MANNUAL AND SOFTWARE BASED NON LINEAR ANALYSIS OF RCC PORTAL FRAME

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Abstract

In recent days there is a lot of light thrown on behavior of structure post elastic limits and to understand the maximum permissible limits the structural members could be subjected before the structure reaches the limit where in it shall not be capable to with stand any more load and any repair or rehabilitation of structure stall not induce any structural strength.

This report deals with Nonlinear Pushover analysis of rcc frame. A single bay portal frame of 6m length beam and 4m long column is subjected to manual analysis by slope deflection and kani's method and is verified with software output values and the structural members are designed in accordance with Indian standard code in limit state method and its plastic moment values are validated.

Keywords: *Portal frame, pushover analysis, Nonlinear static analysis, Manual validation, hinges, kanis method, concrete design*

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1. INTRODUCTION

Nonlinear static method/ pushover method of analysis is used to structures with single degree of freedom. An structure is pushed till it fails And observations are made and studied as to the Cause of failure, Weather the structure can be repaired or rehabilitated., Point of failure, Plastic behaviour etc.,

Pushover analysis is a static non straight examination used to decide the power uprooting connection that is limit bend for a structure or component. The technique includes applying a flat drive or load in additions that is pushing the structure and plotting shear power and horizontal relocation until point of confinement state or fall condition is come to.

2. LOADS

Applied live load is 40 kN/m.

3. VALIDATION (Kani's Method)

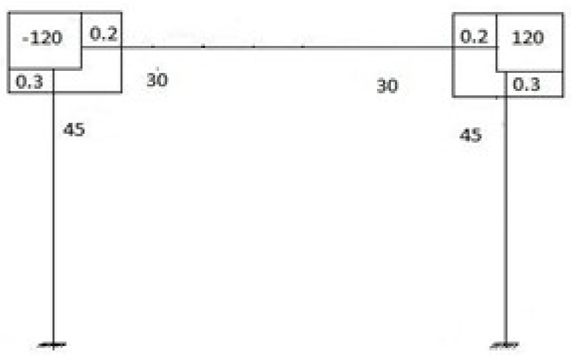

Fig 1 Portal frame for moment calculation by kanis method

Bending moment values:-
MAB= 45 kNm
MBA= 90 kNm
MBC= -90 kNm
MCB= 90 kNm
MCD= -90 kNm
MDC= -45 kNm
At Mid span= wl^2/8= 180 kNm
B.M at mid span= 90 kNm
Calculation of axial force:-
W*l/2= 120 kN.

4. DESIGN

4.1 Beam Design

Material
fy = 500 N/mm2
fck = 30 N/mm2
Section Cover = 25 mm
Width = 400 mm
Depth = 400 mm
d = 367 mm

Bending Moment
Mu = 90 kN-m
Mu,lim = 214.96 kN-m
Mu/bd2 = 1.67 N/mm2
Mu,lim/bd2 = 3.99 N/mm2
pt,lim = 1.13 %
d'/d = 0.10
fcc = 13.38 N/mm2
fsc = 412 N/mm2

To find area of steel required
pt,(reqd.) = 0.413 %

TENSION REINFORCEMENT
Ast,(reqd.) = 605.68 mm2
Provide Y25 2 Nos
pt,(reqd.) = 0.67 %
Ast,(prov.) = 982 mm2

Shear reinforcement
Shear Force Vu = 120 kN
Shear stress = 0.82 N/mm2
BEAM SECTION IS OK
for
pt = 0.669 %
β= 3.483
Design shear strength = ζc = 0.66 N/mm2
Shear capacity of concrete = 104.93 kN
Shear carried by stirrups = Vus= 15.07 kN
Spacing of 2L stirrups
Provide 2L-Y8@ 300mm c/c

On Reverse Calcululation

MU= 0.87 fy *Ast*d(1-(fy*Ast/Fck*b*d)
Mu= 153.38962 kNm
Mp= Mu*1.5= 230 kNm.

4.2 Column Design

Pu = 120 kN
Mux = 90 kN-m
Muy = 0 kN-m
fck = 30 N/mm2
fy = 500 N/mm2
Length of column = 4 mm
b = 600 mm Dia of bar 32
D = 600 mm used
lex/b = 0.01 <12 SHORT COLUMN
ley/D = 0.01 <12 SHORT COLUMN

Assuming 1% steel with reinforcement distributed equally on four sides
Ag = 360000 mm2
p = 1%
Puz = 6210000 kN
Puz = 6210 kN

Moment due to Slenderness
Calculation of Pb
Pb(about x-x axis) = d'/b = 0.08
Pb(about y-y axis) = d'/D = 0.08

Now,
Max = 0.00 kN-m
May = 0.00 kN-m

Moments due to minimum eccentricity
ex = 0.05b = 30 mm
ex = 20.01 mm CONSIDER ECCENTRICITY MOMENT
ey = 0.05D = 30 mm
ey = 20.008 CONSIDER ECCENTRICITY MOMENT
Mux = 2.40 kN-m
Muy = 2.40 kN-m

Total moments for which the column is to be designed
Mux = 90.00 kN-m
Muy = 2.40 kN-m

The section is to be checked for biaxial bending Pu/fck.b.D = 0.05
p/fck = 0.033333333

Mux/fck.b2.D = 0.05 from chart SP 16 for d'/b = 0.05
Mux1 = 291600000 N-mm
Mux1 = 291.6 kN-m
Muy/fck.b.D2 = 0.05 from chart SP 16 for d'/D = 0.05
Muy1 = 291600000 N-mm
Muy1 = 291.6 kN-m
Mux/Mux1 = 0.31
Muy/Muy1 = 0.01
Pu/Puz = 0.02
ifPu/Puz< 0.2 1
ifPu/Puz> 0.8 2

forPu/Puz between 0.2 & 0.8 0.70
Otherwise 0.70

hence 1.00

Check for safety under biaxial loading
0.32 OK
p = 1.00 > 0.8
Steel required = 3600 mm2
Provide Y32 5 Nos

On Reverse Calcululation

On reverse calculation this design can with stand a moment of 250 kNm

Therefore plastic moment formation takes place at 1.5 *250= 375 kNm

Software generated bending moments

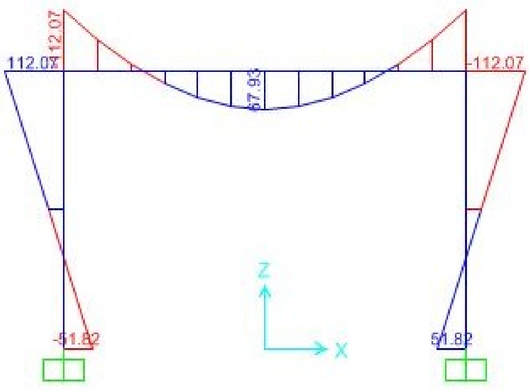

Fig 2. Moment values form software.

Maximum allowable B.M at end= wl^2/12 = 40*6^2/12= 120 kN/m

Maximum allowable B.M At Mid span= wl^2/8= 180 kN/m (with ends simply supported)

B.M at mid span= 112.07-180= 67.93 kN/m (After distribution)

5. CAPACITY SPECTRUM

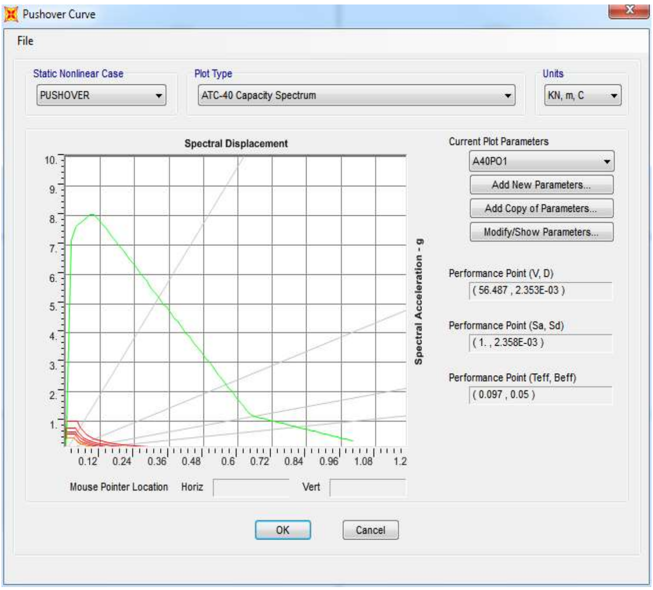

Fig 3.Hinges at performance point

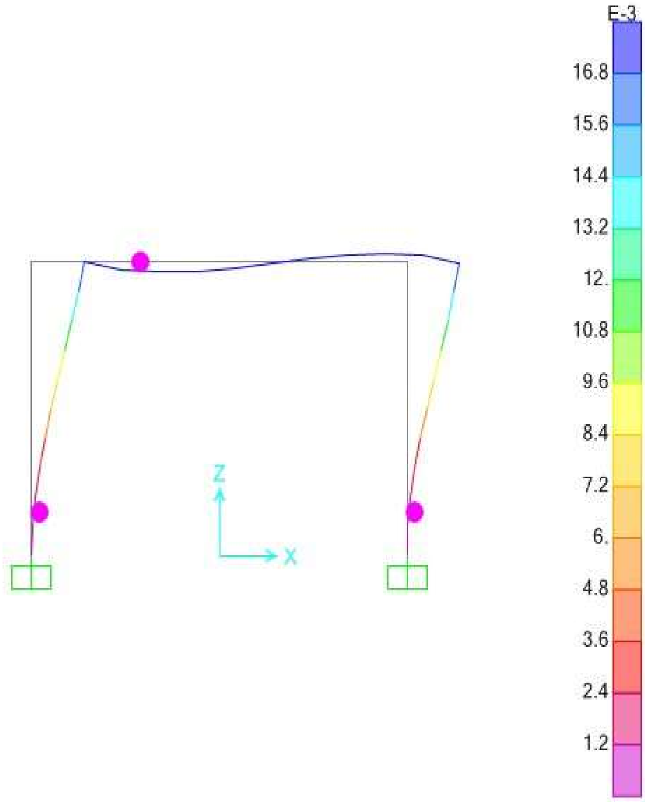

Fig 4.Hinges at performance point

Table 1 Pushover moments of column 1

Column 1		
steps	pushover moment-kNm	
1	357.82	kNm
2	364.68	kNm
3	369.71	kNm
4	373.43	kNm
5	378.45	kNm
6	382.19	kNm
7	387.19	kNm
8	382.27	kNm
9	373.4	kNm
10	366.47	kNm
11	359.55	kNm
12	352.62	kNm

Table 2 Pushover moments of column 2

Column 2		
steps	pushover moment-kNm	
1	378.95	kNm
2	388.81	kNm
3	394.01	kNm
4	398.08	kNm
5	403.26	kNm
6	407.35	kNm
7	412.53	kNm
8	407.19	kNm
9	397.69	kNm
10	390.26	kNm
11	382.86	kNm
12	375.4	kNm

Table 3 Pushover moments of Beam

Beam		
steps	pushover moment-kNm	
1	166.9	kNm
2	207.6	kNm
3	209.77	kNm
4	211.94	kNm
5	214.08	kNm
6	216.25	kNm
7	218.4	kNm
8	221.2	kNm
9	224	kNm
10	226	kNm
11	223.7	kNm
12	221.5	kNm
13	219.2	kNm
14	216.9	kNm
15	214.7	kNm

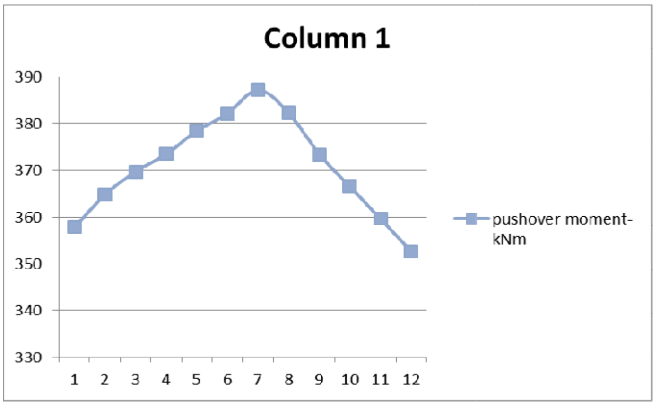

Chart 1. Column 1 pushover moment vs steps.

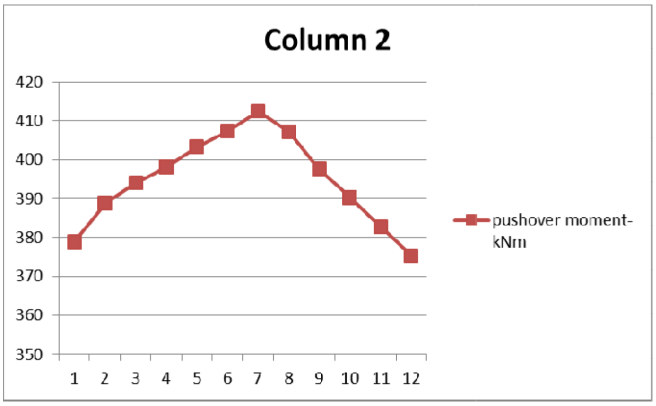

Chart 2. Column 2 pushover moment vs steps.

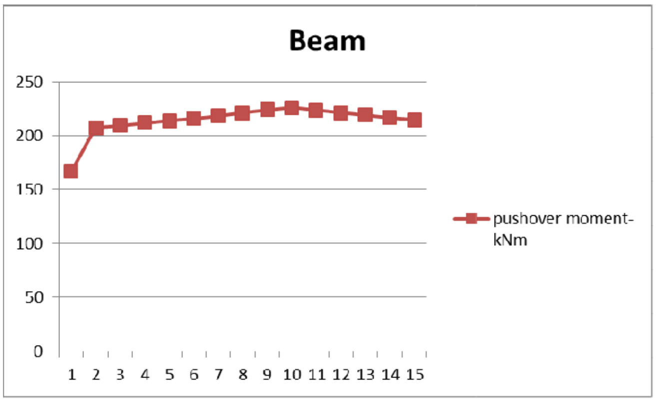

Chart 3. Beam pushover moment vs step.

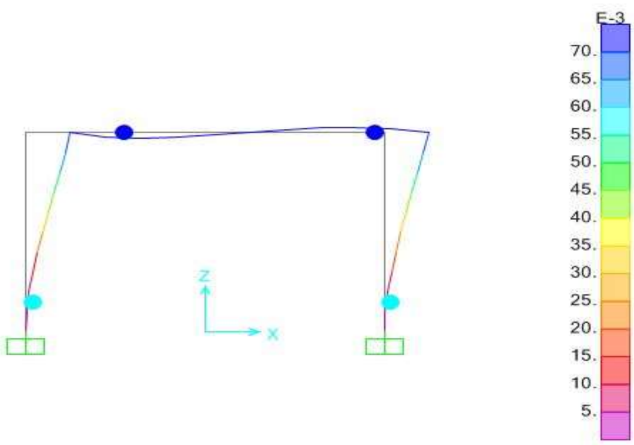

Fig 5. Hinges at Life safety

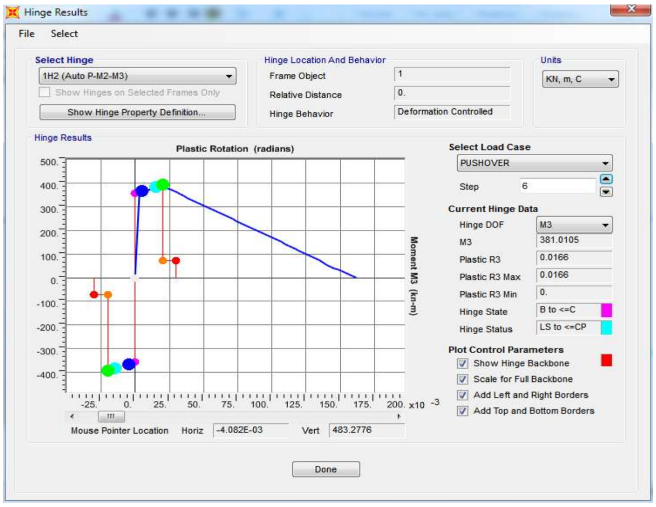

Fig 6. Hinges For column 1,having maximum moment value 381.015kNm.

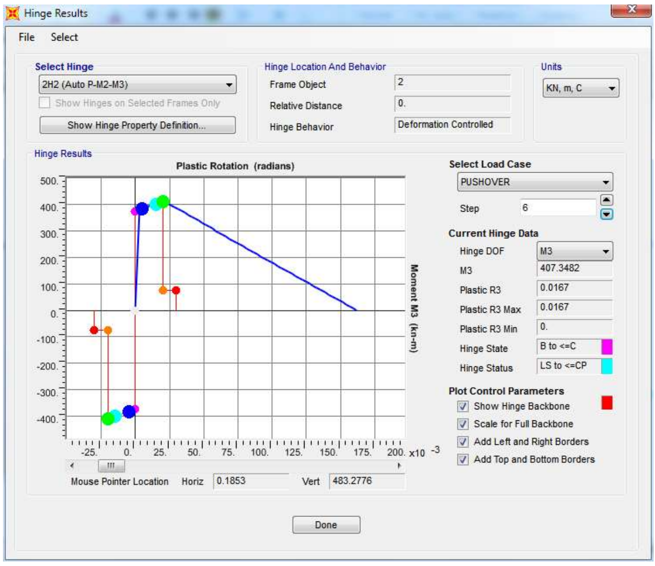

Fig 7. Hinges For column 2, having maximum moment value 407.34kNm

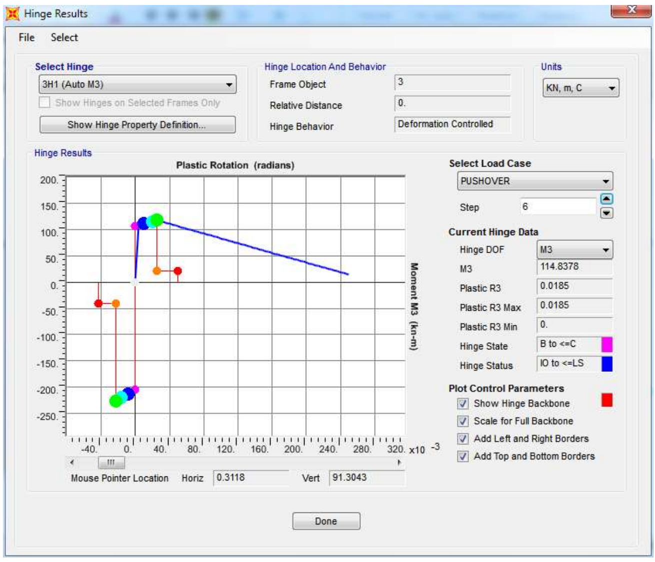

Fig 8. Hinges For Beam @0m, having maximum moment value 114.837kNm

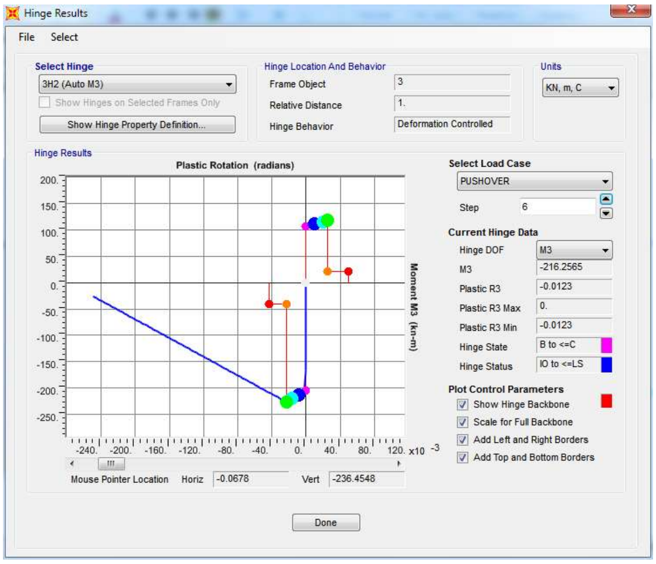

Fig 9. Hinges ForBeam @0m, having maximum moment value 216.25kNm.

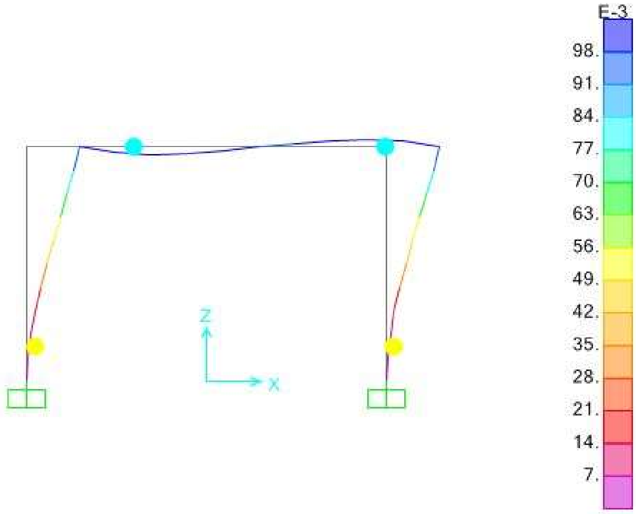

Fig 10. Hinges at Collapse prevention

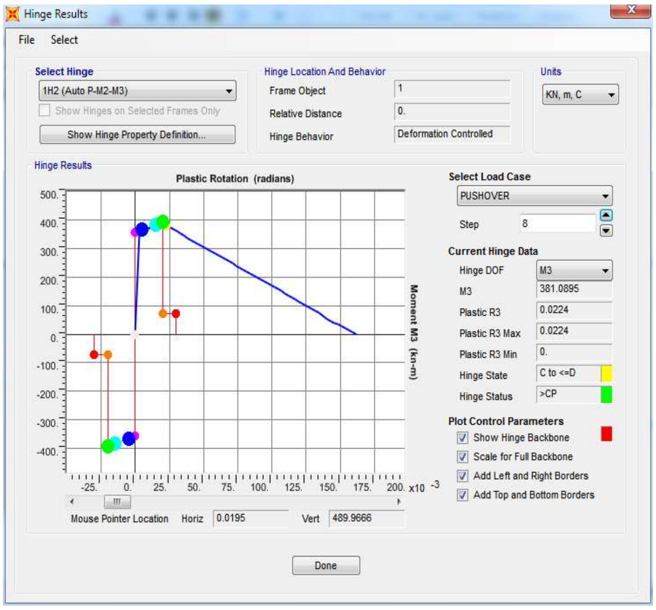

Fig 11. Hinges For column 1,having maximum moment value 381.0895kNm.

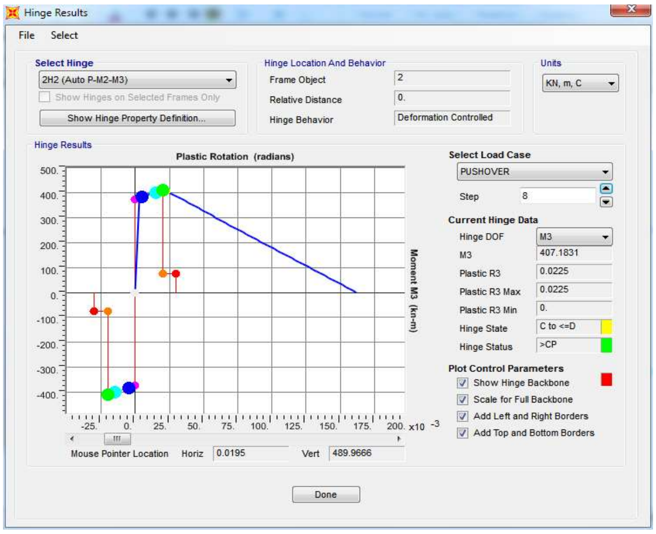

Fig 12. Hinges For column 2, having maximum moment value 407.183Nm.

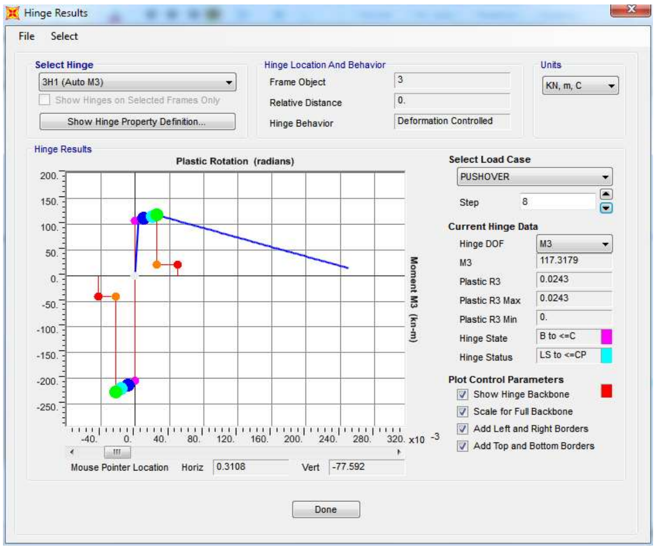

Fig 13. Hinges ForBeam @ 0m, having maximum moment value 117.31kNm.

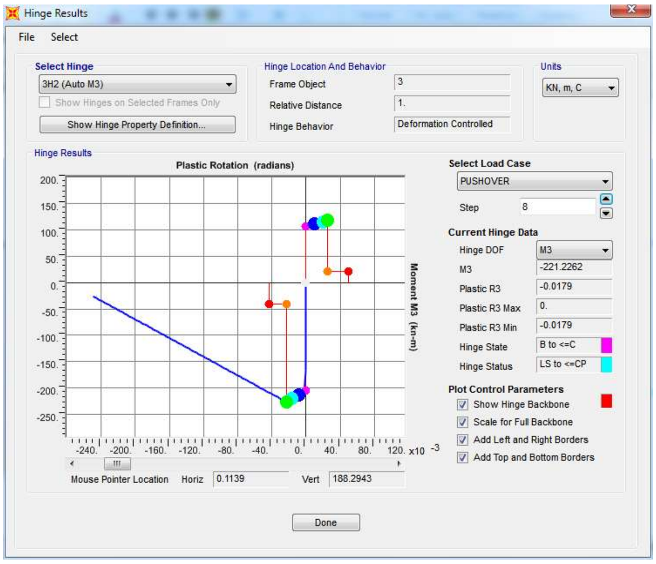

Fig14. Hinges for Beam@8m, having maximum moment value 221.23kNm.

6. SCOPE FOR FUTURE STUDY

Some of the recommendations for future study are listed below:

- Iterative analysis on calculation of lateral load for pushover analysis.
- Pushover analysis on steel frames.
- Varying column and Beam dimensions..
- 3D model analysis.

7. CONCLUSION

- Moment values calculated manually are similar to software moment output values.
- Plastic moment is 1.5 times ultimate moment or design moment value.
- There is a small amount of deviation from expected manual plastic moment values because in software we shall predefine certain parameters like number of bar, minimum bar diameter and above that software is programed for Optimum design
- Capacity spectrum doesn't give accurate results.

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