DMJM HARRIS
999 TOWN & COUNTRY ROAD
ORANGE, CALIFORNIA 92668

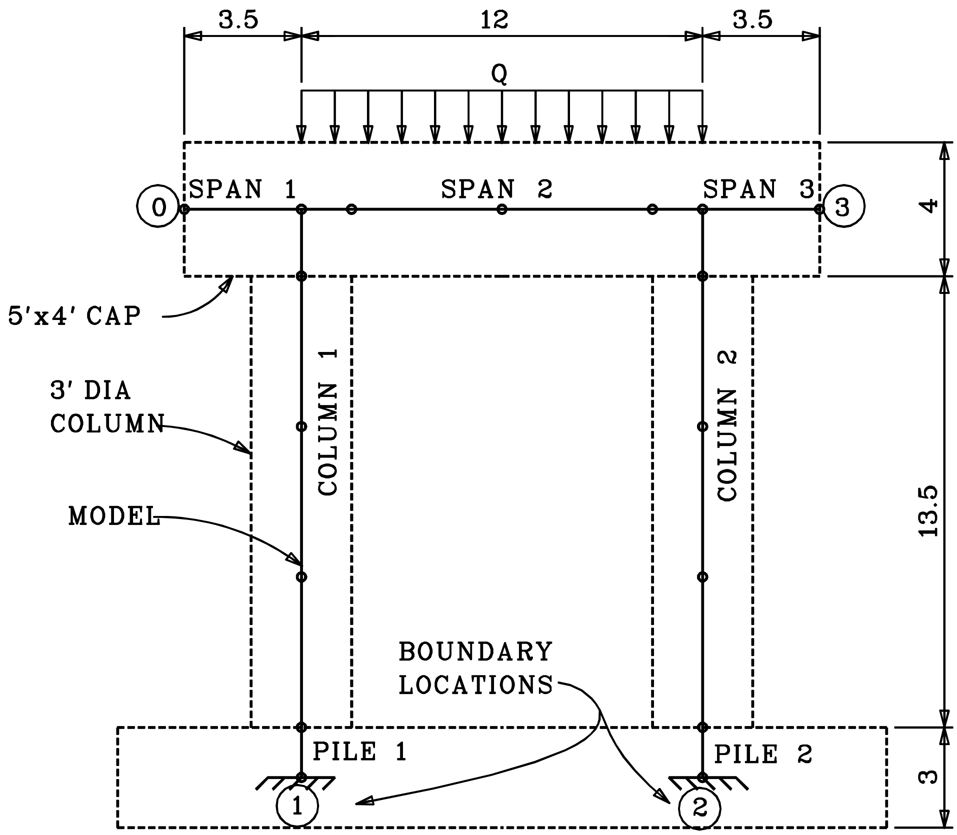
DESCRIPTION

Nonlinear static (pushover) analysis will be performed on a railroad bridge bent using wFRAME to determine its ultimate lateral deflection capability.

Moment hinges are based on Caltrans material properties.

ANALYSIS MODEL

The analysis model configuration is shown below.

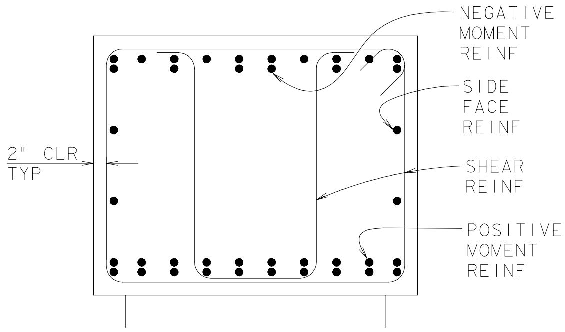


BENT MODEL

Superstructure load, w = 653 / 12 = 54.42 k/ft

MEMBER PROPERTIES

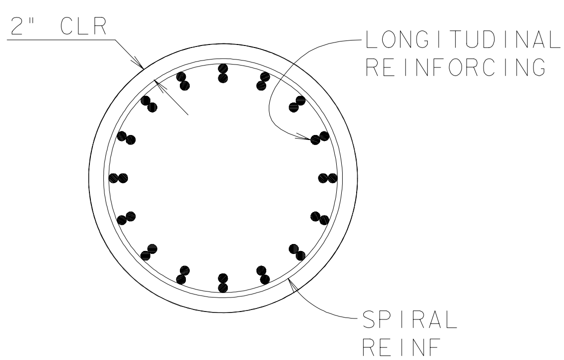
- CAP



BENT CAP SECTION

width = 5 ft.
height = 4 ft.
Area = 4 x 5 = 20 ft^2
I_g = 5(4)^3 / 12 = 26.67 ft^4
Use I_e = 0.75 x 26.67 = 20 ft^4
Use 10 x I_e at joint area

- COLUMN



COLUMN SECTION

diameter = 3 ft.
radius = 13.875" to centerline longitudinal reinforcement
Area = 3.1416 x (1.5)2 = 7.07 ft^2
I_g = 3.1416 x (1.5)^4 / 4 = 3.976 ft^4
Use I_e = 0.5 x 3.976 = 1.988 ft^4
Use 10 x I_e at joint area

wFRAME ANALYSIS

- Procedure:

A. Approximate final axial load in columns

B. Perform moment-curvature analysis using material properties from Caltrans Seismic Design Criteria section 3.2. This analysis will determine the plastic moment of the column hinges.

C. Define wFPREP input per users manual

HEADER MUST FOLLOW EXACT FORMAT PROVIDED BY CALTRANS FOR PROGRAM TO WORK.

```
wFPREP
VER._1.13,_MAY-06-95
LICENSE    (choices: LIMITED/UNLIMITED)
LIMITED
ENTITY     (choices: GOVERNMENT/CONSULTANT)
CONSULTANT
NAME_OF_FIRM
HOLMES&NARVER
BRIDGE_NAME
RIVERSIDE_AVE_OC
BRIDGE_NUMBER
54-0623
JOB_TITLE
TWO COLUMN BENT ANALYSIS

******************************************************************
All units in kips and feet
******************************************************************

            ***  Analysis Control Block Info ***

The following block of information is for analysis control.
Number of spans and number of link beams are specified.
Direction of push is specified (push to left is not checked yet).
2nd deck out-of-phase push is not checked yet.
******************************************************************
ANALYSIS_CONTROL
    NUMBER_OF_SPANS     3
    NUMBER_OF_LINK_BEAMS    0
    DIRECTION_OF_PUSH       right
    2ND_DECK_OUT_OF_PHASE   no
******************************************************************
```

CHECKED____________ DATE____________

APPROVED____________ DATE____________

TITLE **PUSHOVER ANALYSIS EXAMPLE**

DMJM HARRIS

999 TOWN & COUNTRY ROAD
ORANGE, CALIFORNIA 92668

JOB NO.____________

SHEET____________ OF____________

BY R. MATTHEWS DATE 5/21/01

```
          ***  Structural Data Block Info ***

The follwing block of information is for definition of spans, columns
and piles.  A span/column/pile code and number (example S01) is specified;
followed by total number of elements in span/col/pile; followed by number
of different types of segments over which all elements are defined. The logic
of this version is such that info for S01, C01, P01, S02, C02 P02, etc...
is expected in the specified order. If a column is connected to a pile cap
and a pile group and the user does not wish to model the pile group, then
the portion of the column below ground (usually 2') must be modeled as a pile
and the tip of the 2' pile should be modeled as fixed in X and Y translation
and fixed, partially released (spring), or completely released for moment
for a column to footing connection of pin nature.

For each segment input the following:
Number of elements per segment;
Fixity code (rn= no release, rs=release start, re=release end);
Length of each element (L);
Depth of element in direction of bending (not used in this version);
Area of cross section;
Modulus of elasticity (Ei);
Softened modulus (Ef, not used in this version);
Cracked moment of inertia(Icr);
Uniform dead load q (negative for superstructure elements, zero otherwise);
Positive plastic moment capacity (Mpp);
Negative plastic moment capacity (Mpn);
Tolerance for elasto-plastic transition (.02 recommended);
Element status = e for elastic, i for inactive.
```

MODEL GEOMETRY AND HINGE PROPERTIES

```
#   F   L    D      A      Ei     Ef     I     q      Mp    Mn      T  status
*******************************************************************
STRUCTURAL_DATA
S01   1  1
1  rn   3.5  4.0    20.0   518400 518400 20.00  -3.0   5000.  5000.  0.02 e

C01   4  2
```

NUMBER OF SECTIONS

NUMBER OF ELEMENTS

```
1  rn   2.00 3.0    7.07   518400 518400 19.88  0.     22950. 22950. 0.02 e
3  rn   4.50 3.0    7.07   518400 518400 1.988  0.     2295.  2295.  0.02 e
```

NUMBER OF ELEMENTS IN 2nd SECTION

```
P01   1  1
1  rn   1.50 3.0    7.07   518400 518400 19.88  0.     22950. 22950. 0.02 e
S02   4  3
1  rn   1.5  4.0    20.0   518400 518400 200.0  -57.42 50000. 50000. 0.02 e
2  rn   4.5  4.0    20.0   518400 518400 20.00  -57.42 5000.  5000.  0.02 e
1  rn   1.5  4.0    20.0   518400 518400 200.0  -57.42 50000. 50000. 0.02 e
C02   4  2
1  rn   2.00 3.0    7.07   518400 518400 19.88  0.     27750. 27750. 0.02 e
3  rn   4.50 3.0    7.07   518400 518400 1.988  0.     2775.  2775.  0.02 e
P02   1  1
1  rn   1.50 3.0    7.07   518400 518400 19.88  0.     27750. 27750. 0.02 e
S03   1   1
1  rn   3.5  4.0    20.0   518400 518400 20.00  -3.0   5000.  5000.  0.02 e
*******************************************************************
```

....unused wFRAME input blocks not shown....

***** Boundary node Block Info for spring application *****

This section contains the boundary information where additional springs may be attached to the extreme boundaries of the structure. The locations are at the pile tips and at the abutments.

The boundary locations are identified according to the structural definition listed earlier in the input file. The following possibilities exist:

For transverse analysis of say a 2 column bent (pin at base of columns) on pile group the following assumptions may be made if the user does not wish to model the piles explicitly. The pile group at each footing location may be modeled as providing fixity or spring action in horizontal direction (the user must estimate the spring value, otherwise fixity must be used). Therefore, boundary locations 0 and 3 are the overhangs and they must be released in all components (rx, ry, rz). The locations 1 and 2 will be modeld at column to footing connection as fx, fy, rz. In general for the transverse analysis of bents with "n" columns, locationns 1 and n+1 indicate the ends of cap beam and it usually is free (rx, ry, rz).

For the transverse analysis of the above bent the user may decide to model the entire pile groups at the two foundations. The piles must be numbered as seen on the elevation view of the bent. This example will be presented later due to the complexity of the situation.

For the longitudinal analysis of a 2 span bridge one may input two ficticious column/pile combinations at the abutments with proper releases to model the roller action of the seat abutment support. In this case release the top of the ficticious column for moment (rs in the element) and model the bottom with fx, fy, rz. This column will not carry a shear in the longitudinal push and it will only carry the dead load at the abutment. Attach a spring at the right abutment to model the passive resistance of the soil (sx plus a new line with k1, del1, k2, del2).

**For Location: enter 0 for left end of frame, 1 to xx for tips of piles,
and the last location is for right end of frame.
After boundary location number enter the following info on the next line:
Fixity code for each X, Y and Z directions on consecutive lines:
(rx=release x dir., fx=fix x dir., sx=spring code in x dir. etc.).
If a spring is defined, the next line must be included for the spring
with the following info.:
Number of segments, stiffness and displacements
at breakpoints of the multi-linear curve ((ki,deli) for i=1, 2...)
(Input only 2 segments for this version with the plateaue segment
generated by computer as the third segment).
End bearing at tip of compression piles may be modeled with these springs.**

Data Specific to this bridge:

```
******************************************************************
BOUNDARIES
LOCATION    FIXITY_CODE   NO._OF_SEGMENTS      k1       del1     k2     del2
    0
                rx
                ry      RELEASE Y-DIR
                rz
    1
                fx
                fy
                fz      FIX X-DIR
    2
                fx
                fy
                fz
    3                                                   BOUNDARY CONDITIONS
                rx
                ry
                rz
******************************************************************
```

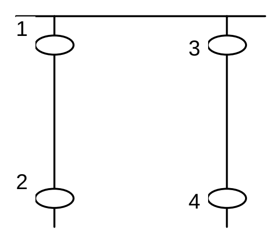
D. Run wFPREP from DOS reboot to get wFRAME input

E. Run wFRAME

- wFRAME results:

File = bentpo

STAGE	DEFLECTION	HINGE
1	0.96"	2
2	1.08"	1
3	1.11"	4
4	1.19"	3



Maximum deflection = 1.11 / 12 + 0.0399 x 13.5 = 0.63 ft.

Therefore the wFRAME results match the SAP2000 results.