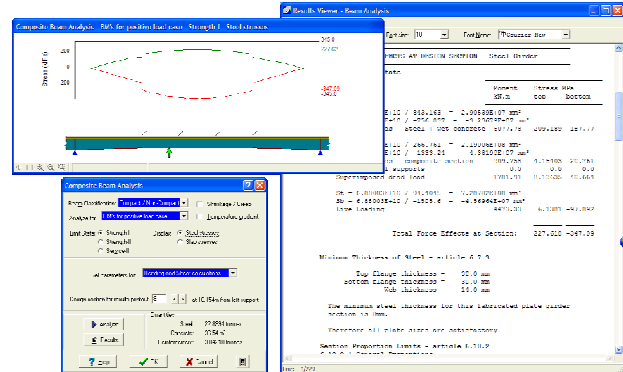
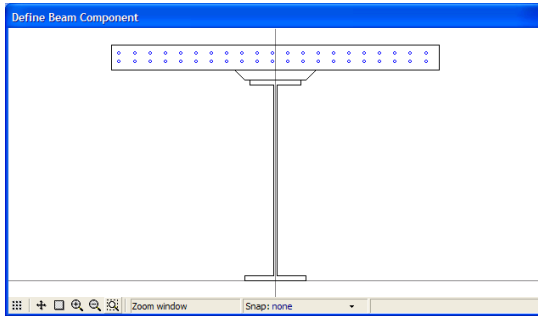


## Beam Design Modules for Eurocodes: B.01<sub>EN</sub>, B.03<sub>EN</sub>, B.04<sub>EN</sub> and B.05<sub>EN</sub>



This is a set of four modules for code checking bridge beams

- B.01<sub>EN</sub>** – Steel/Concrete composite beams
- B.03<sub>EN</sub>** – Pre-cast pre-tensioned beams
- B.04<sub>EN</sub>** – Reinforced concrete beams
- B.05<sub>EN</sub>** – Post-tensioned concrete beams

These modules provide code checking in accordance with EN 1992, EN1993 & EN 1994 for concrete, steel & composite bridges respectively. The section properties used in the code checking are calculated from section module S.01<sub>EN</sub>. They integrate with the structural analysis modules in order to produce fast iterations on the analysis/design cycle. Detailed hand-calculation style reports are produced wherever possible.

Beams can have multiple cross-sections, multiple stages of construction and multiple material properties. All these variations are accounted for when calculating section properties and, in the case of the integrated analysis, member stiffnesses.

Concrete beam sections can be defined using standard pre-defined beams, or any sections defined using the tools of section module S.01<sub>EN</sub>.

Steel beam sections can be standard rolled I sections or plate girders.

National Annexes may be selected within the program. Alternatively the Nationally Determined Parameters can be altered by the user.

There are several benefits to these modules:

- ⇒ The integration with analysis means that one model serves many purposes, and this saves time in defining several different models, saves time in calculating section properties, saves time in transferring results from analysis to code checking, and finally ensures a consistent model.
- ⇒ All the results are displayed graphically, so it is possible to see where design problems occur, and the scale of their magnitude. This makes it easy to make design corrections and check that they have the desired effect.
- ⇒ If the corrections change either the dead weight of the beam or its stiffness, it is simple to re-run the analysis in order to determine the new effects, and thus re-check the beam with its correct action effects. This ensures that the right model is associated with the right loads, and that the design has the correct data throughout.
- ⇒ Wherever possible a mimic of an engineer's hand calculations are created, in order to allow the user to see why and how results are calculated. This allows the user to check the program, and to develop confidence in using it, as well as conforming to many quality standards that require a hard copy of the design calculations.

## Module Specifications B.01 – Design of steel/concrete composite beams

(Not yet available)

- Graphical Section generator and beam elevation generator for composite beams comprising:
  - Rolled steel beam section or I section plate girder
  - Rectangular concrete slab on top of girder
  - One or two layers of reinforcement in the slab
  - Rectangular or trapezoidal concrete haunch between the steel girder and concrete slab.
  - Concrete slab edge detail of any shape.
  - Option for top flange cast into slab
  - Intermediate lateral restraints to compression flanges (unlimited number).
  - Web stiffeners (unlimited number).
- The beam elevation may comprise an unlimited number of different sections specified at different locations along the beam. In addition the elevation of the bottom flange may be described using a series of straight lines, arcs or parabola.
- Actions which may be specified separately are ULS & SLS moments, shears and axial loads for:
  - Differential temperature secondary effects - heating case.
  - Differential temperature secondary effects - cooling case.
  - Shrinkage modified by creep secondary effects.
  - Settlement of supports.
  - Soil pressure.
  - Temperature restraint.
  - Construction stages (up to 3 allowed) for staged concreting along the elevation of the beam.
- Surfacing (any number allowed, for automatic selection of the most adverse) Other permanent actions (eg non-structural concrete).
- String course
- Traffic action Moment and associated Shear for worst positive and worst negative moment cases (any number of load cases)
- Traffic action Shear and associated Moment for worst shear cases (any number of load cases).
- Shear range for fatigue.
- 'Other' variable actions
- Accidental actions
- Seismic actions
- The action effects data may be entered by:
  - Direct entry on screen.
  - Reading from ASCII text file.
  - Generating from applied trapezoidal beam loads.
  - Direct transfer from Sam analysis module results, if licensed.
- Calculation to EN 1993 & EN 1994 for SLS with the Characteristic, Frequent or Quasi-Permanent combinations of actions (i.e. expressions 6.14, 6.15, 6.16), and/or for ULS for Persistent / Transient (expression 6.10) Accidental (6.11) and Seismic (6.12) combinations for the following options:
  - Bending and shear during execution
  - Variable action bending for worst positive or worst negative moment case
  - Variable action shear
  - Variable action bending and shear combined (Interaction plot may be produced)
  - Variable action bending and axial combined
  - Interface shear
- Calculations for differential temperature primary stresses, and shrinkage modified by creep primary stresses.
- Graphical results plot which is the most appropriate from:
  - Permissible stresses and actual stresses
  - Plastic moment and actual moment
  - Unity and 'performance ratio'
- Sections are assessed as Class 1 to Class 4 and the appropriate calculations performed. The user may override this assessment.
- Logical selection of actions during design (e.g. differential shrinkage/creep included only if adverse).
- Fully detailed hand calculation style output is produced for all the calculations listed above.

## Module Specifications B.03 – Design of pre-tensioned pre-stressed concrete beams

- Graphical Section generator and beam elevation generator for beams comprising:
  - Standard pre-cast concrete beams:
    - Comprehensive libraries for UK, USA and Australian ranges.
  - User defined pre-cast concrete beam shape.
  - Standard in situ concrete shapes.
  - User defined in situ concrete shapes (e.g. for parapet upstands).
  - Additional steel reinforcement.
- The beam elevation may comprise an unlimited number of different sections specified at different locations along the beam, with varying soffit and/or crown heights.
- Graphical tendon editor for fast insertion and removal at standard locations, or de-bonding, or deflecting (deflecting available soon). The editor is accessible directly from calculation screens allowing fast modification and repeat analyses.
- Actions which may be specified separately are ULS & SLS moments, shears and axial effects for:
  - Differential temperature secondary effects - heating case.
  - Differential temperature secondary effects - cooling case.
  - Shrinkage modified by creep secondary effects.
  - Settlement of supports.
- Soil pressure.
- Temperature restraint.
- Beam erection (eg temporary supports).
- Construction stages (up to 3 superimposed stages allowed, stage 1 may be split into 2 longitudinal stages)
- Surfacing (any number allowed, for automatic selection of the most adverse).
- Other permanent actions (eg non-structural concrete).
- Traffic actions for bending design (any number of load cases)
- Traffic actions for shear design (any number of load cases).
- 'Other' variable actions
- Accidental actions
- Seismic actions
- The action effects data may be entered by:
  - Direct entry on screen
  - Reading from ASCII text file
  - Generating from applied trapezoidal beam loads.
  - Direct transfer from Sam analysis module results, if licensed.
- Tendon layouts and debond / deflect details can be automatically optimised using a variety of parameters.
- Calculation to EN 1992 for SLS with the Characteristic, Frequent or Quasi-Permanent combinations of actions (i.e. expressions 6.14, 6.15, 6.16), and/or for ULS for Persistent / Transient (expression 6.10) Accidental (6.11) and Seismic (6.12) combinations for the following options:
  - Bending at transfer
  - Bending during erection
  - Bending at construction stages
  - Variable action bending
  - Variable action shear
  - Interface & web/flange shear .
- Calculations for Differential temperature primary stresses, and shrinkage modified by creep primary stresses.
- Graphical results plot of permissible stresses and actual stresses (or permissible and actual moments (ULS) or permissible and actual shears as appropriate)
- Logical selection of actions during design (eg differential shrinkage/creep included only if adverse).
- Fully detailed hand calculation style output and tabular summaries are produced for all the calculations listed above.

## Beam Design Modules for Eurocodes: B.01<sub>EN</sub>, B.03<sub>EN</sub>, B.04<sub>EN</sub> and B.05<sub>EN</sub> (continued)

### Module Specifications B.04 – Design of reinforced concrete beams

- Graphical Section generator and beam elevation generator for beams comprising:
  - Parametric shapes:
    - Rectangle, Circle, Annulus, Voided Slab, H, I, L, T, U, X, Z.
  - Regular polygons
  - Standard pre-cast concrete beams:
    - Comprehensive libraries for UK, USA and Australian ranges.
  - User defined concrete shape.
- Beam elevation generator for beams with varying soffit profile. The soffit profile may be built up from:
  - A series of straight lines
  - Circular arcs
  - Parabola
- The beam elevation may comprise an unlimited number of different sections specified at different locations along the beam. Up to 20 individual shapes may be used for sections within the beam.
- Graphical reinforcement editor for fast definition of reinforcement. Includes options for bent up bars (at one or both ends) for resisting shear; bars parallel to the soffit; horizontal bars. The editor is accessible directly from the calculations screen, allowing fast modification and repeat analyses.
- Actions which may be specified separately are ULS & SLS moments, shears and axial effects for:
  - Differential temperature secondary effects - heating case.
  - Differential temperature secondary effects - cooling case.
  - Settlement of supports.
  - Soil pressure.
  - Temperature restraint.
  - Beam erection (e.g. temporary supports).
  - Surfacing (any number allowed, for automatic selection of the most adverse).
  - Other permanent actions (eg non-structural concrete).
  - Variable actions for bending design (any number of load cases)
  - Variable actions for shear design (any number of load cases).
- The action effects data may be entered by:
  - Direct entry on screen.
  - Reading from ASCII text file.
  - Generating from applied trapezoidal beam loads.
  - Direct transfer from Sam analysis module results, if licensed.
- Calculation to EN 1992 for SLS with the Characteristic, Frequent or Quasi-Permanent combinations of actions (i.e. expressions 6.14, 6.15, 6.16), and/or for ULS for Persistent / Transient (expression 6.10) Accidental (6.11) and Seismic (6.12) combinations for the following options:
  - Bending at construction stages
  - Variable action bending.
  - Variable action shear
- Calculations for Section properties and for Differential temperature primary stresses.
- Graphical results plot of permissible concrete and reinforcement stresses and actual stresses (or permissible and actual moments for ULS or permissible and actual shears as appropriate).
- Logical selection of actions during design (eg differential temperature included only if adverse).
- Fully detailed hand calculation style output and tabular summaries are produced for all the calculations listed above.

## Module Specifications B.05 – Design of post-tensioned pre-stressed concrete beams

(Not yet available)

- Graphical Section generator for beams with all the features of module B.04 as described above. In addition:
  - Up to 4 stages of concrete construction may be defined at a single cross section. (There is no limit to the number of construction stages along the elevation)
  - The first stage of concrete may be defined as pre-cast or in situ.
- Beam elevation generator for beams with varying soffit profile with all the features of module B.04 as described above.
- The beam elevation may comprise an unlimited number of different sections specified at different locations along the beam. Up to 20 individual shapes may be used for sections within the beam.
- The beam elevation, once defined, may be divided into any number of longitudinal segments for purposes of generating construction sequences (e.g. with segmental construction)
- An unlimited number of spans may be defined in a single data set.
- Graphical tendon editor for tendon location and 2D or 3D profile definition. No limit to the number of tendons, which may be defined as external or internal and may be stressed at one or both ends. The tendon editor is accessible directly from calculation screens allowing fast modification and repeat analyses.
- Construction of the beam may be defined in detail allowing for:
  - Addition of concrete in section or elevation
  - Individual tendon partial or full stressing / de-stressing / re-stressing / grouting
  - Addition or removal of construction loading
- Actions which may be specified separately are ULS & SLS moments, shears and axial effects for:
  - Differential temperature secondary effects - heating case.
  - Differential temperature secondary effects - cooling case.
  - Temperature restraint.
  - Shrinkage modified by creep secondary moments.
  - Settlement of supports.
  - Soil pressure.
  - Construction sequence loading (any number allowed)
  - Surfacing (any number allowed, for automatic selection of the most adverse).
  - Other permanent actions (eg non-structural concrete).
  - Variable actions for bending design (any number of load cases)
  - Variable actions for shear design (any number of load cases).
- Secondary effects of pre-stress may be associated with any construction sequence load, or variable action load case.
- The action effects data may be entered by:
  - Direct entry on screen
  - Cut-and-Paste from a spreadsheet with the same table format.
  - Generating from applied trapezoidal beam loads.
  - Direct transfer from Sam analysis module results, if licensed (including secondary pre-stress effects, and elastic deformation effects).
- Calculation of post-tensioning losses
- Calculation check of tendon geometry.
- Calculation of section geometry and stresses allowing for:
  - The presence of defined tendon ducts prior to grouting
  - Offset of tendons due to bunching in ducts
- Calculation of stresses allows for elastic deformation loss of pre-stress according to defined construction sequence.
- Calculation to EN 1992 for SLS with the Characteristic, Frequent or Quasi-Permanent combinations of actions (i.e. expressions 6.14, 6.15, 6.16), and/or for ULS for Persistent / Transient (expression 6.10) Accidental (6.11) and Seismic (6.12) combinations for the following options:
  - Each Construction sequence stage
  - Variable action bending
  - variable action shear with associated bending
  - differential temperature primary stresses.
  - Shrinkage modified by creep, primary stresses.
- Graphical results plot of permissible stresses and actual stresses (or permissible and actual shears as appropriate)
- Logical selection of actions during design (eg differential temperature heating or cooling included)
- Fully detailed hand calculation style output and tabular summaries are produced for all the calculations listed above.