BRACING CROSS SECTION EFFECT TO DISSIPATION ENERGY BY NUMERICAL ANALYSIS

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ABSTRACT: Indonesia is located in the earthquake-prone area. In the planning of earthquake-resisted structures, ductility, stiffness, and amount of structural dissipation energy are very important factors. Experts in the field of structural engineering try to find a structural system that can minimize structural damage due to earthquake loads. The structure system must be able to dissipate the energy due to earthquake load. Earthquake resistant buildings made of steel can have advantages in terms of strength, weight, and ductility compared to reinforced concrete buildings when properly planned. Known earthquake-resistant structures include two types of portal systems: a moment of resisting frame (MRF) and portals with stiffening elements or Braced Frame (BF). The portal system with the stiffening element or the Braced Frame (BF) is divided into two subsystems: Concentrically Braced Frame (CBF) and eccentrically bracedFrame(EBF) Among the three earthquake-resistant structural buildings on top, the structure of Concentrically Braced Frame (CBF) type X.has a higher rigidity. Because the diagonal shape will mechanically have a more rigid nature of the quadrilateral. The absorption of the energy of a concentric mined steel frame earthquake is done through melting and post bending of the stiffening element.

This paper presents numeric study output on ductility, stiffness, and dissipation energy on Concentrically Braced Frames type X as consequence of different structural bracing cross-sectional installation position. The numeric study output by using MSC/Nastran software with conducted five modeling of single-story Concentrically Braced Frames type X (CBF-X) which measures 4m x 6m with the different installation position of the cross-section of bracing and gusset plate. Based on the results of numerical analysis of cyclic and push -over analysis, we get the load curve (P) vs displacement (δ) which explains the energy dissipation behavior of the five structures and analyzing the behavior of the five structures studied in this numerical study due to the monotonic and cyclic loading so as to obtain a clear picture of the structure of CBF- X is best used. The different bracing cross-sectional installation position affects ductility, stiffness, and amount of dissipation energy on Concentrically Braced Frames type-X. It is closely related to a difference of the first yielding location occurring on structures.

The bracing capability to perceive a large inelastic deformation is affected by bracing stability on buckling without the loss of strength and stiffness. Total gusset plates used in Concentrically Braced Frames type-X affects ductility and stiffness values. This numeric study output shows that CBF-X structure is the best for use as earthquake-resisted structures with the position of web bracing cross-sectional stay in one field with web column and beam position and make use a gusset plate where structural first yielding occurred in 2t area at a gusset plate.

Keywords: ductility, stiffness, dissipation energy, Concentrically Braced Frames type X, gusset plate.

1. INTRODUCTION

Earthquake resistant buildings made of steel have advantages in terms of strength, weight, and ductility compared to reinforced concrete buildings when properly planned.

Earthquake-resistant structures include two types of portal systems: moment resistant portals or Resisting Frame Moments (MRF) and portals with Braced Frame (BF). The portal system with a stiffening element or Braced Frame (BF) is divided into two subsystems: Concentrically Braced Frame (CBF) and Eccentrically Braced Frame (EBF).

This study will discuss the steel structure of Concentrically Braced Frames type X. Among the three earthquake-resistant structural buildings on top, the framework of steel structure Concentrically Braced Frames type X has a higher stiffness, because the diagonal shape will mechanically have a more stiffness compare of the quadrilateral. The absorption of the earthquake energy of Concentrically Braced Frames earthquake is carried out through melting and post-bending of the stiffening element.

Some earlier researchers have examined the inelastic behavior of bracing elements against cyclic loading. The slimness and compactness of bracing cross sections are important parameters that influence the bracing behavior so that in the design of the structure with the stiffener is required limitation of these parameters in order for the structure to have ducktail.

This study aims to study the effect of changing the position of mounting of bringing cross-section to stiffness and ductility on Concentrically Braced Frame type X structures on the behavior of earthquake dissipation energy.

For simplified analysis, some limitations are taken, such as:

1. A numerical study was conducted on different bunded sectional mounting positions on two single-layer X-type concentrated steel frame structures with the different installation of buhul plates. Used knot plate with welding for bracing connection to column-beam. Welding problems were not addressed in this study.
2. The cross-column and bracing elements used are section I, regardless of imperfections of the material.
3. The steel stress-strain curve relationship is modeled by the ability of strain hardening to reach a breaking state (bilinear elasto-plastic with strain-hardening). This material behavior is uniform across the cross-section and along the elements.
4. The loading conditions of the structure are static monotonic and cyclic displacement

2. HEADINGS

2.1.Concentrically Braced Frames type X

The Concentrically Braced Frames type X (CBF-X) is a steel building frame that holds lateral load through the axial rigidity of each element. The hallmark of this system lies in the diagonal confession on each frame. This diagonal shape will mechanically have a more rigid nature of the quadrilateral. The main purpose of adding a stiffening element is to nail the structure in such a way that its deviation is still eligible.
The absorption of earthquake energy of bracing element is done through melting and post-bending of the stiffening element. The buckling element of the cyclic loading causes the load capacity to decrease drastically, so the higher the cycle of the pinching cyclic load will be more clearly visible on the energy dissipation curve of the P-δ structure.

The value of ductility of the structure can be obtained as a comparison between total deformation and deformation when melting. In this study, the value of yield stress deformation used is the first yield stress when the shift occurs in structures that can be obtained from the analysis of MSC / Nastran. For the total deformation, the value used is the value of displacement when the ultimate load is reached.

2.2.Plastic Analysis

Plasticity-based designs have several advantages including more efficient in the use of structural profile sizes than elastic designs, can make more accurate estimates of maximum structural load calculations so as to make safety factors more accurate than elastic designs, and more easily applied for more complex structures compared to elastic designs.
In steel structures with perfectly elastic-plastic strain conditions, the structural parts having yield stress cannot withstand additional stress. The structure will melt to an additional load or the stress will be transferred to another part of the structure that has not reached the melting, which is still in the elastic region and is able to withstand the additional voltage. In this case, the plasticity will balance the stress in case of overload.
The stress-strain diagram is assumed to have an ideal shape such as figure II.4. The melting point and proportional limit are assumed to be at the same point for steel, and the stress-strain diagram is assumed to be straight in the plateau region. Outside the plateau area, there is a strain hardening area. In this area theoretically, the steel can withstand additional stress with a very large strain.

3. TABLES, FIGURES, AND EQUATIONS

In general, this research is done with the following stages:
1. Study the literature to inventory the parameters that affect the ductility and energy absorption that have been done by previous researchers.
2. With the help of MSC / Nastran software, perform two modeling of a single floor type CBF- X structure measuring 4 m x 6 m with different bracing cross-sectional position and gusset plate.
3. Based on the results of numerical analysis of cyclic and push -over analysis, we get the load curve (P) vs. displacement (Δ) which explains the behavior of energy dissipation of both structures.
4. Analyzing the behavior of the two structures studied in this numerical study due to monotonic and cyclic loading to obtain a clear picture of the best structure of Concentrically Braced Frame type X is used.

The portal system under consideration is the longitudinal direction (4 x 6) m

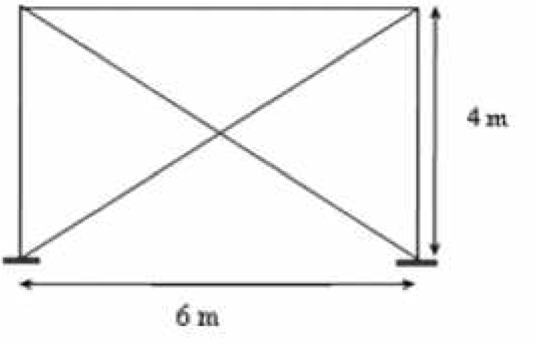

Fig 3.1. CBF-X structure reviewed

Reference Planning
Planning of this type of concentric steel frame structure X is based on the provisions of Seismic Provision for Structural Buildings in 2002 and Procedures for Planning Steel Structure for Building in 2002.

Building Data
- The location of the structure is in region 3 with hard soil type with the price of Ca and Cv = 0.18 and 0.23
-The important factor of structure (I) for the office is 1
- Ratification modification factor (R) for CBF-X portal system retrieved = 6.0

Material Quality

õ f_y = 250 MPa

õ E = 200000 Mpa

Material Modeling

In this study used steel materials with parameter values for modeling in MSC / Nastran as follows:

The mechanical properties of the Magnitude Symbol
Modulus of elasticity (E) = 200000 MPa
Poisson ratio υ = 0.3
fy = 375 Mpa
fu = 508 MPa

Element Modeling

The structural form analyzed is the CBF type X structure. The profile used for the beam, column, and bring components is profiled I. The structural elements are modeled as elements up to the QUAD4 plate with meshing elements such as the drawing.

The condition of the structure placement is the perfect fixed by reining in all the displacements and rotations that occur on all three Cartesian axes. In the panel, zone area is given a diagonal bracing to prevent buckling in the panel zone area.

The distribution of the element meshing in the area of the bushel plate, bearing, and bracing is sufficiently small to allow the deformation and stress-strain distribution occurring in the structure as well as on its elements to be well visualized. The meshing division is intended to speed up the execution time and minimize the running memory in cyclic loading.

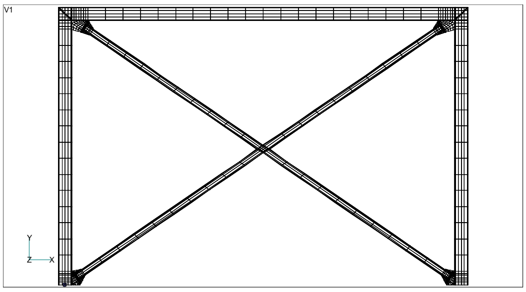

Fig. 3.2. Modeling Elements on CBF-X

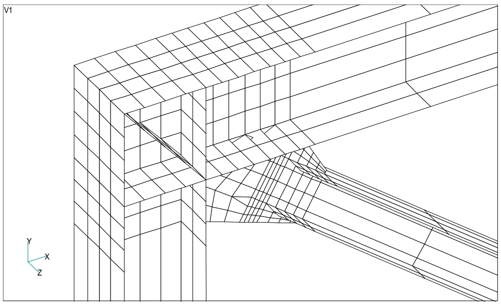

Fig. 3.3 Modeling Element in the panel zone area

Structured Modeling

This numerical study modeled five centrifugal structured steel frame structures of type X (CBF-X) with different beveled cross-sectional and plate mounting positions. For the purpose of explaining the positioning of the dressing cross-sectional positioning on the five structures, the figure shows the thickness of the plate elements. However, in modeling MSC / Nastran structural elements are QUAD4 plate elements.

The Position of Bracing On Structure

In this position, the dressing is placed with the position of the body in one field with the position of the column body and the beam is mounted parallel to the portal plane, as shown in the figure

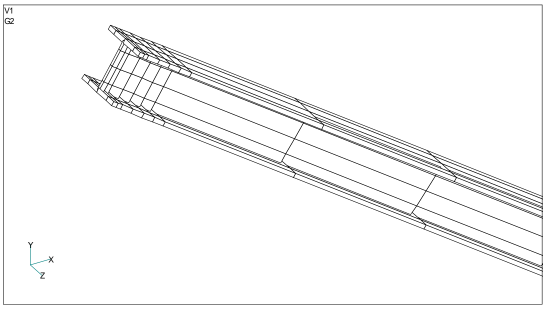

Fig.3.4 Installation Position

Modeling the Structure

The CBF - X structure was studied using profiles I for beams and columns of the following size:
B = 100 mm, h = 100 mm, tw = 6 mm, tf = 8 mm

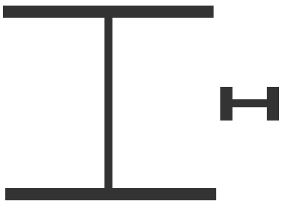

Fig. 3.5. Profile Size I for beams and columns

A. Structure I

The structure I use is in the form of profile I with size 100.100.6.8 mm. Bring is mounted in an I mounting position and mounted on a 20mm thick plate of buhul plate welded on bring wings, columns, and beams. The modeling is as shown in the figure

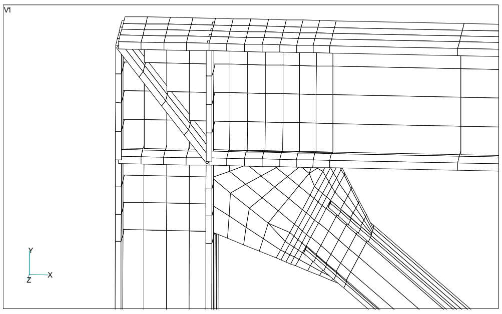

Fig 3.6. Modeling on Structure I

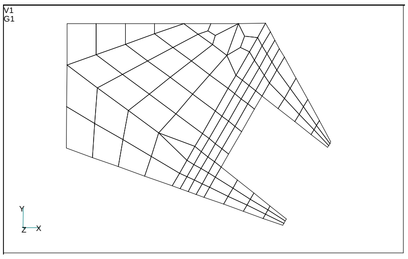

Fig. 3.7. Detailing gusset plate on structure I

The structure is designed for the first melting position to occur in the 2t area (2 x thick gusset plates) on the gusset plate. In the 2t region, meshing elements are made more tightly to be able to clearly see the first melting position and the tension on the elements and the position of the plastic joints formed in the 2t region.

B. Structure II

Structure II using being in the form of profile I with size 100.100.6.8 mm. Bring is mounted with an I mounting position on two 10 mm thick gusset plates that are welded on both wing bracing, column wings, and beams. The modeling is as shown in the figure.

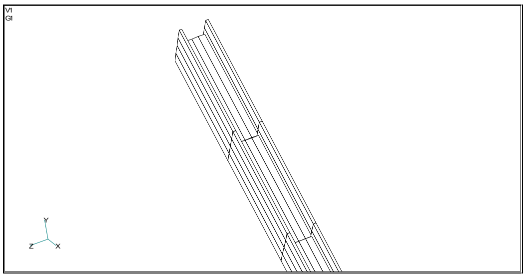

Figure 3.8. Modeling on Structure II

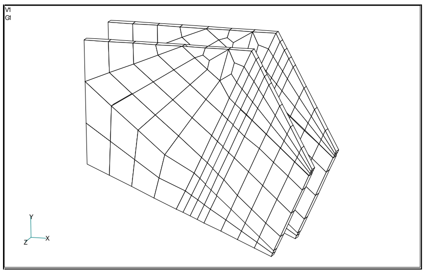

Figure 3.9 Detailing gusset plate on structure II

Detailing Gusset Plate

Connection gusset plate and bracing is designed as pins bearing so that rotation can occur at the end of bracing and on the plate buhul plastic joints occur. To ensure rotation can occur at the bracing ends then the connection detailing must meet the following requirements: A.End of bracing parallel to melting line of gusset plate

B. The axis of the line of the gusset plate is perpendicular to the axis of bracing.

C. The distance from the end of bracing to the melting line of the gusset plate is 2 times the thickness of the gusset plate.

The loading is monotonic loading and cyclic loading by providing a horizontal load centered on the nodal in the panel zone. The method used in the calculation is the displacement control method. In this method, the load is in the form of a displacement load. The load is given gradually with the increase of the load arranged in such a way by controlling it at each stage of loading. Monotonic loading is given to obtain the first yield stress (y) in the structure. The cyclic loading is applied to the structure to obtain the load-displacement hysteretic loop so that energy dissipation can be calculated as the area of the hysteretic closed curve.

4. CONCLUSION

The result of the monotonic loading of structure I am shown below:

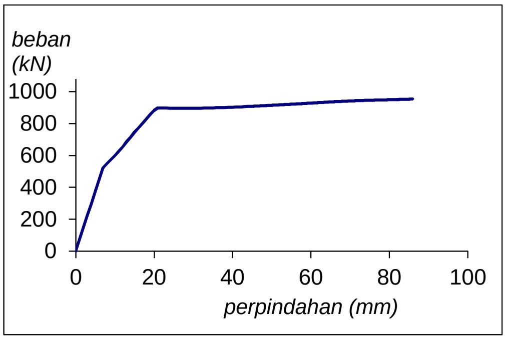

Figure 4.1.Load curve vs displacement monotonic in structure I

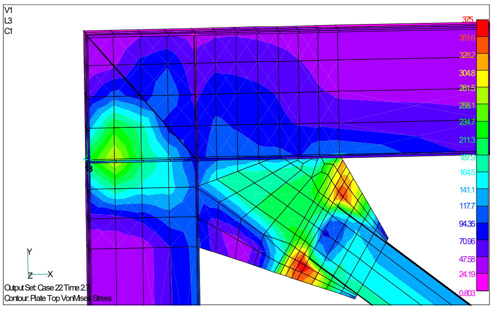

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Figure 4.2. Load curve vs displacement monotonic in structure I

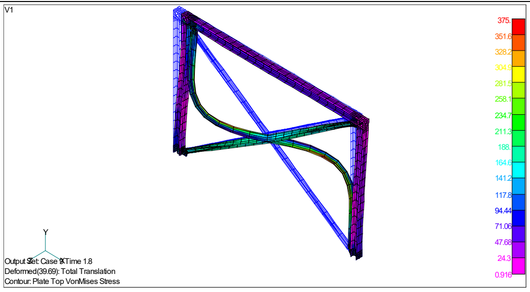

Figure 4.3. Contour of structural stress at 9 mm displacement load(Isometric direction)

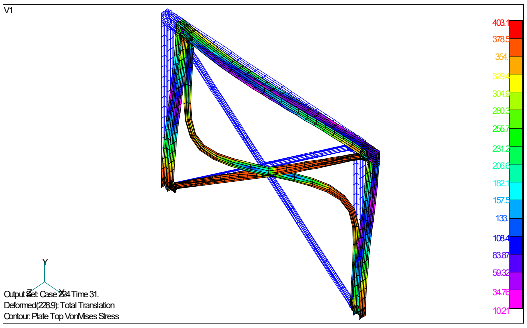

Figure 4.4. Contour of structural stress at 86 mm displacement loa(Isometric direction)

From the curve above can be explained the behavior of the structure of each load increase. The first melt occurred on the 8 mm displacement with a load value of 548.8 KN at 2t area on the buhul plate on press brewing. Before melting occurs, the structure is still elastic in that each load increase will be followed by the displacement of the structure which is still linear, so that the elasticity value (k1) is high because the displacement value of the structure is still small with a considerable load increase. After the first meeting in the 2t region on the buhul plate in being press, the structure enters the inelastic region. Melting process will occur in all directions, both in the direction of being cross-section and other outer fiber parts. In the area of 2t on the gusset plate will occur plastic joints. In this condition, the elastic stiffness value (k2) becomes less than k1. After buckling on being press, the displacement of 21 mm tensile bring began melting. The melt in this tensile stretch will cause a large deformed structure with a fairly small increase in load, where the stiffness value (k3) is close to zero. As the load increases, the bottom column begins to melt. Then at the 86 mm displacement with a load of 953.2 KN of the lower wing area on the starting blocks yielding. At 87 mm displacement, the structure is not able to withstand load because the beam is getting yielded until the collapse occurs.

Load curve vs displacement monotonic structure II

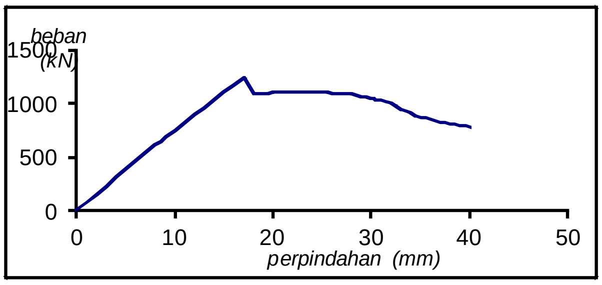

Figure 4.5. .Load curve vs displacement monotonic in structure II

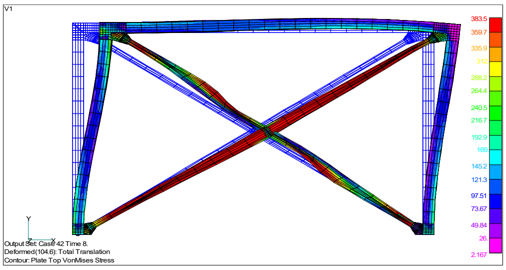

Figure 4.6 Contour of structural stress at displacement load 40 mm (XY direction)

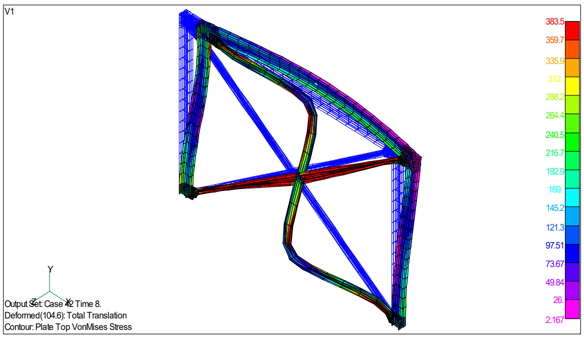

Fig 4.7 Contour of structural stress at displacement load 40 mm (isometric direction)

From the curve above can be explained how the behavior of structure II due to monotonic loading. At a displacement load of 14 mm, the structure melts first in the wing area on the press bracing with a load of 1036.9 KN. As a result, press bracing bends toward the weak axis of the cross-section or into the field of the portal. As the load increases, melting occurs in all parts of the press bracing. In this condition, the structure is in inelastic condition so that it can deform with a considerable load burden. But on the displacement load 18 mm, press bracing tap more bend in the direction of the field of the portal resulting in significant load decrease.

After press bracing bend in the field of the portal, with increasing load, tensile being starts to melt with a not too large load increase. At a displacement value of 23.5 mm, the magnitude of the load begins to fall again due to the occurrence of melting on the wing of the beam. As a result, the load will decrease as the value of structural displacement due to bending on mm displacement load (Isometric direction)

From the curve above can be explained the behavior of the structure of each load increase. The first melt occurred on the 8 mm displacement with a load value of 548.8 KN at 2t area on the buhul plate on press brewing. Before melting occurs, the structure is still elastic in that each load increase will be followed by the displacement of the structure which is still linear, so that the elasticity value (k1) is high because the displacement value of the structure is still small with a considerable load increase. After the first melting in the 2t region on the bushel plate in being press, the structure enters the inelastic region. Melting process will occur in all directions, both in the direction of being cross-section and other outer fiber parts. In the area of 2t on the plate, but will occur plastic joints. In this condition, the elastic stiffness value(k2) becomes less than k1.
After buckling on being press, the displacement of 21 mm tensile bracing began melting. The melt in this tensile stretch will cause a large deformed structure with a fairly small increase in load, where the stiffness value (k3) is close to zero. As the load increases, the bottom column begins to melt. Then at the 86 mm displacement with a load of 953.2 KN of the lower wing area on the starting blocks melting (figure IV.1c). At 87 mm displacement, the structure is not able to withstand load because the beam is getting melted until the collapse occurs.

As a result, press bracing bends toward the weak axis of the cross-section or into the field of the portal. As the load increases, melting occurs in all parts of the press bracing. In this condition, the structure is in inelastic condition so that it can deform with a considerable load burden. But on the displacement load of 18 mm press bracing tap more bend in the direction of the field of the portal resulting in significant load decrease.
After press bracing bend in the field of the portal, with increasing load, tensile being starts to melt with a not too large load increase. At a displacement value of 23.5 mm, the magnitude of the load begins to fall again due to the occurrence of melting on the wing of the beam. As a result, the load will decrease along with the increase of the displacement value of the structure due to buckling on the press being and the larger beam so that the structure can no longer withstand the load.

Cyclic Loading

The result of cyclic loading in structure I am shown in Figure 4.8

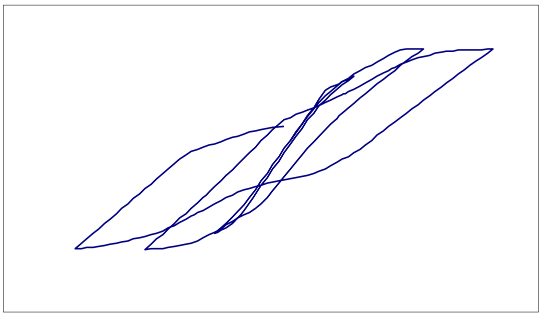

Figure 4.8. The cyclic load-displacement curve of structure I

The cyclic loading of structure I am carried out over three cycles of 1.5 δyield, 3 δyield, and 4 δyield. The first cycle is provided with a maximum displacement load of 12mm(1.5δyield).

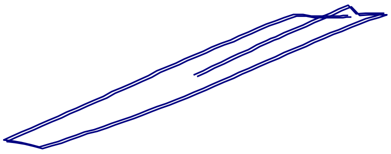

Fig. 4.9 The cyclic load-displacement curve of structure

In structure, I with one gusset plate, the first melt of the structure occurs in the area of 2t on the gusset plate with an 8 mm displacement value and a load of 538.1 kN. Whereas in structure III with two plates of the first yield stress of structure occurs in the wing area on the press being with a displacement value of 14 mm and the weight of 1036.9 KN. It appears that structure III has a better ability to increase the stiffness of the structure due to lateral loads, where the first yield stress of structure II occurs at load values and displacements that are almost twice as large as that of structure I. However, the first melt in structure II occurs in the press wing bracing area, not as expected in the design of the CBF-X steel frame structure where in the plastic joint is not formed in the 2t region of the gusset plate. As the load increases, the press bracing further bends the weaker axis and there is a significant drop in load. This is due to the position of the installation of bracing cross sections that cause the slimness value of bracing in the direction of weak axis increases because both ends of the wing bracing welded to the gusset plate resulting in the condition of the ends of bracing clamped rigidly. Unlike structure I where the plastic joints are formed in the 2t region of the knot plate so that the conditions of the breeding tips in the case of bending to the weak axis of the bracing are closer to the joints.

The position of bracing cross-sections affects the stiffness and ductility of the structure. The structure with the position of mounting of bracing cross section like structure I will more ductile compared to the position of installation of structure II. . This is due to the position of mounting of bracing cross section on structure II causing the slimness value of bracing in the weaker axis direction is bigger because both ends of the wing bracing section are welded to the gusset plate causing the condition of the brass ends to be clamped rigidly, so the structure II is more rigid. A bracing such as structure II provides a yield displacement load value 1.5 times larger than the position of the bracing cross-section of structure I. But the ductility value of the structure is smaller than structure I

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