Revised 4/07/08

DDBD-BRIDGE

SOFTWARE FOR DIRECT DISPLACEMENT BASED DESIGN OF BRIDGES

USER MANUAL

Vinicio A. Suarez and Mervyn J. Kowalsky

INTRODUCTION

DDBD-Bridge has been developed for automation of the DDBD method for highway bridges. In most design cases DDBD can be applied with manual or spreadsheet calculations. However, time in the application of the First Mode Shape (FMS) or Effective Mode Shape (EMS) algorithms and section design can be saved by programming the algorithms into a computer code.

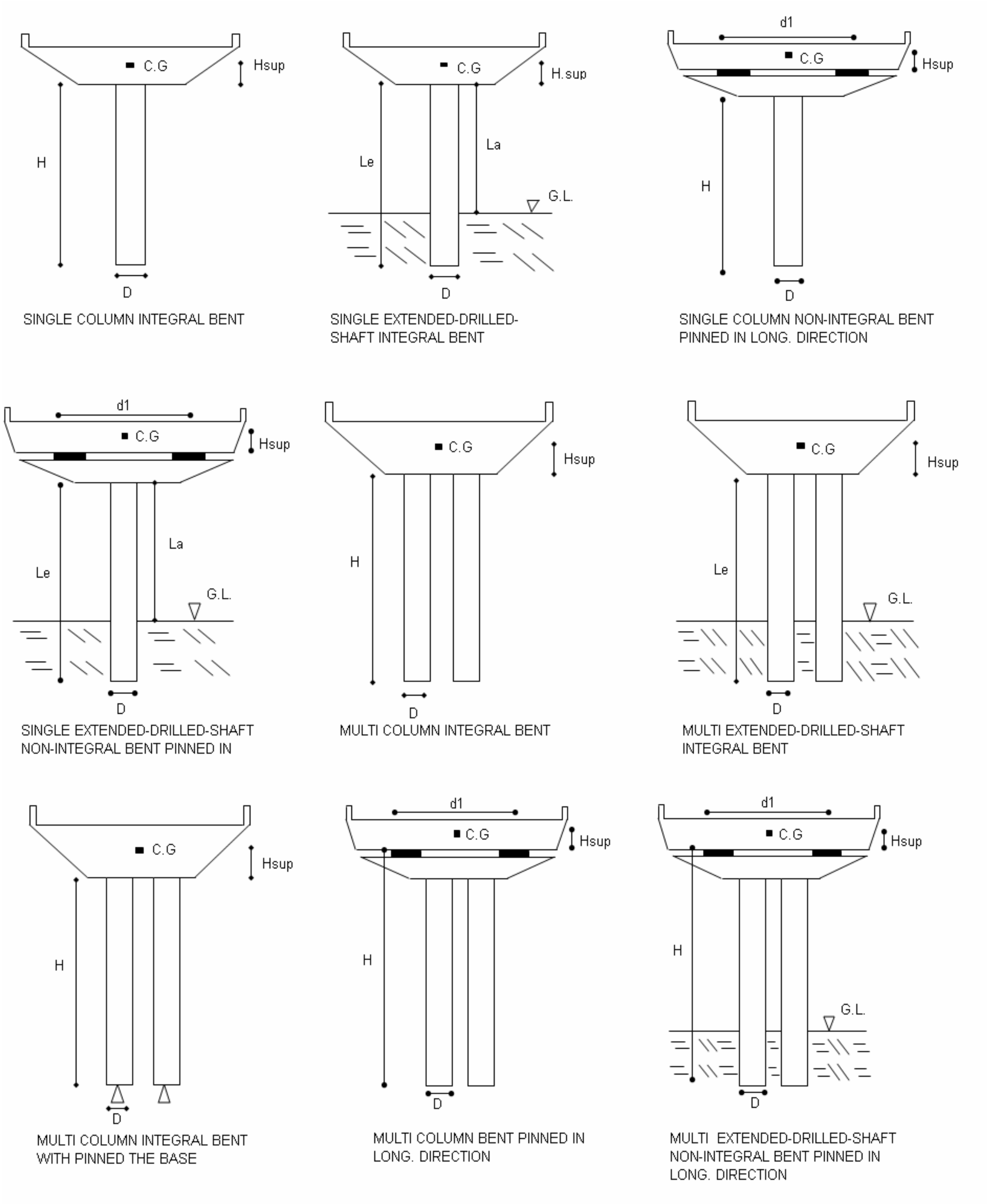
DDBD-Bridge has been programmed following the general procedure presented in a companion paper by the authors entitled "Implementation of DDBD for Highway Bridges".

DDBD-Bridge has the following features:

- DDBD of highway bridges in the transverse and longitudinal directions
- Design using the direct, FMS and EMS algorithms
- Continuous superstructures or superstructures with expansion joints
- Supports Integral or seat-type abutments
- Supports skewed piers and abutments
- All types of piers shown in Figure 1
- Automated section design

The program and its documentation can be accessed and used on-line though the Virtual Laboratory for Earthquake Engineering (VLEE) at: www.utpl.edu.ec/vlee. The VLEE provides an interactive user interface for DDBD-Bridge and other related programs such as ITHA-Bridge.

Figure 1. Pier configurations supported by DDBD Bridge



RUNNING DDBD-BRIDGE

To run the program the user must input the data requested in the web interface and run the program on-line. Then, the user can download a design report that is automatically generated.

INPUT DATA

When using the web interface, the user inputs a number of design variables. These parameters are defined next

Bridge Configuration

NSPAN	Number of spans **[1-8]**
SLENGTH	Length of the superstructure **[> 0]**
PHIYS	Allowable curvature in superstructure (1/m) **[> 0]**

Superstructure

SWEIGHT	Weight of the superstructure section (kN/m) **[>0]**
SHEIGHT	Distance from the soffit to the centre of gravity of the superstructure section (m) [>0]
SINERTIA	Superstructure inertia around the vertical axis (m^4) [>0]
SEM	Elastic modulus of the superstructure (MPa) [>0]
NSJOINTS	Number of expansion joints in the superstructure (0 if none) [0-3]

Design Spectra

TC Corner period in displacement design spectra [>0]

MDISP Maximum spectral displacement [>0]

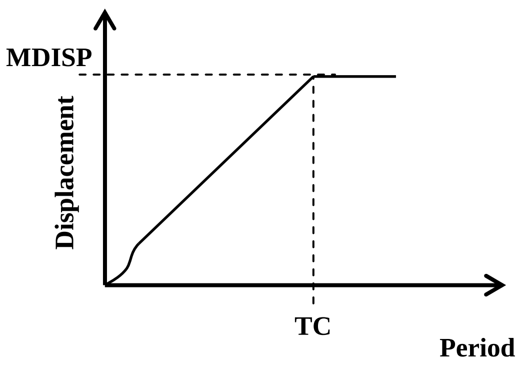
TB **Periond at end of acceleration plateu.** See Fig…. [>0, TB>TA]

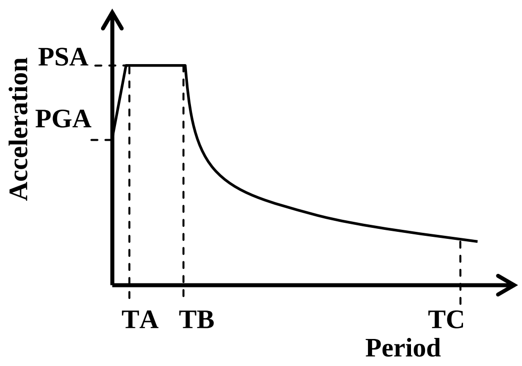
TA **Periond at begining of acceleration plateu.** See Fig…. [>0]

PSA Peak spectral acceleration (m/s^2) [>0]

PGA Peak ground acceleration (m/s^2) [>0]

ALPHA
- **0.5** if fault is more than 10 km away from the site
- **0.25** if fault is less than 10 km away from the site





DDBD

SDIST
- **1** To get columns with same reinforcement (typical)
- **2** To get same shear in all piers (appropriate for seismic isolated piers)

NITER Max number of iterations allowed (10-30)

TOL Tolerance in convergence of displaced shape (0.01-0.1)

SST (Assumed) fraction of total base shear taken by abutments in transverse direction (0-1)

SSL (Assumed) fraction of total base shear taken by abutments in longitudinal direction (0-1)

UDDS 0 Program uses a transverse Rigid Body Translation Patter

1 Program uses a user defined transverse displacement profile. In which case the user must provide the displacement values (m) at each substructure location

2 Program used the First Mode Shape design algorithm

3 Program uses the Effective Mode Shape design Algorithm

Material Properties

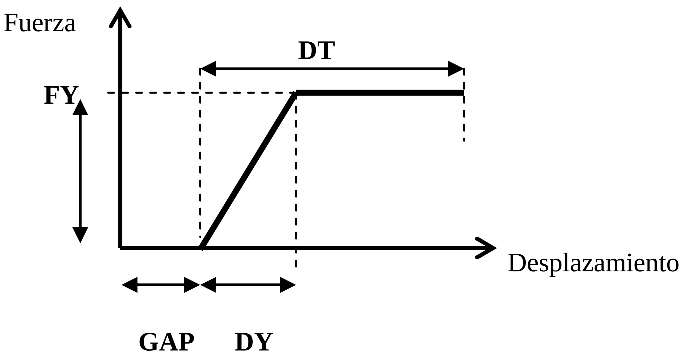
WC	Unit weight of concrete (kN/m^3) [>0]
FPC	Specified unconfined compressive strength of concrete (MPa) [>0]
FY	Specified yield stress of longitudinal reinforcement bars (MPa) [>0]
FUR	Ratio between ultimate and yield stress of longitudinal reinforcement bars [>1]
ESU	**S**train at maximum stress of longitudinal reinforcement bars [0.06-0.12]
FYH	Specified yield stress of transverse reinforcement bars (MPa) [>0]
FURH	Ratio between ultimate and yield stress of transverse reinforcement bars [>1]
ESUH	**S**train at maximum stress of transverse reinforcement bars [0.06-0.12]

Substructure Types

Elastic Abutment

STA	Distance from the left end of the bridge to the element (m) [0 or SLENGTH]
SKEW	Skew angle (Degrees measured from axis perpendicular to bridge) [0 a 90]
DTOUT	Out-of-plane displacement capacity (m) [>0]
DTIN	In-plane displacement capacity (m) [>0]
DAMP	Equivalent damping (%)[5%-10%]
AWEIGHT	Effective weight of the abutment [>=0]

Elasto-plastic abutment



STA	Distance from the left end of the bridge to the element (m) [0 or SLENGTH]
SKEW	Skew angle (Degrees) [0-90]
DTOUT	Out-of-plane displacement capacity (m) [>0]
DTIN	In-plane displacement capacity (m) [>0]
DYOUT	Out-of-plane yield displacement (m) [>0]
DYIN	In-plane yield displacement (m) [>0]
FYOUT	Out-of-plane strength (kN) [>=0]
FYIN	In-plane strength (kN) [>=0]

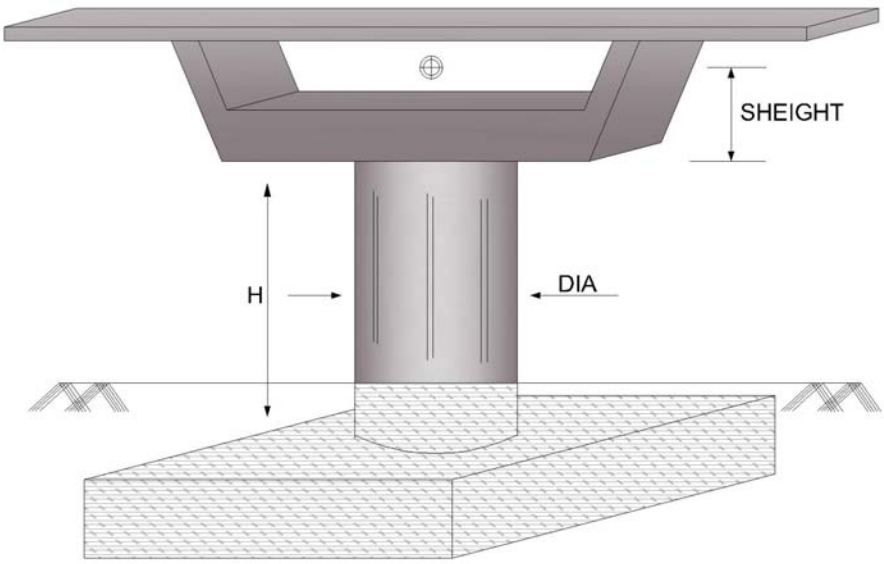
GAP Longitudinal gap between superstructure and abutment (m) [>=0]

B Parameter that defines the equivalent damping, ξ, as a function of the ductility demand, μ, for the element. If B >0, B is used in the equation below to compute ξ. If B = 0 or omitted then B is taken as 60 as for an elasto-plastic system. If B < 0, the absolute value of B is taken as constant damping for the abutment.

$$\xi = 5 + B\frac{\mu - 1}{\pi\mu}$$

AWEIGHT Effective weight of the abutment [>=0]

Single column integral bent



STA	Distance from the left end of the bridge to the element (m) [0-SLENGTH]
DIA	Diameter of the column (m) [>0]
H	Height of the column (m) [>0]
D1 D2	Parameters that control how target displacement is calculated If D1>0 and D2>0 then D1 and D2 are taken as the limit STRAINS for concrete and steel respectively If D1 = -1 then D2 is the target DRIFT value for transverse and longitudinal response (drift is expressed as the ratio of top displacement and height of the column) If D1 = -2 and D2 = 0 then target displacement is found for DAMAGE CONTROL limit state If D1 = -3 and D2 = 0 then target displacement is found for moderate plastic action using the implicit procedure in LRFD-Seismic for SDC “B”

If D1 = -4 and D2 = 0 then target displacement is found for minimal plastic action using the implicit procedure in LRFD-Seismic for SDC "C"

If D1 = -5 then target displacement is computed for the displacement ductility limit specified in D2

DBL Diameter of longitudinal rebars (mm). [>=0]. If DBL = 0, program uses minimum reinforcement ratio

DBH Diameter of spiral (mm). [>=0] If DBH = 0, program uses minimum reinforcement

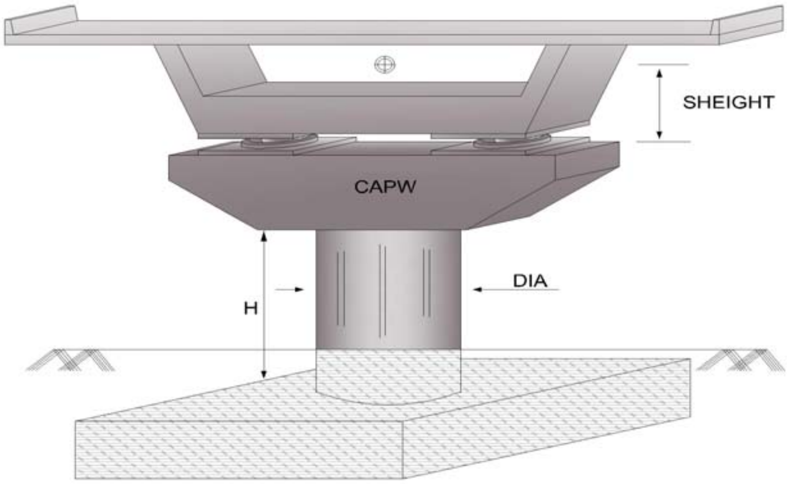
SHB Spacing of spiral (mm). [>=0] If SHB = 0, program uses minimum reinforcement

COV Concrete cover to spiral (mm) [>0]

CAPW Weight of integral cap built into superstructure (kN) [>=0]

MGT Moment in plastic hinge regions caused by gravity loads that is to be added to seismic moment in transverse direction (kN.m) [>=0]

Single column bent

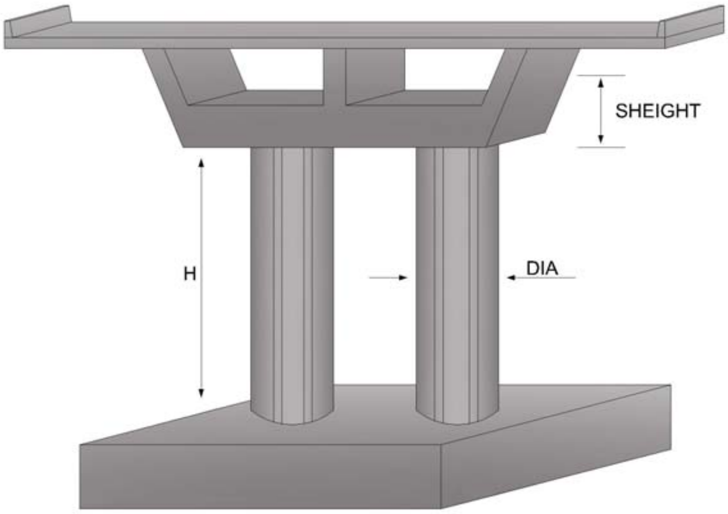


STA	Distance from the left end of the bridge to the element (m) [0-SLENGTH]
DIA	Diameter of the column (m) [>0]
H	Height of the column (m) [>0]
D1 D2	Parameters that control how target displacement is calculated If D1>0 and D2>0 then D1 and D2 are taken as the limit STRAINS for concrete and steel respectively If D1 = -1 then D2 is the target DRIFT value for transverse and longitudinal response (drift is expressed as the ratio of top displacement and height of the column) If D1 = -2 and D2 = 0 then target displacement is found for DAMAGE CONTROL limit state If D1 = -3 and D2 = 0 then target displacement is found for minimal plastic action using the implicit procedure in LRFD-Seismic for SDC “B” If D1 = -4 and D2 = 0 then target displacement is found for moderate plastic action using the implicit procedure in LRFD-Seismic for SDC “C”

If D1 = -5 then target displacement is computed for the displacement ductility limit specified in D2

DBL	Diameter of longitudinal rebars (mm). [>=0] If DBL = 0, program uses minimum reinforcement ratio
DBH	Diameter of spiral (mm). [>=0] If DBH = 0, program uses minimum reinforcement
SHB	Spacing of spiral (mm). [>=0] If SHB = 0, program uses minimum reinforcement
COV	Concrete cover to spiral [>0] (mm)
CAPW	Weigtht of integral cap built into superstructure (kN) [>=0]
MGT	Moment in plastic hinge regions caused by gravity loads that is to be added to seismic moment in transverse direction (kN.m) [>=0]

Multi column integral bent



STA	Distance from the left end of the bridge to the element (m) [0-SLENGTH]
DIA	Diameter of the column (m) [>0]
H	Height of the column (m) [>0]
NCOLS	Number of column is bent [>1]
D1 D2	Parameters that control how target displacement is calculated If D1>0 and D2>0 then D1 and D2 are taken as the limit STRAINS for concrete and steel respectively If D1 = -1 then D2 is the target DRIFT value for transverse and longitudinal response (drift is expressed as the ratio of top displacement and height of the column) If D1 = -2 and D2 = 0 then target displacement is found for DAMAGE CONTROL limit state If D1 = -3 and D2 = 0 then target displacement is found for moderate plastic action using the implicit procedure in LRFD-Seismic for SDC "B" If D1 = -4 and D2 = 0 then target displacement is found for minimal plastic action using the implicit procedure in LRFD-Seismic for SDC "C"

If D1 = -5 then target displacement is computed for the displacement ductility limit specified in D2

DBL Diameter of longitudinal rebars (mm). If DBL = 0, program uses minimum reinforcement ratio [>=0]

DBH Diameter of spiral (mm). If DBH = 0, program uses minimum reinforcement [>=0]

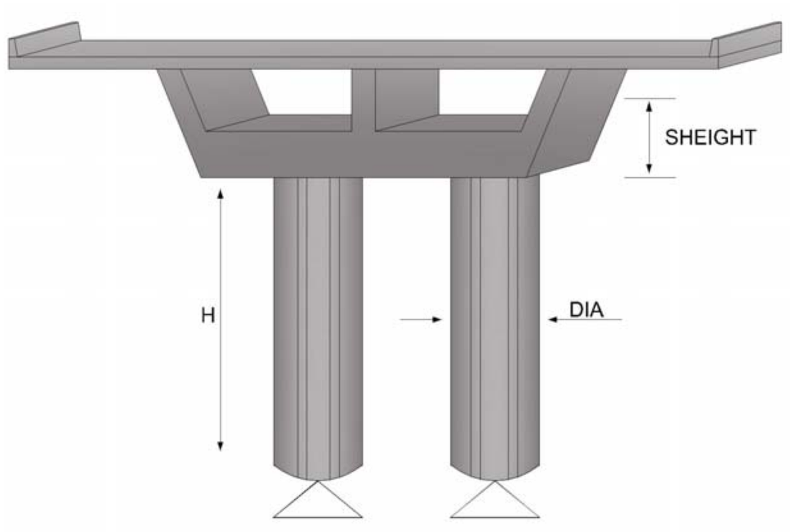
SHB Spacing of spiral (mm). If SHB = 0, program uses minimum reinforcement [>=0]

COV Concrete cover to spiral (mm) [>0]

CAPW Weigtht of integral cap built into superstructure (kN) [>=0]

MGT Moment in plastic hinge regions caused by gravity loads that is to be added to seismic moment in transverse direction (kN.m) [>=0]

Multi column integral bent with pinned base



STA	Distance from the left end of the bridge to the element (m) [0-SLENGTH]
DIA	Diameter of the column (m) [>0]
H	Height of the column (m) [>0]
NCOLS	Number of column is bent [>1]
D1 D2	Parameters that control how target displacement is calculated If D1>0 and D2>0 then D1 and D2 are taken as the limit STRAINS for concrete and steel respectively If D1 = -1 then D2 is the target DRIFT value for transverse and longitudinal response (drift is expressed as the ratio of top displacement and height of the column) If D1 = -2 and D2 = 0 then target displacement is found for DAMAGE CONTROL limit state If D1 = -3 and D2 = 0 then target displacement is found for moderate plastic action using the implicit procedure in LRFD-Seismic for SDC “B” If D1 = -4 and D2 = 0 then target displacement is found for minimal plastic action using the implicit procedure in LRFD-Seismic for SDC “C”

If D1 = -5 then target displacement is computed for the displacement ductility limit specified in D2

DBL Diameter of longitudinal rebars (mm). If DBL = 0, program uses minimum reinforcement ratio [>=0]

DBH Diameter of spiral (mm). If DBH = 0, program uses minimum reinforcement [>=0]

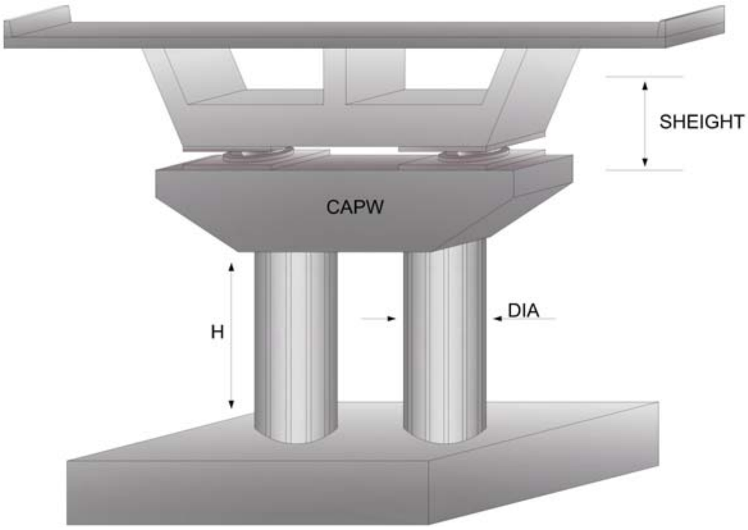
SHB Spacing of spiral (mm). If SHB = 0, program uses minimum reinforcement [>=0]

COV Concrete cover to spiral (mm) [>0]

CAPW Weigtht of integral cap built into superstructure (kN) [>=0]

MGT Moment in plastic hinge regions caused by gravity loads that is to be added to seismic moment in transverse direction (kN.m) [>=0]

Multi column bent



STA	Distance from the left end of the bridge to the element (m) [0-SLENGTH]
DIA	Diameter of the column (m) [>0]
H	Height of the column (m) [>0]
NCOLS	Number of column is bent [>1]
D1 D2	Parameters that control how target displacement is calculated If D1>0 and D2>0 then D1 and D2 are taken as the limit STRAINS for concrete and steel respectively If D1 = -1 then D2 is the target DRIFT value for transverse and longitudinal response (drift is expressed as the ratio of top displacement and height of the column) If D1 = -2 and D2 = 0 then target displacement is found for DAMAGE CONTROL limit state If D1 = -3 and D2 = 0 then target displacement is found for moderate plastic action using the implicit procedure in LRFD-Seismic for SDC "B" If D1 = -4 and D2 = 0 then target displacement is found for minimal plastic action using the implicit procedure in LRFD-Seismic for SDC "C"

	If D1 = -5 then target displacement is computed for the displacement ductility limit specified in D2
DBL	Diameter of longitudinal rebars (mm). If DBL = 0, program uses minimum reinforcement ratio [>=0]
DBH	Diameter of spiral (mm). If DBH = 0, program uses minimum reinforcement [>=0]
SHB	Spacing of spiral (mm). If SHB = 0, program uses minimum reinforcement [>=0]
COV	Concrete cover to spiral (mm) [>0]
CAPW	Weigtht of integral cap built into superstructure (kN) [>=0]
SKEW	Skew angle [0-90]
HCBEAM	Height of the cap-beam [>0]
MGT	Moment in plastic hinge regions caused by gravity loads that is to be added to seismic moment in transverse direction (kN.m) [>=0]

General Pier

STA Distance from the left end of the bridge to the element (m) [0-SLENGTH]

DYT Yield displacement in transverse direction (m) [>0]

DYL Yield displacement in longitudinal direction (m) [>0]

DTT Displacement capacity in the transverse direction (m) [>0]

DTL Displacement capacity in the longitudinal direction (m) [>0]

B Parameter that defines the equivalent damping, ξ, as a function of the ductility demand, μ, for the element. If B >0, B is used in the equation below to compute ξ. If B = 0 or omitted then B is taken as 60 as for an elasto-plastic system. If B < 0, the absolute value of B is taken as constant damping for the abutment.

$$\xi = 5 + B\frac{\mu - 1}{\pi\mu}$$

AWEIGHT Effective weight of the pier [>=0]

Expansion Joint

STA Distance from the left end of the bridge to the element (m) [0-SLENGTH]

GAP Longitudinal gap provided at the expansion joint (m) **[>=0]**