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Elastic-Plastic Analysis of Plane Portal Frame by STAAD.

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Abstract-*Construction Company is growing as it has never been before; there is always something under new construction. It is seen that there is growing trend and need too of portal frame structure and thus is very much important to use new technology and methods to analyze the structure for better shear analysis.*

This Project includes comparative study of R.C.C with plane portal frame which includes storey stiffness, displacement, drifts, axial force in column, shear force, twisting moment, and bending moments in composite with respect to R.C.C. Sections. Reinforced section can provide an effective and economic solution to most of these problems in medium to plane portal frame. STAAD Pro is a computer program with graphic interface which provides basic concepts for Portal Frame structure calculations and procedures. The graphic interface is expected to help architecture students to understand the design process. The analysis consists of four basic members slab, beam, column and footing per Indian standard codes. Structural modeling tool helps to establish three mathematical models including; a structural model consisting of three basic components: structural members or components, joints (nodes, connecting edges or surfaces), and boundary conditions (supports and foundations); a material model; and a load model. Depending upon the tabulated results and graphs that is obtained during testing of the Plane Portal Frame the evaluation of conclusion is done.

***Key Words*:- Stress, Stiffness, Drifts, Moments and STAAD PRO**

1. INTRODUCTION

Portal frames are the most commonly used for low rise industrial structures. Portal frames can be defined as two-dimensional rigid frames that have the basic characteristics of a rigid joint between column and beam. They are comprised of columns and horizontal or pitched rafters, connected by moment resisting connection. These frames are composed of tapered stanchions and rafters. They are constructed mainly using hot-rolled sections, supporting the roofing and side cladding via cold-formed purling and sheeting rails. Portal frames of lattice members made of angles or tubes are common, especially in the case of longer spans. They are very good for enclosing large volumes and so they are generally used for industrial and commercial purposes.

Portal frame construction is a method of building and designing structures, primarily using steel or steel-reinforced precast concrete although they can also be constructed using laminated timber such as Glulam. The connections between the columns and there afters are designed to be moment-resistant, i.e. they can carry bending forces. "They were first developed in the 1960s, and have now become the most common form of enclosure for spans of 20 to 60 m"

So basically, portal frames are set of normal beam and column only with additional bending strength. Because of the very strong and rigid joints, some of the bending moment in the rafters is transferred to the columns. This means that the size of the rafters can be reduced or the span can be increased for the same size rafters. This makes portal frames a very efficient construction technique to use for wide span buildings.

Portal frame construction is therefore typically seen in warehouses, barns and other places where large, open spaces are required at low cost and a pitched roof is acceptable

1.1 Origin of portal frames

They were first developed in the 1960s, and have now become the most common form of enclosure for spans of 20 to 60 m". Because of these very strong and rigid joints, some of the bending moment in the rafters is transferred to the columns. This means that the size of the rafters can be reduced or the span can be increased for the same size rafters. This makes portal frames a very efficient construction technique to use for wide span buildings.

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Portal frames can be defined as two-dimensional rigid frames that have the basic characteristics of a rigid joint between column and beam. The main objective of this form of design is to reduce bending moment in the beam, which allows the frame to act as one structural unit.

1.2 Types of Portal Frames

i. Simple or Plane Portal Frame.
ii. Pitched Portal Frame.
iii. Hunched Frame.
iv. Gable Frame.

v. Glulam Frame.
vi. Braced Portal Frame.
vii. Mezzanine Floor Portal Frame
viii. Propped Portal Frame

1.3 Elastic-Plastic Section

It is the zone where some of the fibers from the outermost edge are in plastic zone i.e. stressed to yield stress and some of the interior fibbers are in elastic zone i.e. doesn't exceeds the yield stress.

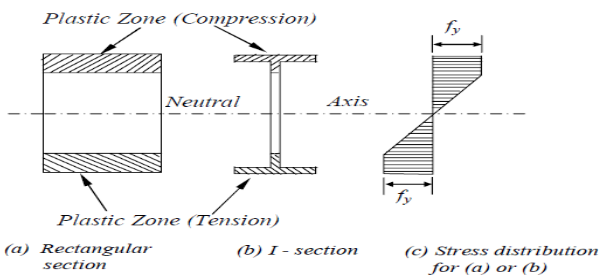

Figure -1: Elastic-Plastic Section

1.4 Plastic Section

Further increase of moment will result in further spread of yield in the interior fibers. Finally a stage is reached when all the fibers are stressed to yield stress & the section is fully plasticized. In this the N.A is known as Equal Area Axis.

A=Total area of stress diagram

A_1= Area of compression zone

A_2= Area of tension zone

The moment corresponding to this stage is called fully plastic moment or Ultimate plastic moment of the section or simply the plastic moment of the section denoted by M_p or M_{ult}.

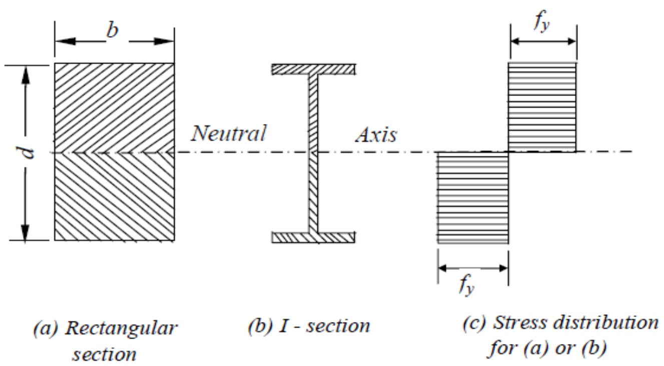

Figure -2: Plastic Section & its Yield Stress Distribution

Fully plastic moment or Ultimate plastic moment- It is defined as "The maximum moment of the resistances of a fully plastic section or yield cross-section in that all the fiber of the cross-section are stress to the yield stress".

2. MATERIAL USED AND EXPERIMENTAL WORK

1. Column Member section = ISHB250
2. Beam Member section = ISMB200
3. Material = STEEL
4. Code = IS: 800 -2000
5. Loads =
   a. Self Weight = Factor -1
   b. Live load = -3 KN/m
   c. Wind load ward along X-axis = 60 Km/Hr wind
   d. Combination = DL+LL+WL
6. Support = Fixed type.
7. Bays in X direction = 1
8. Bays in Z direction = 4
9. Length in X direction = 6 m
10. Length in Y direction = 3.5 m
11. Length in Z direction = 4 m

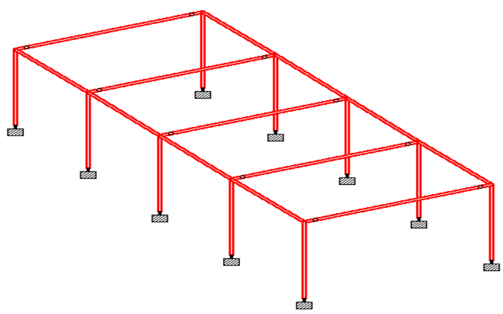

Figure -3: Portal Frame Plotted in software.

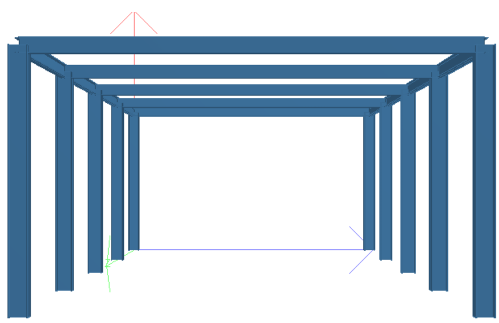

Figure -4: Portal Frame with assigned section in 3D

3. RESULTS ANALYSIS

Table -1: Portal Frame beam end forces summary

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max F_x	4	3 COMBINATION LOAD CASE 3	4	10.538	1.741	-0.003	0.000	0.004	6.094
Min F_x	14	3 COMBINATION LOAD CASE 3	11	-0.019	0.122	-0.000	-0.000	0.001	0.088
Max F_y	9	3 COMBINATION LOAD CASE 3	9	0.838	9.795	0.015	-0.000	-0.044	0.000
Min F_y	9	3 COMBINATION LOAD CASE 3	10	0.838	-9.795	0.015	-0.000	0.044	-0.000
Max F_z	22	3 COMBINATION LOAD CASE 3	16	0.028	0.134	0.022	0.000	-0.044	0.096
Min F_z	10	3 COMBINATION LOAD CASE 3	10	0.028	0.102	-0.022	-0.000	0.044	0.032
Max M_x	22	3 COMBINATION LOAD CASE 3	16	0.028	0.134	0.022	0.000	-0.044	0.096
Min M_x	10	3 COMBINATION LOAD CASE 3	10	0.028	0.102	-0.022	-0.000	0.044	0.032
Max M_y	16	3 COMBINATION LOAD CASE 3	12	1.675	-9.795	0.015	-0.000	0.045	-0.000
Min M_y	18	3 COMBINATION LOAD CASE 3	16	1.675	-9.795	-0.015	0.000	-0.045	-0.000
Max M_z	3	3 COMBINATION LOAD CASE 3	3	10.538	1.742	-0.003	0.000	0.004	6.099
Min M_z	2	3 COMBINATION LOAD CASE 3	10	9.897	0.873	0.014	0.000	0.032	-0.000

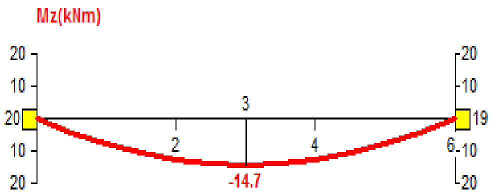

Figure -5: Portal Frame showing selected beam

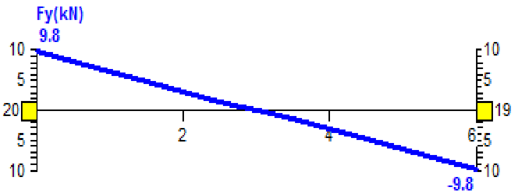

Figure -6: Bending Moment in Portal Frame beam

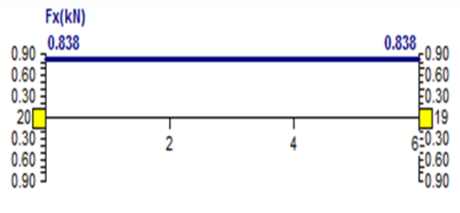

Figure -7: Shear Force in X- axis in Portal Frame

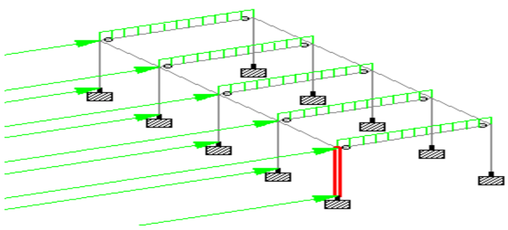

Figure -8: Portal Frame showing selected column

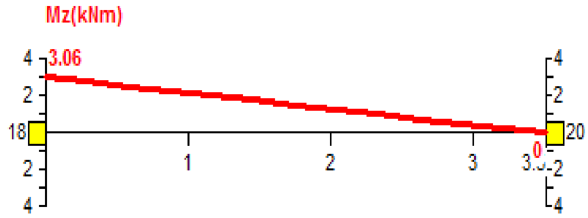

Figure -9: Bending Moment in Portal Frame column

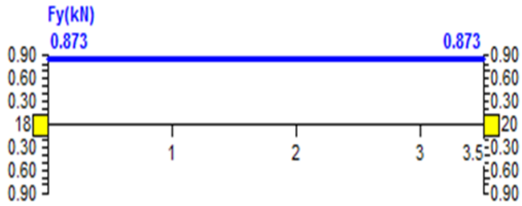

Figure -10: Shear Force in Y- axis in Portal Frame

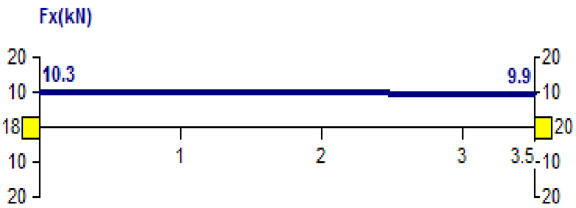

Figure -11: Shear Force in X- axis in Portal Frame

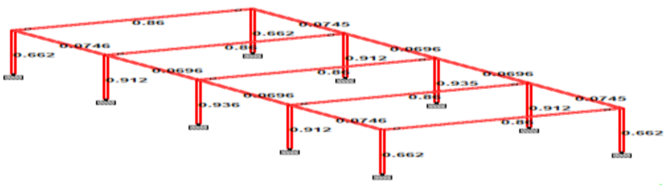

Figure -12: Utility check ratio of Portal Frame

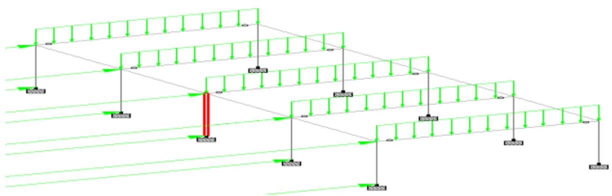

Figure -13: Portal Frame showing selected column at mid span

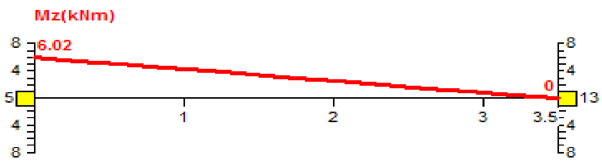

Figure -14: Bending Moment in Portal Frame column at mid span.

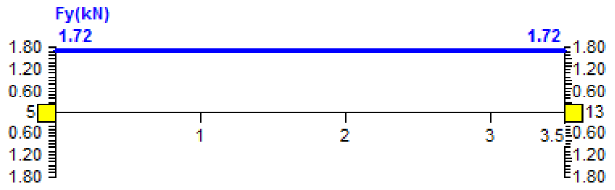

Figure -15: Shear Force in Y- axis in Portal Frame at mid span

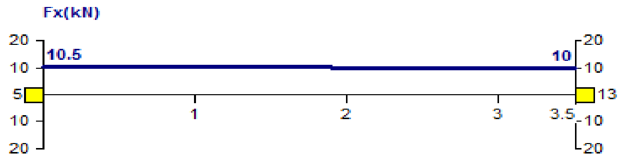

Figure -16: Force in X- axis in Portal Frame at mid span

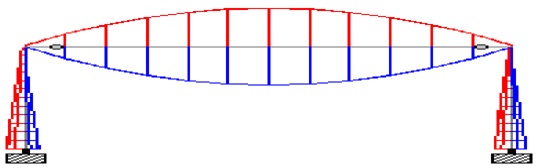

Figure -17: Stresses in Portal Frame

4. DISCUSSIONS

From the above analysis and optimization, in order to find out the elastic-plastic behavior of portal frame under loading cases it is better to use Software based analysis as it is comparatively less time taking and also enables to analyses various codes at a single window and get an optimize result. Here in this project, analysis of Portal frame for finding Elastic-Plastic behavior Euro Code-EC3 is assigned along with the Indian Standard codes IS: 800:2000. Due to this, there is considerable optimization in section used and the values of forces are distributed as per the material based non linear property and its action under loading. The spot of each plastic hinge will be resolved as it is formed and the load factor and deformed state of the structure will be yield as each such load case is applied.

It has been seen that for similar beam there has been various changes as per various codes. The local stability, compactness and slenderness of the steel member cross-sections are relative and it depends on the loading level or material utilization ratio.

5. CONCLUSIONS

From the above analysis and result discussion the conclusion obtained may be summarized as below.

i. This method is rapid and provides a rational approach for the analysis of the structure.

ii. In a portal frame, points of maximum bending moments usually arise at joint connections.

iii. Remarkable compensation includes the abandon of the theory of effective length for member check.

iv. The complete set of regulations included in any code of practice can be utilized in staad.pro software for optimization.

v. There is considerable saving in the section member dimensional and by weight configuration after optimization.

vi. Analysis of portal frame in Indian standard code is for non linear properties is restricted which might be minimized by using other codes.

vii. The portal frame being a combination of beam and column structure, hence; follows full deflection bending and flexural action under various loads.

viii. Beam is always under tension and column under compression loading but in portal frame it is partially under both conditions.

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