BaFin 1.0: Motor for modeling plates and box girder bridges using the finite strip method

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Keywords: *finite strip method, plates, box girder bridges, GiD, BaFin*

Abstract: *this paper presents the results of developing an application computational of finite strip method for plates and box girder bridges and makes a comparison with results obtained using the SAP2000 program in order to show the variations from a commercial finite element. The GiD program is used as a platform for pre/post-processing and FORTRAN as a language of the finite strip motor, called "BaFin 1.0".*

1 INTRODUCTION

The finite strip method is a unified technique for the analysis of prismatic structures (geometric properties constant along one direction), among which may include plates, straight and curved bridges cell section, shells and revolution shells, which generally retain a constant cross section along its length straight or curved. A finite strip solution for a prismatic structure is achieved by combining a finite element formulation to characterize the cross behavior and Fourier series expansions for the longitudinal behavior, however, you may use other types of interpolators for approximating longitudinal behavior (BSpline for example), however, has used the basic formulation of the Fourier series, as this provides a decoupled system for the different harmonics calculated. The key advantage of the method is the reduction of variables associated with the longitudinal direction and consequently reducing the computational cost concerning a classical three-dimensional finite elements. The combination procedure MEF-Fourier series is based on semi-analytical approximation of Kantorovich. A good number of researchers have made important contributions and studies of the method among those Grafton and Strome, Wilson, and Ahmad in Shells and Solids of revolution, Cheung, Loo and Cusens in bridges and shell structures, Onate and Suarez in different shell structures using Reissner – Mindlin Theory, Zienkiewicz and Too expanded the method to the analysis of prismatic solids under the name of finite prism method, among others.

In this paper we apply the finite strip method to determine preliminarily the behavior of a simply supported rectangular plate under point load and distributed. This paper presents a basic description of the method in plates and box girder bridges, the implementation in the compute of motor BaFin 1.0, the use of this and its comparison against a SAP2000 FEM model of a simply supported plate, given the length restrictions of this publication are not extensive in applications, however, the example shown is enough to see the performance and the benefits calculation of the developed motor.

2 SYNTHESIS OF THE FINITE STRIP METHOD IN PLATES AND BOX GIRDER BRIDGES

The Figure 1 show the process flow diagram of methods suited to plates and bridges of type box section. These steps are used for the development of BaFin 1.0.

(1)	Election of the basic theory
-	Reissner – Mindlin Theory (plates and box girder bridges)
-	Fields of displacements, strains and stresses
-	Total potential energy of the structure
(2)	Combination of finite elements and harmonic functions
-	Discretization
-	Field of displacements for strip
-	Development of the external loads harmonic
-	Minimization of the total potential energy
-	Decoupling of the equations of stiffness
-	Assemble and transformation coordinate (special case for box girder bridges)
(3)	Implementation of the line element explicitly
(4)	Adaptation of a direct or iterative solver for the linear system of equations

Figure 1 : Finite Strip Method in Plates and Box Girder Bridges

3 IMPLEMENTATION

3.1 GiD interface and BaFin implementation

The GiD program makes the pre and post-process activities, however, when a calculation motor is developed, is necessary to generate an interface to keep in mind the models particularities. This process is made through six files explained next, shortly:

Bafin.prb: it provides the window to load the information of the problem general parameters. **Bafin.cnd**: it informs GiD about the conditions imposed to the model (on lines and points): Desplazamientos and Loads.**Bafin.mat**: it provides information about the materials physical properties and some geometrical properties of the strip (Modulus of elasticity, Poisson ratio, thickness, strip length). **Bafin.bas**: it provides the format of file data which will be exchanged between GID and the code. **Bafin.bat**: it throws the calculation module. The GiD “Calculate” option executes this file. **Bafin.exe**: it is the calculation motor developed in FORTRAN (it solves the problem for approach in finite Strip)

3.2 Bafin development

The motor is made of 8 basic subroutines, which are supported by other subroutines to develop of the repetitive operations, such as calculating elementary stiffness matrices for each harmonic, the calculation of force vectors for each harmonic, among others. The first one reads the data of the "*. dat" file. From the second to sixth subroutine executes a cycle controlled by the harmonic ll up the maximum number of harmonics specified by the user. The second subroutine arm the system of linear equations to solve to find the nodal displacement for the harmonic ll. The third is made to solution the assembled system for the harmonic ll using the direct method of factorization LDLt adapted to the system (it plans to incorporate other solvers, iterative mainly). The fourth and fifth subroutine is responsible for calculating and adding the curvatures vector for each harmonic. The sixth accumulates the nodal displacement for the harmonic ll, in this subroutine closes the loop of harmonics. The seventh calculates the generalized stress (moments and shear) in a cross section of interest located by the user in the basic data section of the problem (Bafin.prb). Finally, The eight subroutine generates the "*. flavia.res" file. The displacement and generalized stress values that GID uses to execute the post-process phase are stored in this file.

	VARIABLES DECLARATION
(1)	Data reading from *.dat file (this file is generated for GID-BaFin)
do	ll = 1, number of harmonics
(2)	Assemble the system of linear equations to solve to find the nodal displacement for the harmonic ll
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(6)	Accumulation of the nodal displacement for the harmonic ll calculated in (2)
enddo	
(7)	Computation of generalized stress in the section specified by the user.
(8)	Results writting
	END

Table 1 : Bafin chart

4 RESULTS, POST-PROCCES AND SAP2000 COMPARISON

The figures 2, 3, 4, 5, 6, 7, 8 and 9 show the GID and SAP2000 solution of two flow problems (plate simply supported at its longitudinal ends with point charge at its centroid and plate simply supported at its longitudinal ends with distributed load centered on the length).

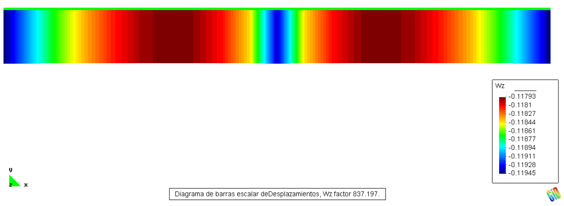

Figure 2 : BaFin-GiD z deflextion line diagram (Puntual load Model)

Figure 3 : BaFin-GiD My line diagram (Puntual load Model)

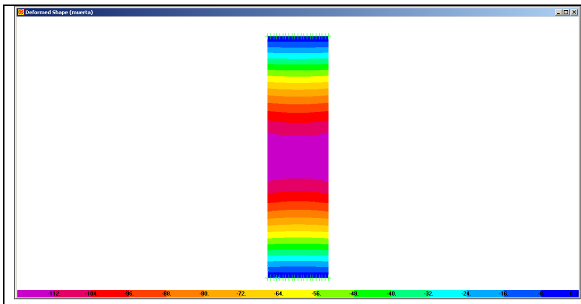

Figure 4 : SAP2000 z deflextion iso-contours
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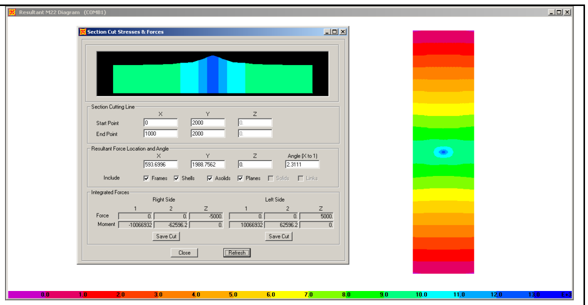

Figure 5 : SAP2000 My line diagram and iso-contours
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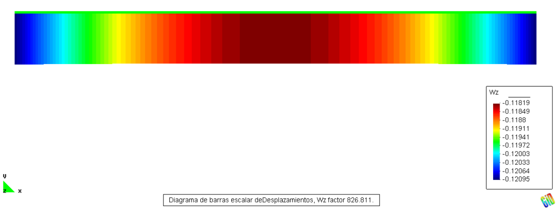

Figure 6 : BaFin-GiD z deflextion line diagram
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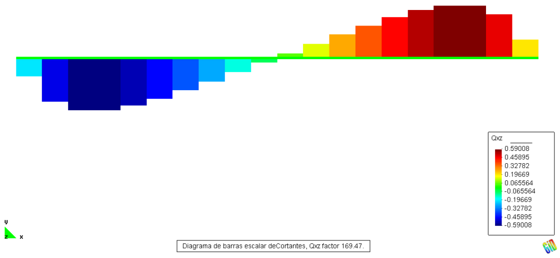

Figure 7 : BaFin-GiD Qxz line diagram
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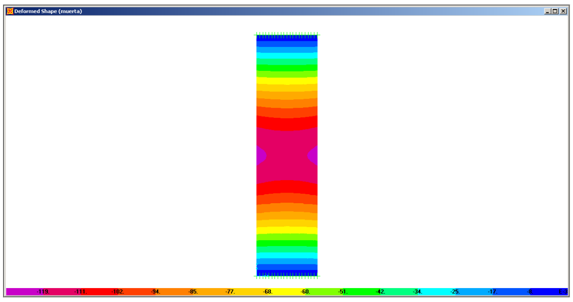

Figure 8 : SAP2000 z deflextion iso-contours
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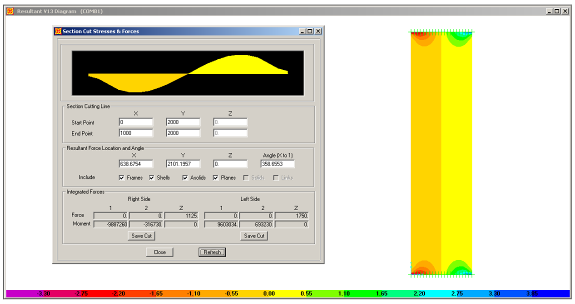

Figure 9 : SAP2000 V13 line diagram and iso-contours
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5 CONCLUSIONS

- The finite strip method shows advantages over the FEM in terms of computational cost, simplicity of the discretized model, performance over time user, among others.
- In general, the correspondence between BAF results and SAP2000 results, validates the ability of strips to solve problems prismatic structures.
- The numerical methods are a great tool to the modeling engineering problems, the same thing that the computational tools developed for it, such it is the case of GiD, a pre and post-process platform excellent to model this problem type.

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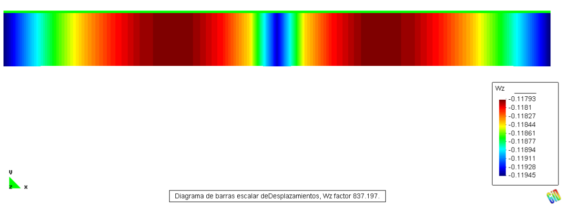

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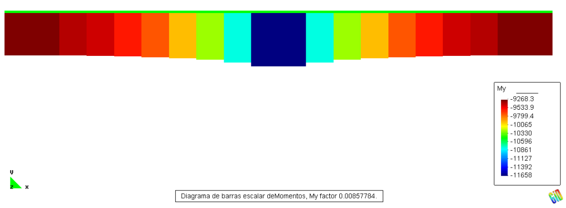

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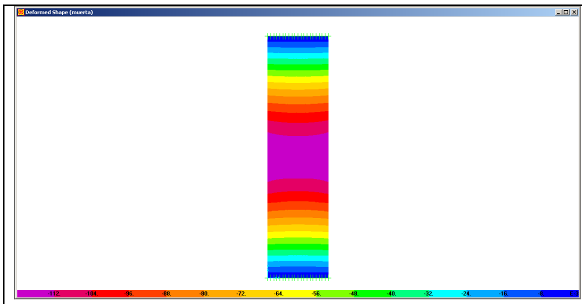

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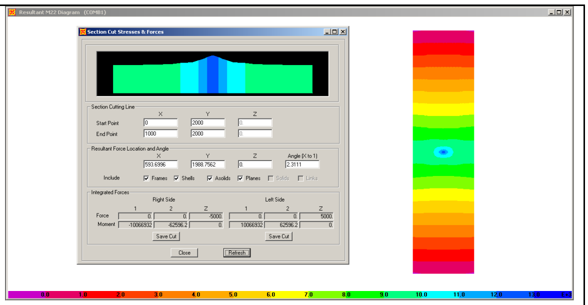

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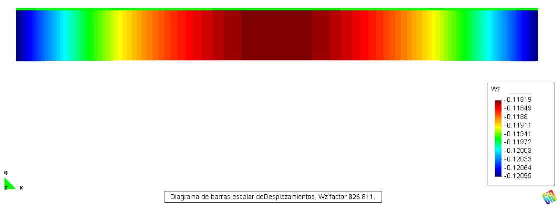

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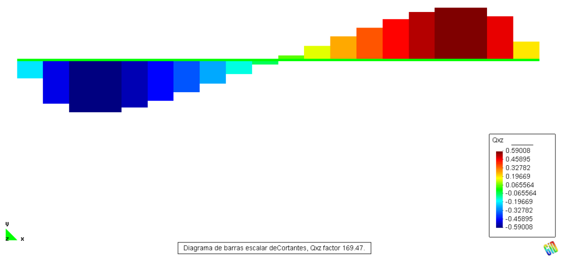

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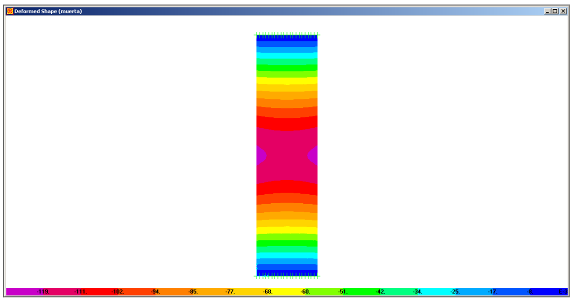

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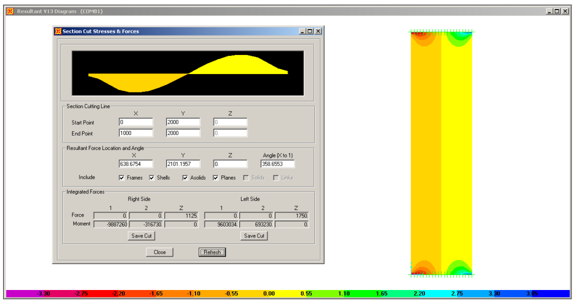

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