Pedagogical Computational Environment about the Behavior and Dimensioning of Composite Beams

Maria Aparecida Gozzi Siqueira Costa[1], Walnório Graça Ferreira[2], Rodrigo S. Camargo[3], Elisa Boina[4]

Abstract - Composite beam is a system made of steel and concrete elements, a combination which takes advantage of each material, structural steel sections, concrete slabs and shear connectors, in structural terms as well as in constructive terms. This work presents the design and constructive aspects of composite beams summarized in a computational system made in Visual Basic language. The objective is to show pedagogical purposes of theoretical and practical learning of the calculations of steel and concrete composite beams, simply supported, according to ultimate-strength-limit state, supported, unsupported, with partial or full interaction, and subjected to uniformly distributed load, and presenting comments and quotations from the ABNT (Technical Standards Brazilian Association) NBR 8800/86.
This work provides knowledge about this subject to undergraduate and graduate students, as well as guidance to any professional in need of this information. The software interface is in Portuguese.

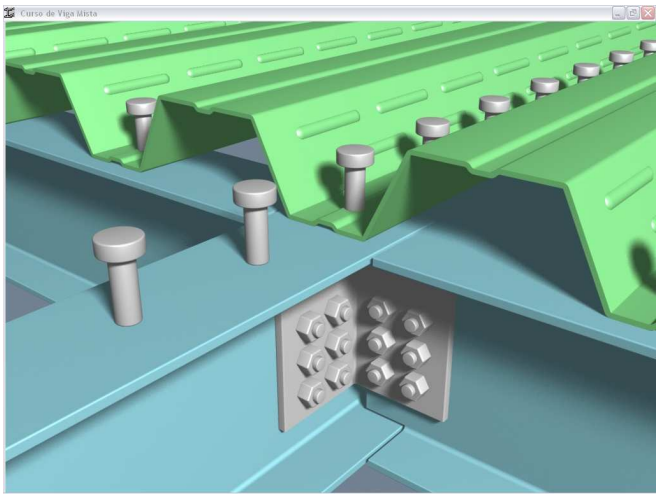
Index Terms - composite beams, pedagogical computational environment.

INTRODUCTION

Composite beams have long been recognized as the most economical elements for floor systems built of a concrete slab and supporting steel sections. It is a perfect use of the principal virtues of component materials: the tensile strength of steel and the compressive strength of concrete.
Their ease of construction, superior strength and stiffness-to-weight ratios, and favorable fireproofing characteristics make them the preferred system components in applications where the floor is required to carry primarily gravity loads.
The program was devised to facilitate the learning and with educational objectives, describes in a practical and simple way, explaining all the steps to follow a complete calculation and analyses the composite beams in pedagogical computational environment that provides structural engineers with a unique guide towards an early adoption of the innovative technology that will enable them to furnish their clients with better more economical structures.

THE PROGRAM

The pedagogical program was created according to ABNT (Technical Standards Brazilian Association) NBR 8800/86 to calculate composite beams simply supported. The data is shown below and the screens are in Portuguese.
The initial screen is shown in picture 1.



PICTURE 1
INITIAL SCREEN OF THE PROGRAM

The program allows choosing or inputting data:

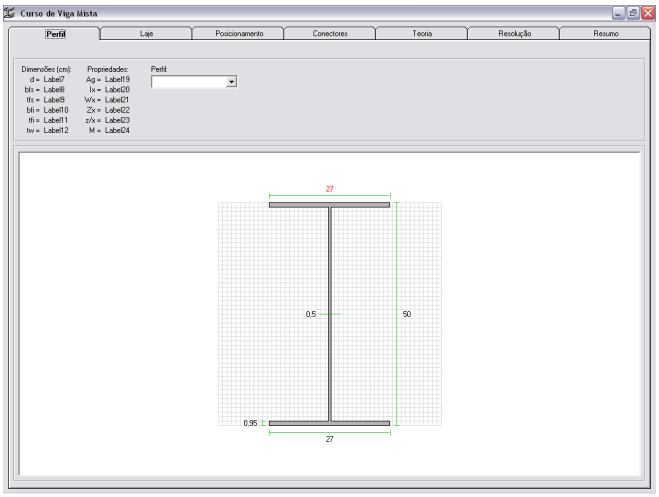
- The profile in the wide-flange sections table or enter with dimensions manually – picture 2.
- The kind of slab, steel deck or normal concrete slab – picture 3 and picture 4.
- The beam spacing – picture 5.
- The length of beam – picture 5.
- Various others parameters of building, like supported or unsupported building – picture 5.
- The interaction, full or partial (in that case the degree of interaction), – picture 6 and picture 7.
- The direction the slab if is parallel to ribs of formed deck or perpendicular to the ribs – picture 5.
- The kind of shear connectors, stud bolt or profile U – picture 6 and picture 7.

And gives complete calculation and analyses the composite beams in reports:

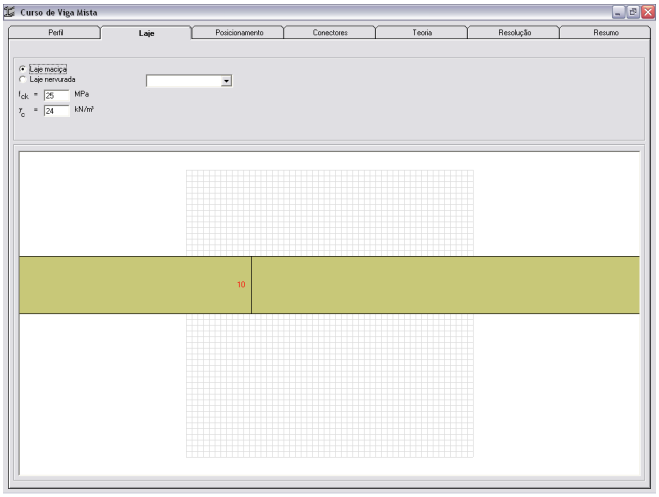
1 Engenheira Civil, Especialista em Projetos de Investimentos da Companhia Siderúrgica de Tubarão - CST do Grupo Arcelor Mittal, Mestre em Engenharia Civil da Universidade Federal do Espírito Santo - UFES, Vitória, ES, Brasil, aparecida.costa@arcelor.com.br; mcostagozzi@hotmail.com; ma.costa@superig.com.br.
2 Engenheiro Civil, Professor Doutor Adjunto do Departamento de Engenharia Civil da Universidade Federal do Espírito Santo-UFES, Vitória, ES, Brasil, walgraf@npd.ufes.br.
3 Engenheiro Civil, mestrando do Curso de Pós-Graduação em Engenharia Civil - UFES, bolsista do NEXEM – Núcleo de Excelência em Estruturas Metálicas da Universidade Federal do Espírito Santo-UFES, Vitória, ES, Brasil, rodrigo_camargo2000@yahoo.com.
4 Estudante de Engenharia Civil da Universidade Federal do Espírito Santo - UFES, Vitória, ES, Brasil, elisaboina@yahoo.com.br.

- A detailed report is calculated by the program and shows, in the screen 9, the items 1 to 8 described below
  1- Materials properties
  1.1- Steel beams
  1.2- Connectors
  1.3- Concrete slab
  2- Geometric Properties
  2.1- Steel profile of composite beam
  2.2- Connectors stud bolt or profile U
  2.3- Steel deck slab
  3- Loadings
  3.1- Effective width definition
  3.2- Loadings before the concrete has cured
  3.3- Loadings after the concrete has cured
  3.4- Over weight loads
  3.5- Loadings composition
  4- Design steel beam alone
  4.1- Local slenderness of flange
  4.2- Local slenderness of table
  4.3- Local slenderness torsion parameters
  4.4- Moment bending
  5- Composite beam calculation
  5.1- Effective width calculation
  5.2- Profile class definition
  5.3- Neutral axis verifying
  5.4- Interactions beam considerations
  5.5-Transformed section calculation
  5.6- Supported beam considerations
  6- Deflection verify
  7- Shear strength in the profile flange
  8- Shear connectors
  8.1- Connectors number calculation
  8.2- Connectors building dispositions
- A resume report is calculated by the program and shows, in the screen 10, the items 1 to 5 described below:
  1- Design steel beam alone
  1.1- Local slenderness of flange
  1.2- Local slenderness of table
  1.3- Local slenderness torsion parameters
  1.4- Moment bending
  2- Composite beam calculation
  2.1- Effective width calculation
  2.2- Profile class definition
  2.3- Neutral axis verifying
  2.4- Interactions beam considerations
  2.5-Transformed section calculation
  2.6- Supported beam considerations
  3- Deflection verify
  4- Shear strength in the profile flange
  5- Shear connectors
  5.1- Connectors number calculation
  5.2- Connectors building dispositions
- Screens with theory resume about composite beams.

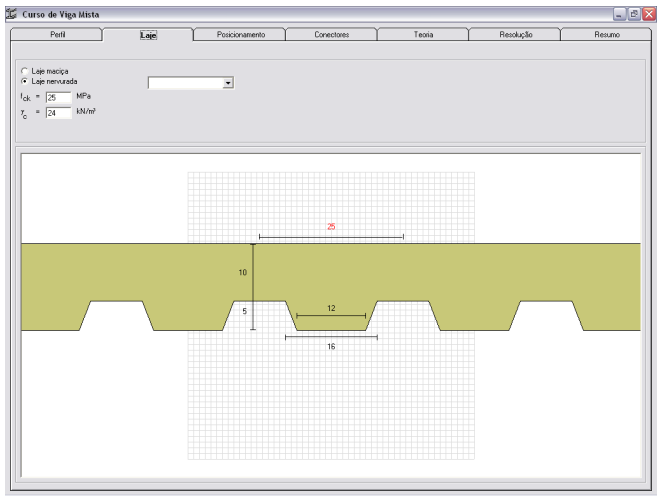
The pictures 2 to 12 show the program screens in agreement these stages.



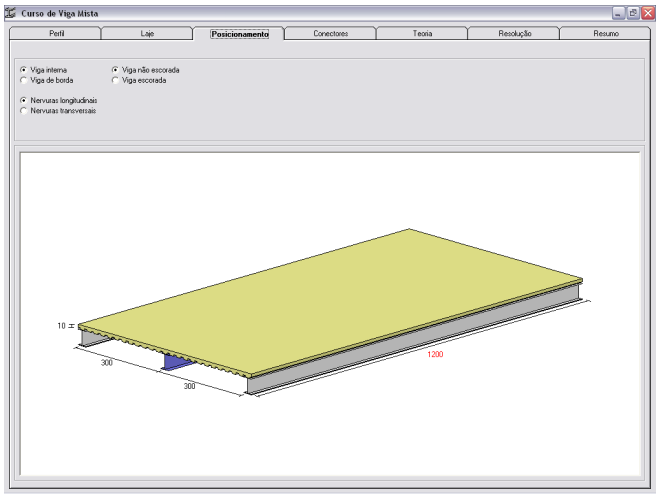
PICTURE 2
PROFILE IN THE WIDE-FLANGE DEFINITION SCREEN



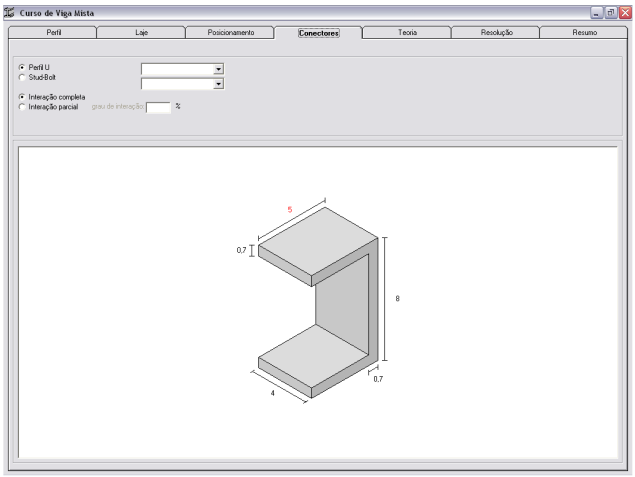
PICTURE 3
SLAB PARAMETERS DEFINITIONS NORMAL CONCRETE SCREEN



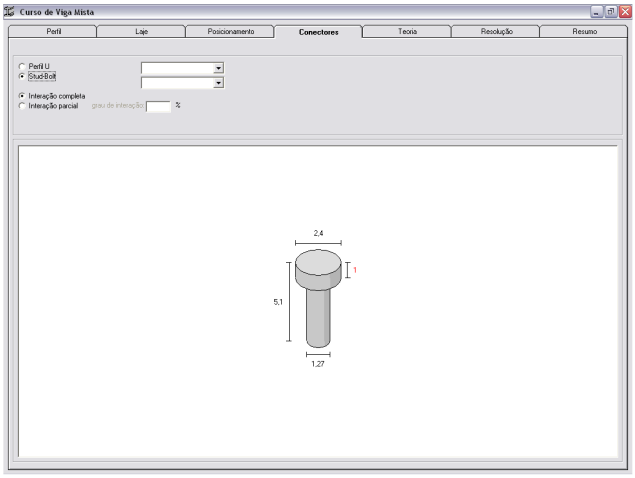
PICTURE 4
STEEL DECK SLAB PARAMETERS DEFINITIONS SCREEN



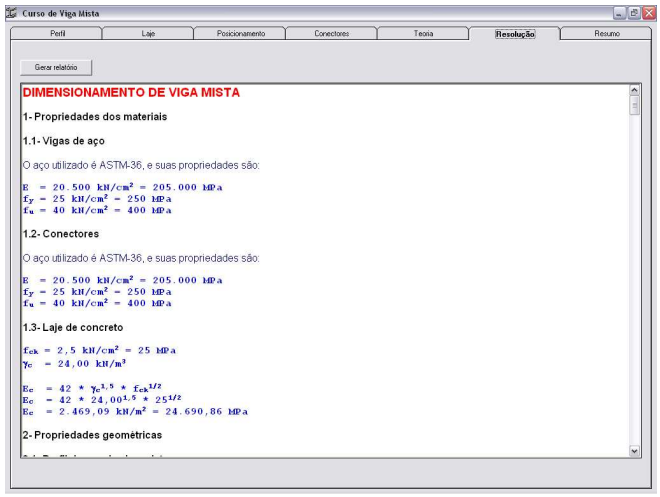
PICTURE 5
INPUT SCREEN BUILDING DEFINITION, BEAM SPACING, BEAM LENGTH, SUPPORTED OR UNSUPPORTED, FULL OR PARTIAL INTERACTION



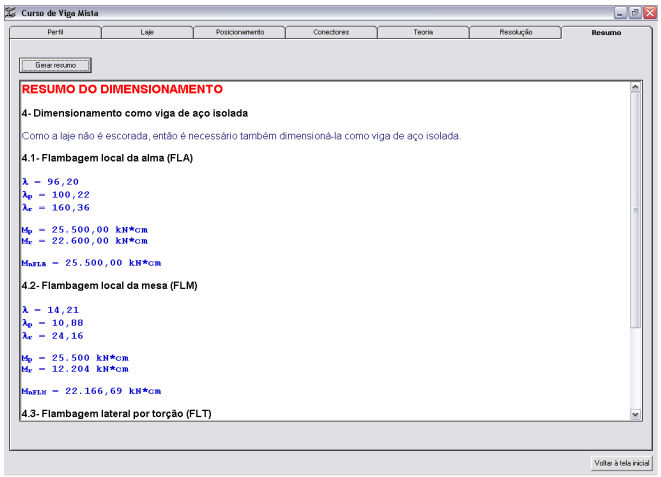
PICTURE 6
PROFILE U - SHEAR CONNECTORS DEFINITIONS SCREEN



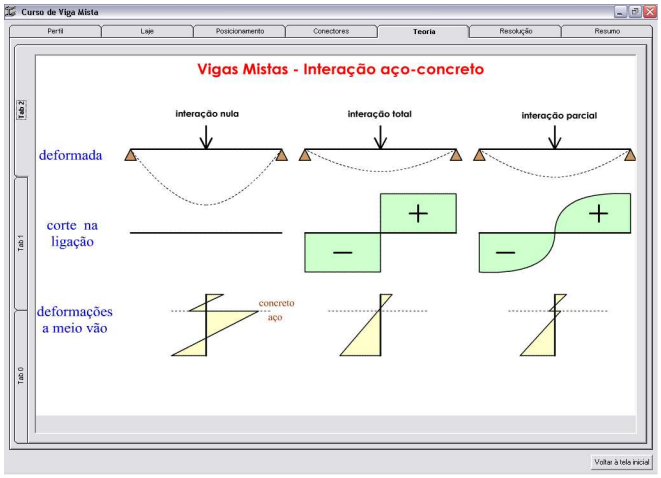
PICTURE 7
STUD BOLT - SHEAR CONNECTORS DEFINITIONS SCREEN



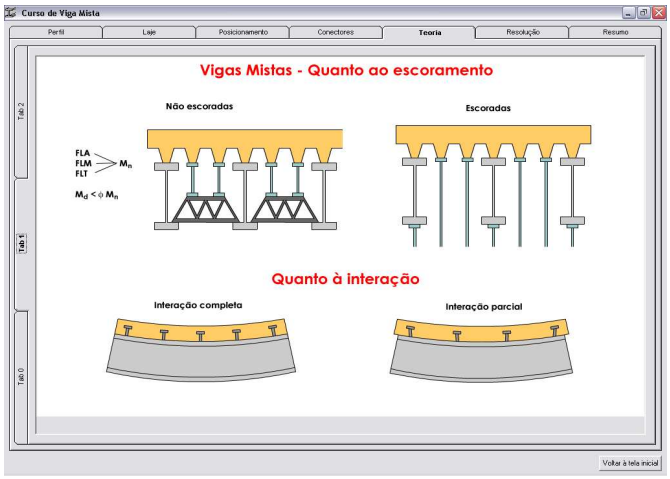
PICTURE 8
DETAILED REPORT SCREEN



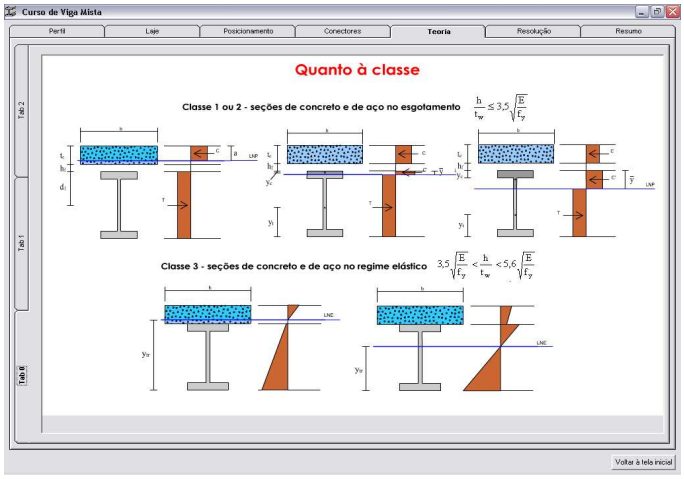
PICTURE 9
RESUME REPORT SCREEN



PICTURE 10
THEORY RESUME ABOUT COMPOSITE BEAMS SCREEN 1/3



PICTURE 11
THEORY RESUME ABOUT COMPOSITE BEAMS SCREEN 2/3



PICTURE 12
THEORY RESUME ABOUT COMPOSITE BEAMS SCREEN 3/3

CONCLUSIONS

The program was devised to facilitate the learning and with educational objectives, describes in a practical and simple way, explaining all the steps to follow a complete calculation and analyses the composite beams in pedagogical computational environment that provides structural engineers with a unique guide towards an early adoption of the innovative technology that will enable them to furnish their clients with better more economical structures.

ACKNOWLEDGMENT

The authors are grateful to Núcleo de Excelência em Estruturas Metálicas e Mistas - NEXEM, and Companhia Siderúrgica de Tubarão – CST – Arcelor Mittal and the Universidade Federal do Espírito Santo - UFES for the support to development of this work.

REFERENCES

[1] Associação Brasileira de Normas Técnicas, 1986. NBR 8800 – Projeto e execução de estruturas de aço em edifícios, Rio de Janeiro.

[2] Associação Brasileira de Normas Técnicas, 2004. NBR-6118: Projeto de estruturas de concreto. Rio de Janeiro.

[3] Associação Brasileira de Normas Técnicas, 1980. NBR-6120: Cargas para o cálculo de estruturas de edificações. Rio de Janeiro.

[4] Fakury, R. H. et al, 1997. Cálculo de Vigas Mistas de Edifícios Segundo a NBR 8800/86, Décimo Oitavo Seminário Nacional de Estudandes de Engenharia, Salvador, Bahia.

[5] Ferreira, W. G., 2004. Dimensionamento de Elementos de Perfis de Aço Laminados e Soldados. Com Exemplos Numéricos, Grafer Editora. Vitória.

[6] GILSON, Q.; PIMENTA, R.P., 2001. Elementos das estruturas mistas aço-concreto. Editora O Lutador, 336 p., Belo Horizonte.

[7] Malite, M., 1990. Sobre o cálculo de vigas mistas aço-concreto: ênfase em edifícios, Dissertação de Mestrado – Escola de Engenharia de São Carlos – Universidade de São Paulo. São Carlos.

[8] Vasconcellos, A. L., 2003. Cálculo Completo de um Edifício de Aço com Estruturas Mistas. São Paulo.

[9] Viest, I. M. et al, 1997. Composite Construction Design for Buildings.