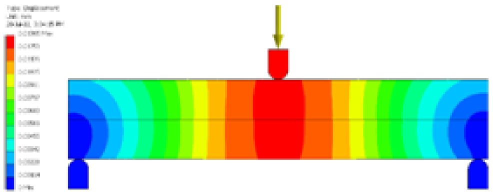

Fig 6. Displacement of beamswith Separation-No Slidingcontact

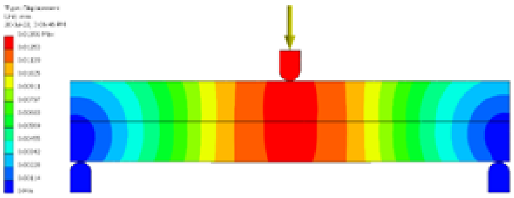

Fig 7. Displacement of beamswith shrink fit-No Slidingcontact

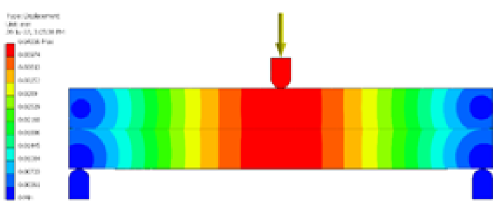

Fig 8. Displacement of beamswith shrink fit- Slidingcontact

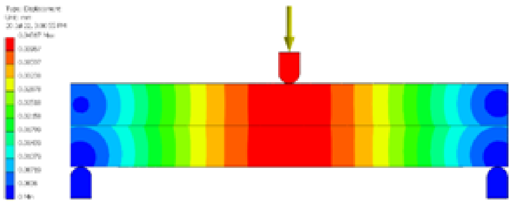

Fig 9. Displacement of beams with Sliding-No separationcontact

Table 2. The maximum displacement values

Contact	Maximum displacement (mm)	Contact	Maximum displacement (mm)
Bonded	0.01228	*Shrink fit- No sliding*	0.01336
Separation	0.04336	*Shrink fit- sliding*	0.04336
Separation - No sliding	0.01336	*Sliding – No separation*	0.04317

V. Conclusion

Internal connections in beams greatly affect the overall displacement of the structure. The connection for the beam structure that closely resembles the homogeneous beam will give the smallest displacement, with discrete or separate connections, the displacement on the beam has a large value.For the overall load-bearing structure, in order to be effective, there are not only purely technical calculations but also other criteria must be ensured, so to have a suitable beam connection in the case of composite beams. then the above conclusions can be used as reference in the process of calculation and application.

ACKNOWLEDGEMENT

The authors are grateful to Thai Nguyen University of Technology – TNUT, mechanical laboratory, for the helpful supports of laboratory equipment as well as fruitful discussion we had on this subject.

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