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The effect of internal connections on the stress of composite beam structures

Nguyen Quang Hung
Thai Nguyen University of Technology, Tich Luong ward, Thai Nguyen city, Vietnam

Corresponding Author: **Nguyen Quang Hung**

Abstract
Today, composite structures are widely applied in many fields of science, engineering and life because of their outstanding advantages. However, when using composite structures, the design calculation process will be more complicated, so the finite element method is used quite commonly when calculating composite structures. In structures subject to flexural loads, composite beams are used quite commonly, with changing the shape of beam cross-sections and even using composite materials with high efficiency. In this paper, we investigate the influence of internal connections in the load-bearing structure on the stress on the beams, and a flexural double cantilevered beam problem model is built to describe that effect.

Keywords: Composite Beams, Composite Structures, Double-Beam, Cantilevered Beams

1. Introduction

In structures subjected to flexural loads, in many cases, girders are used to obtain a large moment of inertia of the cross-section and at a reasonable cost. In some cases, cross-sectional combinations of the same material are used, in some cases different materials are used.

The moment of inertia of the beam cross section needs to be accurately determined in order to calculate the stress on the beam. With a section of basic shape and made of the same material, it is easy to determine the moment of inertia. However, for some beams that have a complex cross-sectional geometries or different types of materials, in such cases many methods have also been proposed to calculate beams for example, such as the homogenization method, the finite element method [1], etc.

2. Method of stress-strain analysis for composite beams

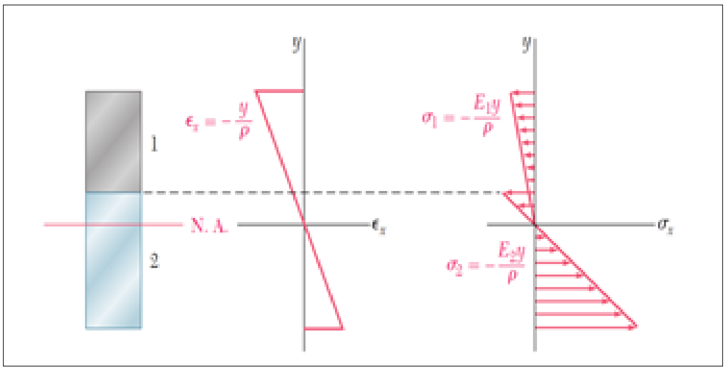

Fig 1: Strain and stress distribution in bar made of two materials

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 (Fig1).

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].

3. Numerical model of beams in bending load

In the composite beams, interactions between the beams will also affect the overall stress of the structure. The beam model below (Fig 2) will determine that effect on the stress on the beam with the load P=1000(N)

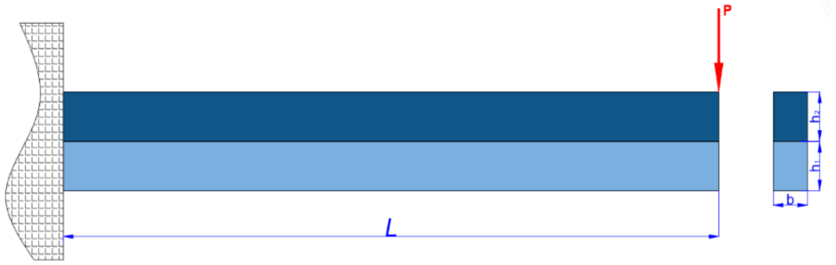

Fig 2: Cantilevered composite beam

To determine the stress and influence of internal interactions on the beam, the element method is used to investigate. Beam 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

The investigated bearing beam model has a cantilever connection, the load causes bending in the vertical plane, and the load is placed at the free end. Ignoring the effects of stress concentration at the load position, considering only the stress arising on the beam, the stress value is determined according to the Von-mises strength theory.
The problem model is built with different types of interactions between the two beams, including: Bonded, sliding, no sliding, separation, shrink, shrink fit.

4. Results

The stress on the beam is determined according to the Von-Misses strength theory under the same boundary conditions.

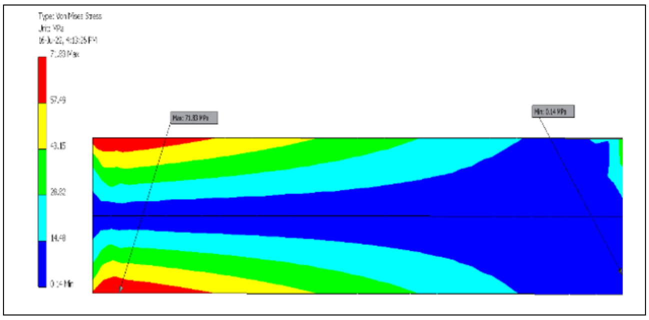

Fig 3: Beams stress with bonded contact

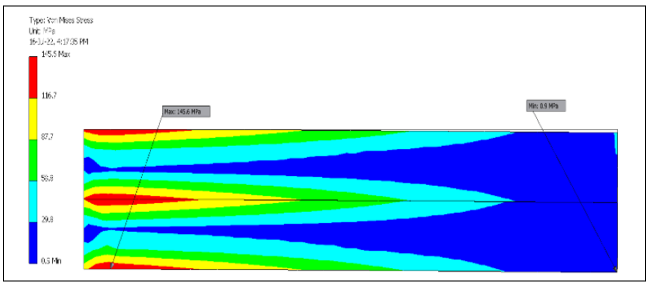

Fig 4: Beams stress with separation contact

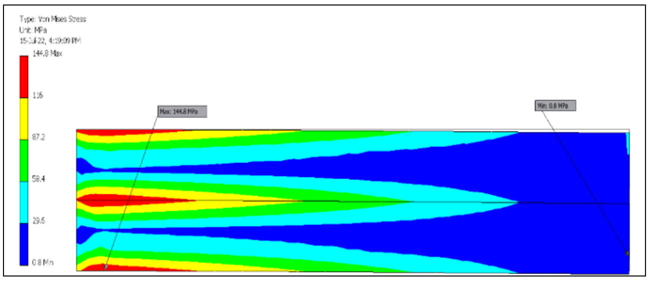

Fig 5: Beams stress with separation-no sliding contact

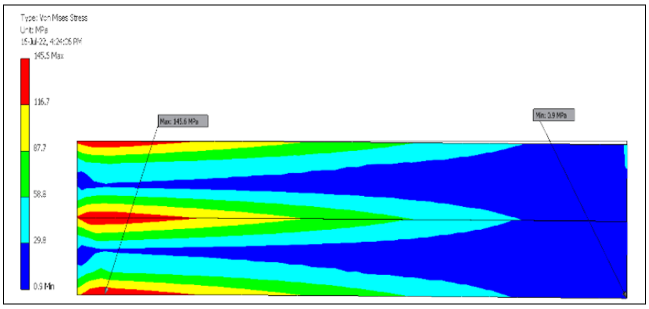

Fig 6: Beams stress with shrink fit- no sliding contact

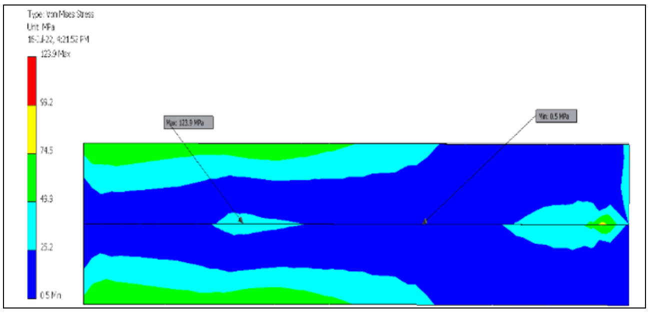

Fig 7: Beams stress with shrink fit- sliding contact

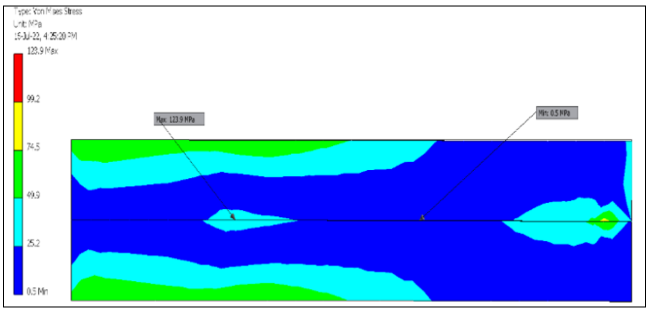

Fig 8: Beams stress with sliding – no separation contact

The comparison of the maximum stress value corresponding to each connection case (Table 2), the stress value determined according to the Von-mises strength theory and the position of the maximum stress on the beam is shown in the figure.

Table 2: The maximum stress values

Contacts	Maximum stress (MPa)	contacts	Maximum stress (MPa)
Bonded	71.83	Shrink fit- No sliding	123.9
Separation	145.6	Shrink fit- sliding	145.6
Separation - No sliding	123.9	Sliding – No separation	144.8

5. Conclusion

Internal connections in beams greatly affect the overall stress of the structure. The connection for the beam structure that closely resembles the homogeneous beam will give the smallest stress, with discrete or separate connections, the stress 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.

6. Acknowledgement

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7. References

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