North Bay Seismic Design
Structural Analysis and Design
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ANALYSIS AND DESIGN - BRIDGE STRUCTURES
PARTIAL LIST OF PROPRIETARY PARAMETRIC SOFTWARE TOOLS
NBSD STRUCTURAL ANALYSIS AND DESIGN REFERENCE TOOL LIBRARY

2. NBSD Software Tools - Bridge Structures

Task	NBSD Software Tool	Code References	Description	Comment
Analysis	**SAP2000 Pre and Post Processor for Static or Dynamic Loads**			
	Reinforced Concrete Box Girder Model Description:		- Flexible, efficient, and transparent modeling, visualized first graphically in Excel pre-processor, reproduced exactly on SAP2000 screen, and included in separate Excel results post processor (input data and results) for complete documentation. The entire process is automated by means of Excel Macros at each stage. - Permits analysis of wide range of bridge structures (vehicular, rail, High Speed Rail, etc), as well as transitions between dissimilar interconnecting Box Girder (BG) shapes in the superstructure. - Transparent Horizontal and Vertical curve data modeling for superstructure nodes. - One or Two user defined RC Box Girder decks, modeled as spine frame elements w/ inteconnecting elements at C.G. discontinuities. Platform Deck (at Stations) modeled as spine distributed mass, and point loads on betcaps at Platform Box Girder web locations. - Up to 5 user defined Box Girder section definitions, assigned at each superstructure node defined. Input parameters define entire Box Girder cross section (Max 6 cells), used to determine Box Girder and Bentcap section properties. - Up to 10 hinges can specified for the superstructure, with either restraint or foundation spring values at boundaries, and constraint or spring values at hinge locations. - Up to 15 Bentcaps can be specified with 5 columns max per bent. Bentcaps use Box Girder webs on either side along their alignments in order to define effective Bentcap section properties per Caltrans criteria. - Flexible Column data input for material, location, geometry, height and number of nodes. - Concrete cracking parameter (fraction of E) specified separately for Bentcap, Pier, and column plastic hinge locations. - Use of Foundation restraints and/or Soil Springs. (expandable to discretized nodal p-y, q-u, t-z springs for pilecaps and piles in soft soil conditions) - Acceleration Response Spectrum (ARS) curve Data for Dynamic loads. - SAP2000 Vehicular Live Loads as specified in various codes (AASHTO HL loads, etc); output from program is used in RC Superstructure Design software tools (under Design Task).	Input Data by user is plotted on spreadsheet and used to create a **SAP2000** analytical model input file, which is imported from within the program and run; results for all nodes and elements are then extracted from SAP2000 to be effectively displayed in tabular form and plotted on a Results spreadsheet (also showing relevant Input Data).
	Equivalent Static Analysis (Longitudinal)			
	Longitudinal Secant Stiffness Analysis with Plastic Action Hysteretic Damping	"Seismic Design and Retrofit of Bridges" by Priestley and Seible	Model considers a system of piers and abutments connected by a rigid deck acting in parallel. Pier bi-linear behavior and abutment force-deformation behavior, as well as ARS data, are inputted to obtain system displacement and pier force D/C ratios.	For evaluation of Longitudinally Stiff structures where system acts as a single unit. Hysteretic damping (Takeda) at piers and soil mobilization at abutments per reference.
	Rocking Analysis (Tranverse)			
	Rocking Response of Single Column Spread Footings	"Seismic Design and Retrofit of Bridges" by Priestley and Seible	Tranverse rocking response force equation for the various conditions are obtained from equilibrium of the overturning and resisting parameters. The analysis procedure consists of assuming an initial system deflection, obtain system force from equation, determine system stiffness, spectral acceleration, and damped spectral displacement which is compared with initial assumed value. The assumed system deflection is then adjusted until it equals the resulting damped spectral dislacement. If rocking response is stable, deformations will converge.	Where Caltrans Rock program was applicable for the transverse response modeled, results were found to yield comparable force and displacement results.
	Rocking Response of Two-Column Bent Spread Footings			
	Rocking Response of Single Column Piled Footings	"		
	Rocking Response of Two-Column Bent Piled Footings	"		
		"		
	Miscellaneous Analysis			
	Hinge Restrainer Analysis for Simply Supported Spans	Caltrans Bridge Design Aids 14-11	Cable parameters, system weight, ARS, and available gap are provided to obtain number of restrainers required and resulting system displacement.	

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Task	NBSD Software Tool	Code References	Description	Comment
Design	**Steel Frame Members**			
	Determination of Ultimate Flexural Capacities:			
	Wide-Flanged Section (I, S, etc)		For relevant dimensions, plastic section capacity in Strong and Weak axis bending are provided at yield strength specified.	
	Box Section (TS, HSS, etc)		"	
	Bridge Truss Sway Frame Girder or Sheave Beams (Flange and Web plates connected w/ Angles)		"	
	Same as above, with perforated Web plate		"	
	Built-up Column Section (Opposing Channels w/ Plate reinforced Webs)		"	
	Capacity of Latticed Built-up Sections (Opposing Channels w/ lacing or stay plates)		"	
	Built-up Tower Column Section (Crucible column w/ plate reinforced Flange)		"	
	Reinforced Concrete - Superstructure Design			
	RC Box or T Girder Flexural Design	ACI 318-05, Caltrans Bridge Design Specifications	User Input defines Superstrucure Cross-section, Flexural Demands at 1/10 Span intervals (from analysis), No. and location of bars (A-F bars, as defined in BDS). Program determines section properties and effective tension flanges, and plots Flexural Demands with overlaid rebar flexural strength provided per group, as well as bar development lengths and cut-off locations, along entire Section Span.	Positive reinforcement flexural strength can be compared against demands for regular or hinged RC Box Girders along their entire span; Negative reinforcement flexural strength can at checked at bentcaps and overhanging spans on each side.
	RC Box or T Girder Shear Design	ACI 318-05, Caltrans Bridge Design Specifications	User Input defines Superstrucure Cross-section, Shear Demands at 1/10 Span intervals (from analysis), No. and spacing location of U-Shaped Shear reinforcement. Program determines section properties and effective tension flanges, and plots Shear Demands with overlaid bar Shear strength provided for spacings selected.	
	Bearing and Hinge Design			
	Elastomeric Bearing Pad Design	Caltrans Bridge Design Specifications, Memo to Designers	Movement rating for the bridge, Point of zero movement, and Caltrans Stress-Strain Data (fiberglass and steel pads) are determined for bearing pad design.	
	PTFE Elastomeric Bearing Pad Design	"	"	
	Hinge Design		Required Hinge Seat width and RC Corbel calculations are performed for Bridge Hinge Seat design. Also performed is the design of transverse Shear Keys.	
	Reinforced Concrete - Column Design			
	Circular Column Reinforcement Data	-	For a given circular column diameter and reinforcement bar data, the number (and coordinates) of bars for 1 - 2 reinforcement rings is provided, along with the total bar area and reinforcement ratio.	Spreadsheet could be upgraded to provide the P-M interaction diagram for the circular column. Otherwise use bar coordinates generated for input of Moment-Curvature software (X-Section, BIAX, etc) used.
	Moment-Curvature Relationship for Concrete Piers	"Seismic Design and Retrofit of Bridges" by Priestley and Seible	For a given Column (or Bent) cross-section analyized with a moment curvature analysis progrram (BIAX, X-Section, etc), the Moment-Curvature, Moment-Rotation, and Force-Displacement relationships are plotted.	The elastic and plastic displacement and rotation Capacities are obtained here, which can be compared against the elastic displacement Demands obtained in analysis.

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Task	NBSD Software Tool	Code References	Description	Comment
Design	Shear Capacity in Plastic Hinge Region - Circular Section	Caltrans Memo To Designers 20-4	The Shear capacity of the plastic hinge zone is determined for given axial force, displacement demands, column reinforcement data (longitudinal and hoop), and material data.	
	Shear Capacity in Plastic Hinge Region - Square Section	"	"	
	Reinforced Concrete			
	RC Section Flexural Capacity RC Section Flexural Capacity - Working Stress RC Section Shear Capacity	ACI 318-08 Section 11, Caltrans Bridge Design Specifications	Rectangular RC section capacity obtained for relevant input design parameters.	
	Foundations			
	Spread Footing w/ Eccentric Loading	ACI 318-08 Sections 11.2, 11.4, 11.10, 11.11, 11.14,12.2, 15.4	Alan Williams SE Review Prob 1991 C-3	
	Piled Footing w/ Eccentric Loading	"Seismic Design and Retrofit of Bridges" by Priestley and Seible, Caltrans Seismic Design Criteria, ACI 318-08	Piled foundation is checked for Service and Ultimate loading in both the longitudinal and transverse direction.	Pile D/C Ratios, Rigid Footing Response, adequacy of footing in shear and flexure, reinforcement development length, and joint shear are checked.
	Prestressed Concrete			
	Simply Supported Box Girder	Caltrans Bridge Design Specifications	For a girder with inputted dimensions, span length, load factors, and material properties (concrete, tendons, and mild reinforcement), adequacy of the girder for HS20-44 loads is provided.	Modular unit section properties, live loads, prestressing forces (before and after losses, etc), BDS Stress checks, combined prestress w/ flexural reinforcement section capacity, and shear capacity are provided for section.
	Simply Supported Voided Slab Girder	"	"	"
	Simply Supported Prestressed Girder (AASHTO Type IV)	"	"	"
	Cantilevered Hinge Prestressed Box Girder	"	"	"
Estimating	**Cost Estimating**			
	Miscellaneous Cost Estimating Tools: Structural Concrete, Bridge Structural Concrete, Bridge Footing Diaphragm Bolster Drill and Bond Dowels Drill and Bond, Epoxy Cartridge Core Concrete Column Casings Bar Reinforcing Steel Miscellaneous Metal (Restrainer Type) Miscellaneous Metal (Bridge) Furnish Structural Steel (Bridge) Erect Structural Steel (Bridge) Structure Excavation Structure Backfill	Caltrans Contract Cost Data " " " " " " " " " " " "	Depending upon the nature of the bridge work, one or more of the cost estimating spreadsheet tools will be combined to determine the construction cost of a new or retrofit bridge.	
	Retaining Wall Cost Estimate Tool	Caltrans Standard Plans	Concrete and reinforcement quantities are determined for Caltrans Retaining Wall Type 1 w/ Spread or Piled foundations.	