Providing different type of bracing in the existing building structure under seismic load

R K Rohman¹, S D Cahyono¹, L Fatmawati¹
¹ Civil Engineering Department, Faculty of Engineering, Merdeka University of Madiun, Indonesia

E-mail: rosyid@unmer-madiun.ac.id

Abstract. This paper presented the influence of the providing different types of the bracing system in the existing building structure. The selected object of analysis is Timbul Jaya Plaza building that located in Madiun City Indonesia. The system of building structure is Moment Resisting Frame (MRF). Seismic loading analysis use equivalent static analysis base on SNI 1726 2012. Modelling and analysis of structure use computer software ETABS version 9.00. Aim of this research to compare the use of different types of the bracing system under seismic load. Type of bracing that analyzed is X-bracing, V-bracing, and Inverted V-bracing. Model of structure without bracing used as control. Result analysis known that the providing of X-bracing will decrease maximum displacement until 36.28 % compared with existing structure without bracing and increase the stiffness of structure.

1. Introduction
Indonesian country is located in an active seismic region. Indonesia has experienced several major earthquakes. Some of the earthquake events struck modern buildings have been constructed and were expected to resist the earthquake effects. Recognizing this fact, the government revised Code on Seismic Resistant Design for Buildings, SNI-03-1726-2002 by SNI 1726 2012. This code based on the ASCE 7-10 Standard [1].

Rohman (2014) compared the using of SNI 1726 2002 and RSNI 1726 201X for analyzing the model of building structure in Madiun city. Results of the analysis known that earthquake load base on SNI 1726 201X bigger 27.5% compared with SNI 1726 2002 and the lateral load on each floor bigger too. Using SNI 1726 2012 in structural analysis due to increasing of earthquake loading [2]. The existing building that constructed base on SNI 1726 2002 must be analyzed to know its structural stability. If the structural stability cannot fulfill the requirement of the new code, existing building structure must be retrofitted.

One of retrofitting techniques is providing of the bracing system. The bracing system can be provided to enhance stability of building structure[3]. Aim of retrofitting is to increase the stiffness of the structure and the lateral strength. Retrofitting also expected to increase the ductility and to enhance the capacity of energy dissipation and it should be resulted in effective cost. The application of bracing system will enhance the capacity of building structure under seismic load.

There are some research about the using of the bracing system to building structure, such as Barat Patel, et. al[4], Swetha Sunil and Sujith PS[5], Kulkarni and Kore[6], Nauman Mohammed and Islam Nazrul[7], Karthik K and Vidyashree D[8], Muhammad Taher Khaleel and Dilep Kumar U[9], Rishi Mishra, Sharma and Garg[10] and etc. From their study can be concluded that the providing of bracing will decrease the value of displacement at the top story of model structure.
This paper will analyze Timbul Jaya Plaza building located at Pahlawan street, Madiun city. Timbul Jaya Plaza building constructed in 2007. The reference for the planning of this building was SNI 1726 2002. Modelling of structure and calculation of the base shear and displacement value of building structure use ETABS software version 9.00. Structural analysis will be done to an existing structure without bracing and after retrofitted by the bracing system.

2. Methodology
The method that used in this research is modeling and analysis of structure. The bracing is provided at the possible position of the model structure. The position of the bracing on the corner of the building. There are four models of the structure are being analyzed using ETABS software.

Model 1 is Momen Resisting Frame (MRF) non bracing. The structure of existing building was analyzed and its result used as control. The first model of structure shown in figure 1.

Model 2 is Momen Resisting Frame with X bracing type. For the second model, the building structure is provided with X bracing type to enhance the stability of structure under lateral force. The second model is shown in Figure 2.

Model 3 is Momen resisting Frame with V bracing type. The existing building structure is provided with the V bracing type as shown in Figure 3.

Model 4 is Momen Resisting Frame with Inverted V bracing as shown in figure 4.

2.1. Modeling and Analysis of Structure
Modeling of building structure use ETABS 9.0 computer software. The selected object of this modeling was Timbul Jaya Plaza (TJP) building. The location of TJP building at Pahlawan street, Madiun city, East Java Indonesia. The structure of Timbul Jaya Plaza is reinforced concrete structure. The number of stories is 5 and high of each column 4.0 m. The grade of concrete is 25 MPa and the grade of steel is 400 MPa. The bracing system uses steel which grades 240 MPa. The building data used for modelling of building structure was shown in table 1 below.

| Property            | Dimensions                          |
|---------------------|-------------------------------------|
| Length              | 40 m                                |
| Width               | 30 m                                |
| Thickness of slab   | 120 mm                              |
| Beam B1             | 300 x 800                           |
| Beam B2             | 300 x 700                           |
| Beam B3             | 300 x 600                           |
| Columns             | 600 x 600                           |
| Bracing             | WF 250 x 125 x 6 x 9                |

2.2. Equivalent Static Analysis
The seismic load can be calculated use equivalent static analysis for regular building[11]. The calculation of base shear (V) uses the following formula base on SNI 1726 2012[12]:

\[ V = C_s \cdot W \]

where \( C_s \) is coefficient of seismic response, and \( W \) is the total weight of the structure. The base shear is distributed as a lateral force which assigns at the joint of each story level of the building. The calculation of lateral force (Fx) each story was done by using the following equation below:

\[ F_x = C_{vx} \cdot V \]

\[ C_{vx} = \frac{\sum w_i \cdot h_i^k}{\sum w_i} \]

where
- \( w_i \) = weight of story \( i \)
- \( h_i \) = column height of story \( i \)
- \( n \) = number of story
- \( k \) = exponent related to period of structure

3. Result and Discussion
Structural analysis has been conducted by using ETABS software version 9.0. Output analysis is the lateral displacement value on the top level of the building structure. After get analysis output then determine the displacement value and base shear on each type of the provided bracings. The result was analyzed under equivalent static analysis by different type of the bracing. Then maximum displacement and base shear will be compared to get effective of the bracing system. The location of maximum displacement selected at joint of the top story level.

3.1. Displacement value for different types of MRF model
Displacement value (x-axis) was shown in figure 5. From that figure shown that maximum value of displacement at the top story. The value of displacement will decrease due to the using of the bracing system. The using of X-bracing influence displacement value decrease by 36.28 % compared with MRF without bracing (NB). Then displacement value decreases 30.95 % at the existing building which retrofitted by Inverted-V bracing and decreases 26.99 % after retrofitted by V-bracing system.
Displacement value for y-axis can be shown in figure 6. The displacement value after providing by X-bracing at existing building more effective to improve structural stability. The decreasing of displacement value 42.85 % for X-bracing, 42.43 % for Inverted V-bracing and 39.78 % for V-bracing compared with MRF without bracing. It is also concluded that providing bracing enhance of the stiffness of the structure.

![Figure 5. Displacement of each story (x-axis)](image)

![Figure 6. Displacement of each story (y-axis)](image)

3.2. Base shear on the different type of MRF model
Base shear of each model can be shown in table 2. The minimum value of base shear is Momen Resisting Frame non bracing (NB), 18368.59 KN. The maximum base shear is in second model Momen Resisting Frame (MRF) with providing by X bracing type (XB), 18429.43 KN. It is also observed that base shear is higher in X bracing type. It also indicated that providing of bracing system will enhance value of the base shear compared with control (NB).

| Type of Model structure | Base Shear (KN) |
|-------------------------|-----------------|
| Model NB                | 18368.59        |
| Model XB                | 18429.43        |

![Table 2. Base Shear](image)
4. Conclusions
Providing of the steel bracing in the Timbul Jaya Plasa (TJP) building can enhance its structural stability. Application of the bracing system in the existing structure will increase base shear and decrease the maximum displacement value. Providing of the X bracing type will reduce the displacement until 36.28% and more effective compared with Inverted-V bracing and V-bracing.

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