

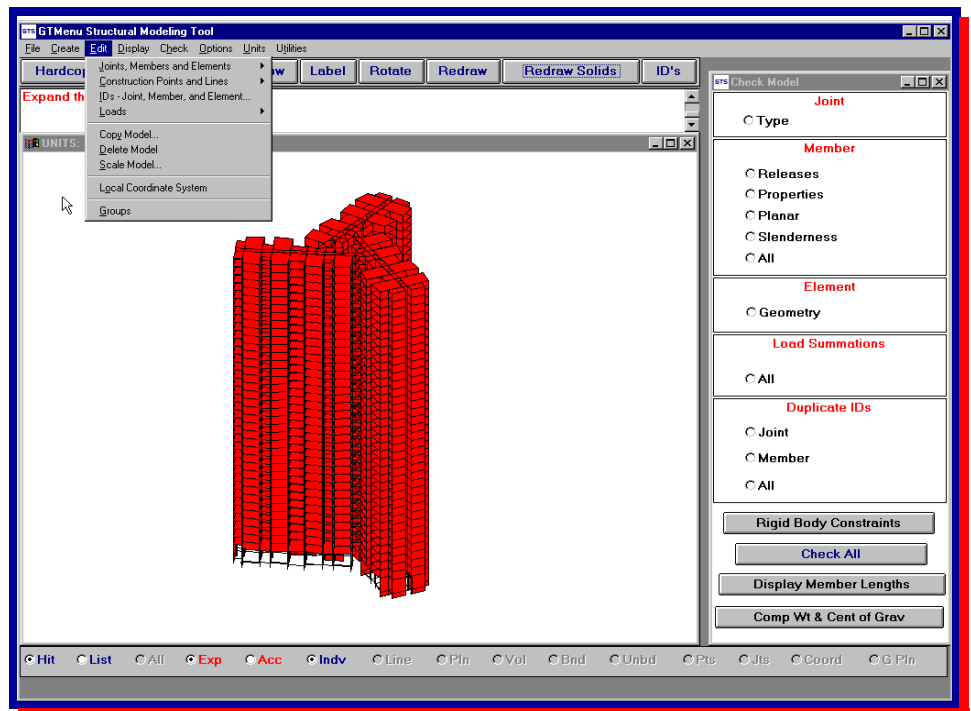
## GT STRUDL Reinforced Concrete Design Overview

GT STRUDL reinforced concrete design facilities are applicable to a wide variety of frame and slab structures. They may be used in conjunction with GT STRUDL's analysis and data base management features, thus permitting the engineer to control the highly result dependent and iterative reinforced concrete analysis/ design/ display/ evaluation/ reanalysis/ redesign/ decision-making process in any manner which is consistent with individual design office practices.

GT STRUDL provides the engineer with maximum flexibility of design, and provides the engineer with one of the most comprehensive and powerful computer-aided engineering design tools for reinforced concrete structures available anywhere.

### GENERAL FEATURES

- C Reinforced concrete framed structures may be designed based on the American Concrete Institute (ACI) Building Code Provisions ACI 318-89, ACI 318-83, ACI 318-77, ACI 318-63, as well as the British Specifications CP110-72 and BS8110. Design utilizes the ultimate strength method.
- C Seismic design and detailing is performed in accordance with ACI 318-83 and ACI 318-89. Both full and moderate seismic conditions are included.
- C Pseudo-static loads and peak loads may be used in the computation of design force envelopes for beam, column, wall, floor slab, and beam-column joint design.
- C Special member, floor slab, and wall panel automatic generation capabilities permit easy modeling of a reinforced concrete structure. Specified uniform floor loads or wind loads, plus dead loads, are distributed automatically to frame members.
- C Design may be performed for beams, columns, one-way slabs including joist systems and two-way flat plate, and flat slab structures. Beams may be designed as rectangular, T, or L shaped sections and include design of flexural, shear, and torsion reinforcement. Columns may be designed as square, rectangular, or round sections with tied or spiral secondary reinforcement.



The Harmony 2 Block Building Model Courtesy of Hong Kong Housing Authority.

- C Wall analysis and design is performed for rectangular and barbell shape walls. Biaxial bending, and compression and tension axial forces are considered.
- C Both the cross-section dimensions as well as the reinforcement may be fully proportioned and detailed.
- C Design by the ACI code is performed in conformance to user specified constraints on any one or more design parameters (such as percent reinforcement, cross-section dimensions, span-to-depth ratio, and many others). The engineer may impose maximum values, minimum values, or fixed values of any of the design parameters, or ratio of parameters, in order to control the design process GT STRUDL will satisfy all user specified constraints, as well as all applicable design code specifications.
- C Design by the British Specifications requires the user to specify beam and column cross-section dimensions, and GT STRUDL will design the reinforcement.
- C Numerous special design parameters may be specified by the engineer in order to guide the design process. Such parameters include  $f'_c$ ,  $f_y$ ,  $f_{sp}$ , the unit weight of concrete, and others.

If not specified, standard values of these parameters are automatically assumed.

- C The engineer may specify a variety of rectangular and parabolic reinforced concrete stress blocks for use in design of structural walls.
- C Uniformity of design may be imposed by the engineer using the MEMBER SIMILARITY specifications for design of members.

### SIMILARITY SPECIFICATIONS TO MODEL PHYSICAL MEMBER DEFINITION

Similarity specifications insure that the resulting design may be constructed in an economical manner. Similarities bring good engineering "common sense" to the computer-based design.

- C A girder can be defined as a collection of analytical members, where the girder may be designed and detailed as a single physical element. Slender column effects may be considered using special P-delta analysis

capabilities. Such a nonlinear analysis accurately reflects the behavior of slender columns. The P-delta analysis satisfies ACI code requirements for a rational analysis and accounts for beam cracking and long term loading effects.

- C Flat plate and flat slab design utilizes an equivalent frame type analysis. Slab thickness is designed for shear due to punching shear plus slab-to-column moment transfer.
- C Pattern loads may be generated for the design of beams under the British CP110-72 and BS8110 code specifications.

### SOME ADDITIONAL FEATURES

Additional reinforced concrete design features include the following:

- C Special line printer plot capabilities are included in order to graphically represent the design results for beam, column, and slab members.
- C ASTM or metric reinforcing bar sizes can be used in the selection and detailing of primary and secondary reinforcement.
- C In the design of beams, a variety of reinforcing steel bar sizes may be specified by the engineer for use as "top" or "bottom" bars. The design procedure first determines beam cross-section dimensions, and then the area of flexural reinforcement is calculated and the bars are detailed (i.e., sized and located within the beam cross-section). Shear and torsion reinforcement is then designed and spaced along the member.
- C Beam design includes consideration of ACI provisions relating to crack-control, minimum spacing between bars, cover, extra stirrup requirements at bar cut-off points, and many others.
- C Bar cut-off points are designed on a basis of an exact development length and moment envelope computation, where the ACI code development length provision are satisfied. Alternatively, bar cut-off points may be specified by the engineer as a percentage of member length.
- C Both stirrup and longitudinal reinforcement for beams are designed for torsional force resistance and for combined shear and torsion.
- C The reinforcing bar detailing capabilities for beams are extensive. Bar lengths and bar arrangements can be detailed according to a broad range of user-controlled specifications.
- C Beam-column joint detailing may be performed.
- C Calculation of required auxiliary longitudinal reinforcement area in deep beams has been implemented.
- C In the design of columns, different size bars, including bundled bars, may be specified for design. Reinforcement may be uniformly

spaced around a column perimeter, or the engineer may specify a non-uniform arrangement. ACI provisions for spacing between bars and for ties or spirals are fully satisfied in the design.

- C Column design procedures include consideration of combined axial compression and biaxial bending, as well as combined axial tension and biaxial bending. A shear check is included as part of the column design procedures. If column design does not satisfy shear strength requirements, a listing of applied shear force and provided shear strength is given. If seismic provisions are in effect, tie spacing or spiral pitch will meet all shear and confinement requirements.
- C Material constants for concrete such as Young's Modulus (E) are computed on the basis of  $f'_c$  and unit weight of concrete according to ACI provisions. Such conditions as reduced shear capacity for light-weight concrete are automatically considered based on the specified value of the concrete's unit weight. Each member may have different material properties. All material properties specified by the engineer takes precedence.
- C Member cross-section properties such as area and moments of inertia may be directly specified by the engineer, or may be automatically computed by **GT STRUDL** on the basis of specified cross-section dimensions.
- C A procedure is included in order to permit a more rational computation of member stiffness to reflect cross-section cracking.
- C Beam, column, and floor slab design may be based upon the clear-span length of the members by using the MEMBER ECCENTRICITIES feature of **GT STRUDL**.
- C Output results present the design or check information and detail the critical information using the active units (imperial or metric). A variety of output command options may be used to yield various degrees of design / detailing information. For beams, the output includes the cross-section dimensions, the theoretical required area of flexural reinforcement, the selected number and size of top and bottom bars and the placement of bars including cover, spacing, and cut-off points. Shear reinforcement is detailed, giving the bar size for a U-shaped stirrup and the spacings between stirrups. Critical design moments and shears are given for convenience of verification. For columns, the output includes the cross-section shape and dimensions, the required area of longitudinal reinforcement, the selected number and size of reinforcement, the spacing and location of reinforcement, plus number, size, and spacing of ties or spirals.
- C The total volume of concrete for beams, columns, and floor systems is computed upon request. The total length and weight of each

size of reinforcing bar is listed, and the combined total weight of all reinforcement is estimated. A great deal of engineering time for estimating material quantities is saved by use of the automated quantity take-off capability.

### ITERATIVE ANALYSIS & DESIGN

- C All member cross-section properties are automatically recomputed and stored in the **GT STRUDL** data base each time a member is designed. This feature allows for iterative analysis and design of reinforced concrete structures to be performed by **GT STRUDL** according to the requirements of the engineer.



Two Prudential Plaza is the second tallest reinforced concrete building in the world. Structural engineering by CBM Engineers, Inc. of Houston, Texas

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