Solution for Bridges
Design & Analysis

The state-of-the-art technology
for the civil engineering world

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Main Features

- Concrete Creep and Shrinkage
- **Bridge layout modeling** (in plan and elevation view)
- Utilities for generating **common bridge sections** and layout design
- Geometric and finite element model generation with both Beams (1D) and Solid elements (3D)
- **Loads Generation**
  - Overloads
  - Moving loads (vehicle’s editor)
  - Utility for Prestressing forces input
  - User loads
- Automatic **Loads combination**
- Simulation of the **construction process**
Concrete Creep and Shrinkage

- Effects of Creep and Shrinkage relative to concrete maturity can be easily considered.
- Allows to obtain the deformed shape as well as the forces, moments and stresses in the model.
Bridge Layout Modeling

• This utility allows to generate the geometry and the finite element model of the bridge from **common engineering blueprints**. It works as a "layout program", allowing to define the layout design in both plan and elevation views

• The procedure used for the bridge layout definition is the following:
  • Definition of the **mileage points** (MP’s) that represent the structure axis
  • Definition of **plan and elevation layout**
Bridges Layout in Plan View

- In plan view, the mileage points line is a succession of user-defined stretches:
  - straight segments
  - circular arcs
  - clothoid arcs
Bridge Layout in Elevation View

- In elevation view, the mileage points line is a succession of user-defined stretches:
  - straight segments
  - parabolic arcs
Bridge Cross Sections

- This module includes a **library** of typical bridge cross sections, which are defined by the outline of the section:
  - **Slab** cross sections
  - **Box** cross sections

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**Bridge Section Types**

- **Rectangular section**
- **Trapezoidal section**
- **Trapezoidal section with flanges**
- **Polygonal section with two bends**
- **Polygonal Asymmetric with two bends**

**Tri-cell box section definition**

Note: The upper line (deck) is always horizontal. The slope must be later defined with the section's bank.
Slab Concrete Sections

- It’s possible to define **holes**
- The sections can be **symmetric** or **asymmetric**
- Sections and the hole diameters might vary along the bridge
Box Sections with Variable Depth

- Any generic box section can be easily defined
- All the necessary input parameters can be introduced either by menu or using the corresponding command (allows performing a parametric design of cross sections, creating macros, etc).

Note:
- \( h_{UR}, h_{Ur}, h_{CUr}, h_{CLr}, h_{CLl}, h_{LCr} \)
- and \( h_{L} \)
- have to be > 0

Tri-cell box section definition
Assigning Attributes

- The cross sections may have the following attributes:
  - Offsets
  - Banks
  - Skew
  - Hollow or solid sections
Model Generation

- Once the layout and cross sections are defined the geometrical and FEM model generation can be **automatically** performed by the program.
Model Generation

• Once the layout and cross sections are defined the geometrical and FEM model generation can be automatically performed by the program.
Model Generation

Just by specifying an element type, a **Solid** finite element model or a **Beam** finite element model can be generated.

**Solid** element model

**Beam** element model (shape option)
A. Suspension Bridges Wizard

Suspension Bridge Generator windows can generate 3D models for:

- **Concrete Suspension Bridges**
  (with a CivilFEM bridge section)

- **Steel Suspension Bridges**
  (with a CivilFEM 3D steel truss pattern)

- **Generic Suspension Bridges**
  (with a CivilFEM generic cross section)

- **Mixed section**, two types of section:
  - Concrete slab over I-section steel beams
  - Concrete slab over a steel box section
A. Suspension Bridges Wizard

- By using this Wizard it is possible to easily introduce the **number of segments** and the **corresponding data** to generate the entire bridge model for both 3D beams and solid elements.
A. Suspension Bridges Wizard

Concrete
A. Suspension Bridges Wizard

• Both concrete and steel truss suspension bridge models are **automatically generated** for any generic configuration by just inputting a few parameters.
A. Suspension Bridges Wizard

Steel

'Suspension Steel Bridge, by CivilFEM'
A. Suspension Bridges Wizard

- Any generic cross section from library and/or any 2D defined using CivilFEM with ANSYS meshed drawing (capture utility) can be used as a bridge cross section.
- Optimization of the geometry and initial tensions of cables.
A. Suspension Bridges Wizard

- **Mixed Section (type 1)**

Bridge section is composed of a concrete slab over I-section steel beams:

```plaintext
bSlab/2

fSL

bSlab

fSR

tWeb

tFL

tSlab

hBeam

tSlab

nB

bB
```

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**Footnotes:**

- `bSlab/2` represents half the width of the concrete slab.
- `fSL` and `fSR` denote the distances from the center of the slab to the nearest edge of the I-section.
- `tWeb` and `tFL` represent the thickness of the web and flange of the I-section, respectively.
- `tSlab` is the thickness of the concrete slab.
- `hBeam` is the height of the I-section steel beams.
- `nB` and `bB` denote the number of beams and the total width of the beams, respectively.
A. Suspension Bridges Wizard

- Mixed Section (type 1)
A. Suspension Bridges Wizard

- Mixed Section (type 1) Example
A. Suspension Bridges Wizard

• Mixed Section (type 2)

Bridge section is composed of a concrete slab over a steel box section:

![Diagram of a suspension bridge section with labeled dimensions and angles.]
A. Suspension Bridges Wizard

- Mixed Section (type 2)
A. Suspension Bridges Wizard

• Mixed Section (type 2) Example

"Mixed Bridge with bracings, by CivilFEM"
A. Suspension Bridges Wizard

• Supported Bridge Examples

"Mixed Bridge with bracings, by CivilFEM"
B. Cable Stayed Bridge Wizard

- Generation window
B. Cable Stayed Bridge Wizard

• Model generation
  • Cable arrangements:

  HARP TYPE

  FAN TYPE
B. Cable Stayed Bridge Wizard

- Model generation
  - **Towers**: Unlimited in number, variable cross sections, vertical or inclined with multiple cable arrangements
B. Cable Stayed Bridge Wizard
B. Cable Stayed Bridge Wizard

- Nonlinear Construction Process Analysis:
B. Cable Stayed Bridge Wizard

• Nonlinear Construction Process Analysis:
B. Cable Stayed Bridge Wizard

- Nonlinear Construction Process Analysis:
  - Cable force optimization: Deflection
B. Cable Stayed Bridge Wizard

- Nonlinear Construction Process Analysis:
  - Cable force optimization: Bending Moment
C. Arch Bridge Wizard

- Arch Bridge Generator (Beam Model)
C. Arch Bridge Wizard

- Depending on the position of the bridge deck compared to the arch, there are different cases:
C. Arch Bridge Wizard

- Beam Model
C. Arch Bridge Wizard
C. Arch Bridge Wizard

- Shell Model
Bridge Components

- CivilFEM with ANSYS allows a detailed analysis of piers, cross bracings, diaphragms, etc.
Special Features

• Any of the bridge parameters (layout, sections, dimensions, etc.) can be easily parameterized by the user, allowing very fast sensitivity analysis, making use of some advanced features:
  • Log files
    the program stores in a file all the orders executed by the program during a job. This file can be edited by the user at any time and the model can be executed again by just reading it
  • Macros (APDL)

• Customization: users are able to create their own windows, commands, etc, customizing the program as much as possible to their own needs
• CivilFEM automatically generates the loads corresponding to the various load hypotheses over a 2D or 3D structure, such as:
  • Moving loads (traffic loads)
  • Surface loads (Overloads)
  • Prestressing tendons

• Any kind of "user defined" loads
• "Smart" load combination of all the load steps generated during the analysis
Loads Generation (Traffic Loads)

- With the **vehicle editor** it is possible to create, import from library, modify, copy, delete and list vehicles.
Loads Generation (Traffic Loads)

- Two different types of vehicles: **Rigid** (truck) or **flexible** (train, adaptable to the path)
- User friendly path definition: road surface and road axis are automatically detected by the program

**Trajectory definition (Rigid vehicle)**
- The tangency occurs in the point (xLoc, yLoc) of the vehicle
- Assembly the bridges nodes and elements, where the loads are applied

**Trajectory definition (Adaptable to the trajectory)**
- Assembly the bridges nodes and elements, where the loads are applied
Loads Generation (Surface Loads)

- Definition of an overload grid over the deck
- Automatic load generation and combinations of all possible load case scenarios
Loads Generation
(Prestressing Cables)

- Definition of points along the cable’s path (automatic adjustment of the points using splines)
- Introduce the tensile force at specific locations in the tendon’s path
- Automatic transfer of the cable action to the structure:
  - the program calculates an equivalent system of forces at each node of the element that equilibrate the system

**3D spline generation**

[Diagram of 3D spline generation]

**Transmission of the cable actions to the model**

[Diagram showing the transmission of cable actions to the model]
Load Combination

• In the bridge analysis process, a great number of load steps are generated, which later on have to be combined looking for the worst case scenario. CivilFEM includes functionalities that can automatically handle all possible load cases.

• Obtains the envelop that considers the worst case scenario for each structural point by specifying a target.

• Concomitance at both global and element levels.

• Variable load coefficients can be defined.

• Combining the moving loads (traffic loads)
  • The program automatically combines them as an "incompatible" load (which is the same as saying that a vehicle can only be located at one position at the same time).
Load Combination

• Combining the surface loads (overloads)
  • CivilFEM will automatically combine them as a "compatible" load (these loads will then be allowed to be located at any possible position over the surface)

OBJECTIVE:
To obtain the envelop of maximum vertical displacements at all nodes
Load Combination

• Combining the prestressing cable loads
  • The program automatically combine them as an "addition" load (adds all the loads and apply them at the same time)

• Combining "user-defined" loads
  • The same procedure is applied simply by defining the combination rule to be used (compatible, incompatible, addition, selection, etc) to find the combined results
Checking & Design

- Serviceability Limit State
- Cracking checking according to codes
Checking & Design

- **Ultimate Limit State**
  - Check and design of the bridge reinforcement according to codes, taking into account all the loads applied to the structure.
Simulation of Construction Process

• The bridges module allows to simulate multiple types of construction process

![Diagram of construction process steps](image-url)
Simulation of Construction Process

Cantilever construction

Puente construido mediante dovelas yuxtapuestas: Situación después del step #3
En la etapa inicial nacen cuatro secciones y solo una de ellas está "empujada" (la una).

En la segunda etapa se empuja una nueva sección (la 2), la sección 1 ha llegado a un apoyo intermedio que al final de la construcción ocupará a la 4.

En la tercera etapa nace la sección 5, pero no se empuja ninguna nueva.

En la cuarta etapa el puente está completo, pero tan solo se empujan dos secciones.

En la última etapa el puente está completo. Las secciones 4 y 1 alcanzan sus apoyos definitivos.

Proceso constructivo de un puente empujado.
Bridge Postprocessing

- CivilFEM with ANSYS performs a wide range of postprocessing calculations: load combinations, results displays, check and design processes, etc.
For more information, you may contact:

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