

Section Design Modules for AASHTO LRFD: S.01_{US}, S.02_{US}, S.04_{US} and S.06_{US}



This is a set of four modules for code checking reinforced concrete sections:

- S.01_{US} – Section properties and torsion properties for any section
- S.02_{US} – Temperature gradient analysis to AASHTO LRFD Specifications
- S.04_{US} – Design of concrete sections to AASHTO LRFD & Standard Specifications
- S.06_{US} – Torsion and shear calculations for any section

The section outline, voids, reinforcement and material properties are all defined in module S.01, which then calculates general section properties. Module S.06 calculates the torsion constant "C" using Prandtl's membrane analogy solved using finite difference equations. It is particularly powerful as it allows for continuous edges, as well as catering for any number of voids. It also calculates the shear properties for non-voided sections.

Module S.01 is the basic building block of the Sam suite, because the sections it defines are used for code checking of reinforced concrete sections, and for defining cross sections of beams, which in their turn are used to define longitudinal members of bridge decks.

The other two modules are used to enter loads, and to determine the effects of these loads on the section. S.02 uses temperature gradient profiles to calculate relaxing moments and forces and self-equilibrating stresses. S.04 uses strain compatibility to calculate the stresses and strains in the section arising from moments applied about the X and Y axes, and applied axial loads. S.04 can also calculate the available bending or axial load capacity.

There are several benefits to these modules:

- ⇒ All numeric data is displayed graphically where possible, so that many errors of data entry are immediately obvious.
- ⇒ All results are displayed graphically, so that tables of numbers become meaningful pictures of results.
- ⇒ The graphical results for strain and stress profiles enable the engineering behavior of sections to be more readily understood.
- ⇒ The modules use the same section data, so that changing between modules, changing loads and changing section outlines is completely seamless.
- ⇒ Interaction diagrams of moment and axial load are easily generated.

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 S.01_{US} and S.06_{US}

S.01_{US} – Data Generation tools

- Graphical section generator containing shape libraries for:
 - Parametric shapes:
 - Rectangle, Circle, Annulus, Voided Slab, H, I, L, T, U, X, Z
 - Regular polygons
 - Standard precast concrete beams:
 - Bulb-Tee, I-Girder, Multi-stem Tee, Double Tee, Channel, Single Tee, Box Beam, Voided Slab and Solid Slab.
 - Standard steel sections (AISC):
 - W, M, S and HP shapes, Standard Channel (C), Miscellaneous Channel (MC), Angles (L) and Standard Tees (WT, MT, and ST).
- Graphical section definer for sections comprising straight lines and arcs (100 nodes maximum).
- Graphical section editor for building complex sections comprising up to 20 individual shapes.
- Graphical reinforcement generator with up to 999 reinforcing bars and up to 999 pre-stressing tendons.
- Section, bar and tendon data may be imported and/or exported using ASCII text files.

S.01_{US} – Basic Calculations

- Section property calculations for:
 - area – cross section area
 - i_{xx} , i_{yy} – second moments of area
 - i_{uu} , i_{vv} – ditto about principal axes
 - alpha – angle from global axes to principal axes
 - i_{xy} – product moment of inertia
 - \bar{x} , \bar{y} – centroid coordinates
- The above properties are calculated for:
 - gross section
 - transformed section (to any E value)
 - net transformed section
- Printer set-up for printing output for all modules
- Page heading set-up for printed and graphical output for all modules.
- Option for changing units for input and output for all modules
 - Default SI units
 - Default US units
- Customized units

S.06_{US} – Torsion and Shear Calculations

- For torsion calculations:
 - Calculation of the torsion constant "C" using Prandtl's membrane analogy solved using finite difference equations.
 - Calculation of the maximum torsion stress.
 - Calculation of the shear centre, shear area and maximum shear stress.
 - For sections comprising more than one element, the same E value must be assumed for the whole of the section.
 - The section may include any number of voids subject to the limitations of module S.01, except for shear calculations, where no voids are permitted.

Module Specifications S.02_{US} and S.04_{US}

S.02_{US} – Temperature gradient analysis for any section

- For all sections defined using module S.01:
 - Temperature gradient generator for:
 - AASHTO LRFD Article 3.12.3
 - Any temperature profile that can be defined by up to 20 temperatures within the depth of the section.
 - Calculation of relaxing moments and self equilibrating stresses, using the method as described by Hamby ["Bridge Deck Behaviour", 2nd Edition, E & F N Spon, 1991].
 - The calculations can be set to either ignore or include any reinforcement present

S.04_{US} – Design and rating of concrete sections

- For sections defined using module S.01 comprising concrete with reinforcement and/or pre-stressed tendons:
 - AASHTO LRFD Strength Limit State analysis to Article 5.7.2.1 and Service Limit State analysis to Article 5.7.1
 - AASHTO Standard Specifications LFD analysis to Article 8.16.2 and ASD analysis to Article 8.15
 - Graphical material properties definition from the following libraries:
 - Concrete
 - Reinforcement
 - Prestress tendons
 - Includes facilities for user defined E values and stress limitations.
 - Loading for the stress analysis may be any combination of axial load, bending about the global x axis, bending about the global y axis.
- Loading options may be used to:
 - Specify M_x and/or M_y and/or A_x to calculate stresses and strains
 - Find limiting capacity for section for positive M_x or M_y or A_x , or negative M_x or M_y .
 - Specify some loads as first option, and find additional loads as second option, which load section to its capacity
 - Calculation of Resistance Factor from AASHTO LRFD Article 5.5.4.2.1 for the combination of loadings specified.
 - Calculation of Resistance Factor from AASHTO Standard Specifications Article 8.16.1.2.2 for the combination of loadings specified.
- Calculation and plot of interaction curves for any combination of M_x , M_y and A_x for any