

Performance Evaluation of Dual System Structure with Belt Truss

Dwi Prasetyo Utomo¹, Roesdiman Soegiarso²

P.G. Student, Department of Civil Engineering, Tarumanagara University, DKI Jakarta, Indonesia¹

Professor, Department of Civil Engineering, Tarumanagara University, DKI Jakarta, Indonesia²

ABSTRACT: In structural engineering applications, boundaries of building deflection or interstory drift are important issues. In tall buildings that are more than or equal to 60 floors in the current era, the Belt Truss System is used in the building structure. The function of the Belt Truss is useful to reduce deflection that occurs in buildings by converting the building's moment to the axial column of the exterior column. The Structure of the Belt Truss itself can use reinforced concrete structures and steel structures. Because the Belt Truss structure is an innovation in the world of structural engineering, the earthquake load parameter values do not depend on the applicable Building Standard Codes. Standard Codes of Earthquake Resistant Building require parameters of the Response Modification Coefficient (R), Over Strength Factor (Ω_o), and Deflection Amplification Factor (Cd) for determining earthquake loads. Because the parameters in the Belt Truss structure are not listed in the Standard Codes of Earthquake Resistant Building, the earthquake load parameters of the Belt Truss were determined. The method used in this research is literature study using Pushover Analysis according to ATC-40 and FEMA 356.

KEYWORDS: Belt Truss, Dual System, ATC - 40, FEMA 356, Modified Response Factor (R), Over Strength Factor (Ω_o), and Deflection Amplification Factor (Cd).

I. INTRODUCTION

Planning a tall building in Indonesia requires a plan that is resistant to earthquake loads, so there are no fatalities resulting from the failure of building structures in the event of an earthquake. High structure building systems with a number of floors of less than 40 floors are most effective using structures using dual system structures (shear walls and special moment frames). While buildings that exceed 40 floors if they continue to use dual systems, the lateral deflection will be very large so it does not meet the ASCE 7-16M [6] requirements. To overcome this huge lateral deflection by adding the Belt Truss structure to the building as a virtual outrigger. Nair [1] that virtual outriggers in 77-story buildings formed from the Shearwall-Belt Truss were able to reduce lateral deviation in buildings well. Fawzia and Fatima [2] using an outrigger and Belt Truss system can reduce interstorey drift or lateral deviation of about 8% - 9%. Faimun, Tavio and Kurnianto [3] the use of outrigger and Belt Truss systems can reduce inter-floor deviations in the dual system structure of the Gunawangsa apartment building in Surabaya. Comparison of lateral deflection in gunawangsaTidar Surabaya apartment building. In terms of building structure design, ASCE 7-16 [6] table 12.2-1 does not specifically specify the value of the response modification factor (R) to design earthquake loads in the structure with the addition of Belt Truss. So that good and correct design results are obtained according to the requirements of ASCE 7-16 [6] and ACI 318-14 [7].

II. LITERATURE REVIEW

Belt Truss is a truss structure that is placed in the exterior columns and surrounds the building outside. Nair [1] introduces Belt Truss as a virtual Outrigger because of its placement which is not in the middle of the building but is still able to function as an Outrigger see Fig. 1 Belt Truss Structure illustration.

Earthquake force acting in the horizontal direction of the building, resulting in a virtual Outrigger connected to the exterior column can withstand rotation on the core wall structure. So that the moment that occurs in the core wall becomes smaller than the core wall works as a cantilever wall.

The virtual Outrigger system eliminates the direct relationship between the sliding wall and the outer columns carried out by the Outrigger beams. The main rationale of this system is the use of a diaphragm floor which has a great rigidity in-plane stiffness to transfer the overturning moment experienced by the core due to lateral force into

horizontal coupling force from the wall to the truss structure. Furthermore Belt Truss will convert the horizontal coupling force on the floor diaphragm into a vertical coupling force on the exterior columns.

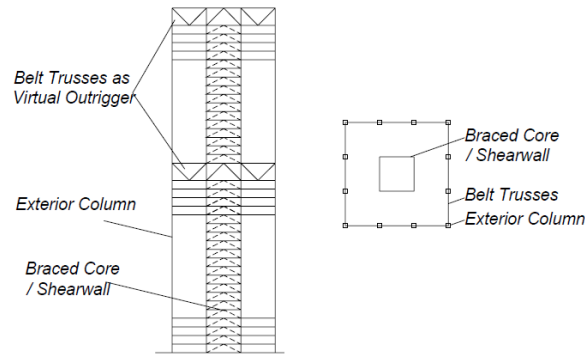
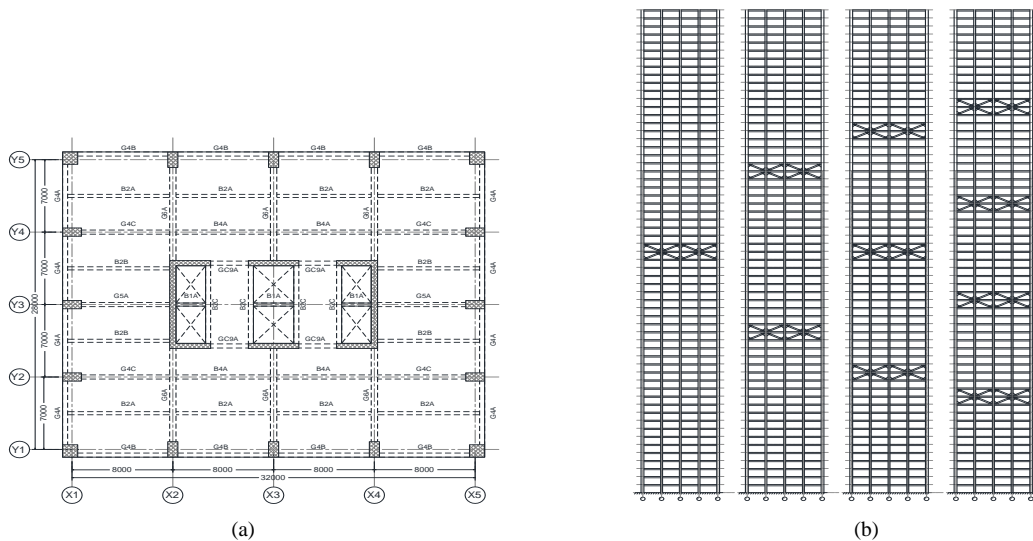


Fig.1. Belt Truss Structure Illustration

III.METHODOLOGY

The research was conducted by studying the textbook literature, articles, journals, encyclopedias, and other sources. The building under review is a building with 60 floors with a Building Plan (the same structural dimensions in all Belt Truss) can be seen in Fig.2 (a). The number of Belt Truss reviewed is 1 Belt Truss to 4 Belt Truss with the most optimum Belt Truss placement according to Krupal Z. Mistry et al. [5] can be seen in Fig.2 (b)



(a) (b)
Fig. 1. Structure Configuration (a) Plan of Building, (b) Belt Truss Location

IV.EXPERIMENTAL RESULTS

The analysis in this study is to get the level of performance and planning parameters of earthquake resistant structures. the performance level analysis is only done on structures with the number of Belt Truss 2 pieces, 3 pieces, and 4 pieces. due to the structure using 1 Belt Truss still over stress on the structure. After analyzing the structure of the dual system with Belt Truss in Fig.3.it can be seen that the interstory drift in buildings using Belt Truss is reduced at the Belt Truss location rather than the structure using only a Dual System (DS).

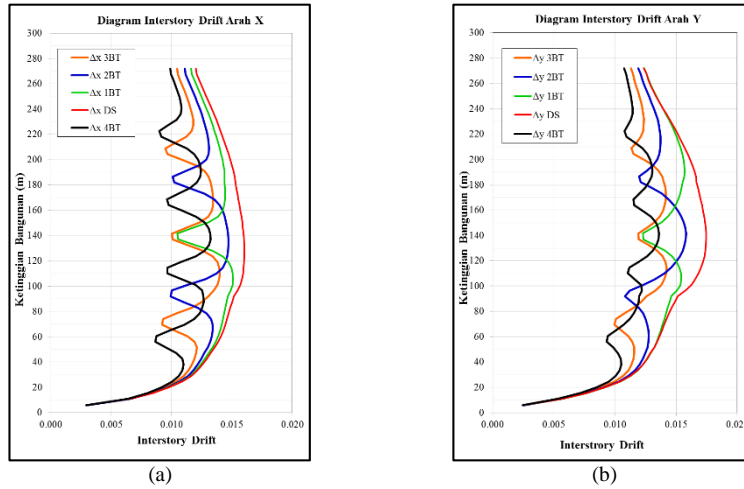


Fig. 3. Interstory Drift, (a) Dir - X and (b) Dir - Y.

Structural Performance Analysis based on ATC-40 [8] using Method B. The results of the ATC-40 [8] performance level analysis can be seen in Fig.4, 5, 6. Based on Fig.4, 5, 6 shows that the performance level of the Belt Truss structure is Immediate Occupancy (IO).

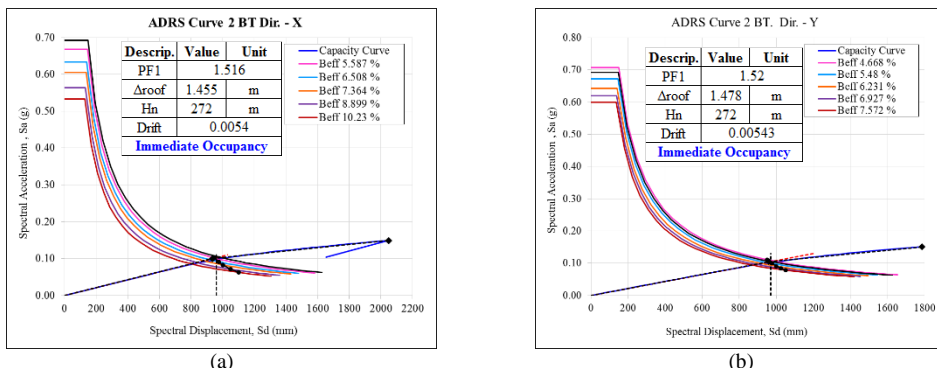


Fig.4. ATC-40 Performance Level 2 BT, (a) Dir - X and (b) Dir - Y.

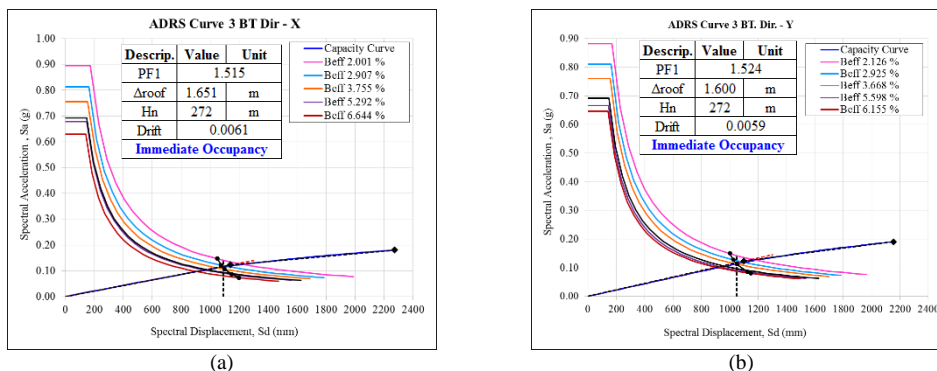


Fig.5. ATC-40 Performance Level 3 BT, (a) Dir - X and (b) Dir - Y.

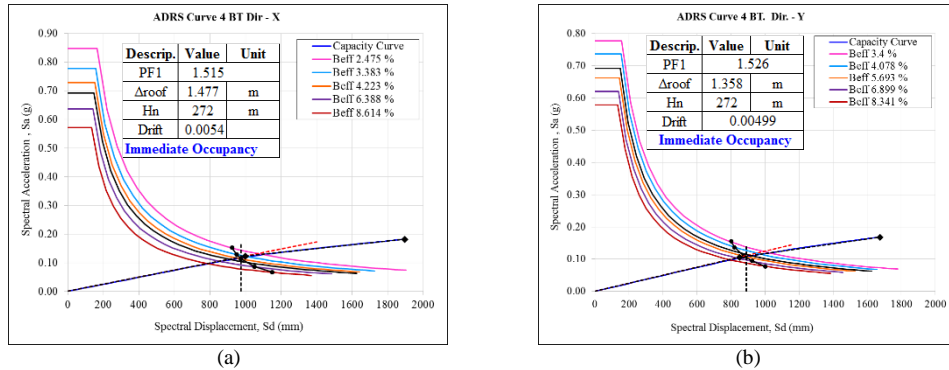


Fig.6. ATC-40 Performance Level 4 BT, (a) Dir - X and (b) Dir - Y.

Structural Performance Analysis based on FEMA 356 [9] using the Target Displacement method. The results of FEMA 356 [9] performance level analysis can be seen in Fig.7, 8, 9. Based on Fig.7, 8, 9 shows that the level of performance of the Belt Truss structure is Immediate Occupancy (IO).

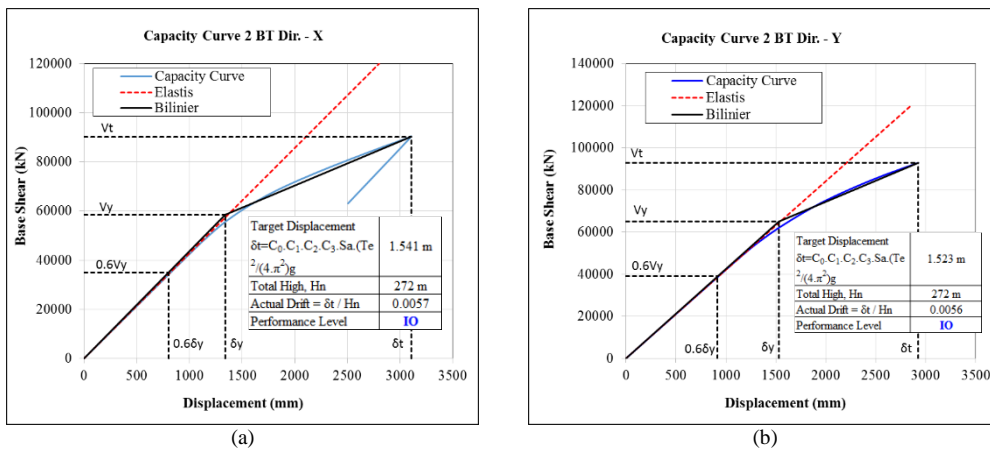


Fig. 7. FEMA 356 Performance Level 2 BT, (a) Dir - X and (b) Dir - Y.

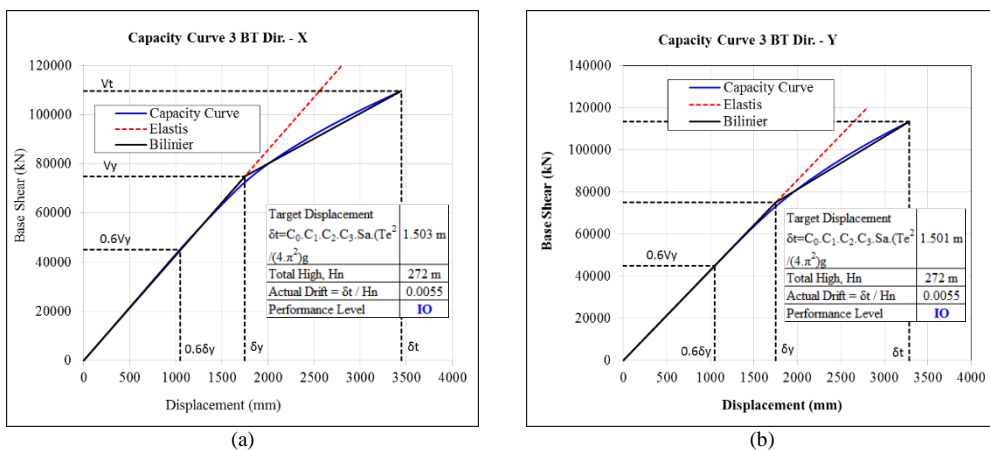


Fig. 8. FEMA 356 Performance Level 3 BT, (a) Dir - X and (b) Dir - Y.

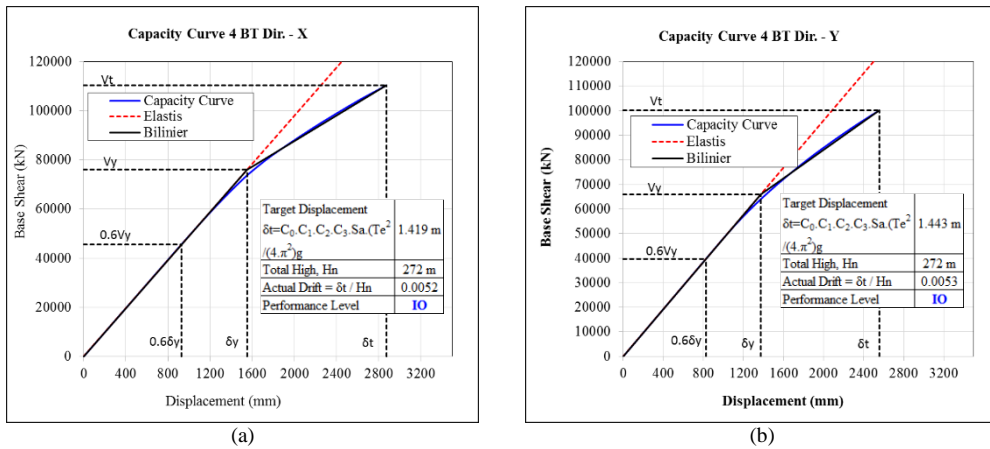


Fig. 9. FEMA 356 Performance Level, (a) Dir - X and (b) Dir - Y.

Analysis of Earthquake Resistant Structure Parameters based on ASCE 7-16M [6] using the Equal Displacement method. The results of ASCE 7-16M [6] Earthquake Resistant Structure Parameter analysis can be seen in Fig.10, 11, 12. Based on Fig.10, 11, 12 shows that the value of the Response Modification Coefficient (R) is 4.5 - 5.0, the Deflection Amplification Factor (Cd) the actual value is 5.0 - 6.0 and Over Strength Factor (Ω_o) the actual value is 3.0 - 4.0.

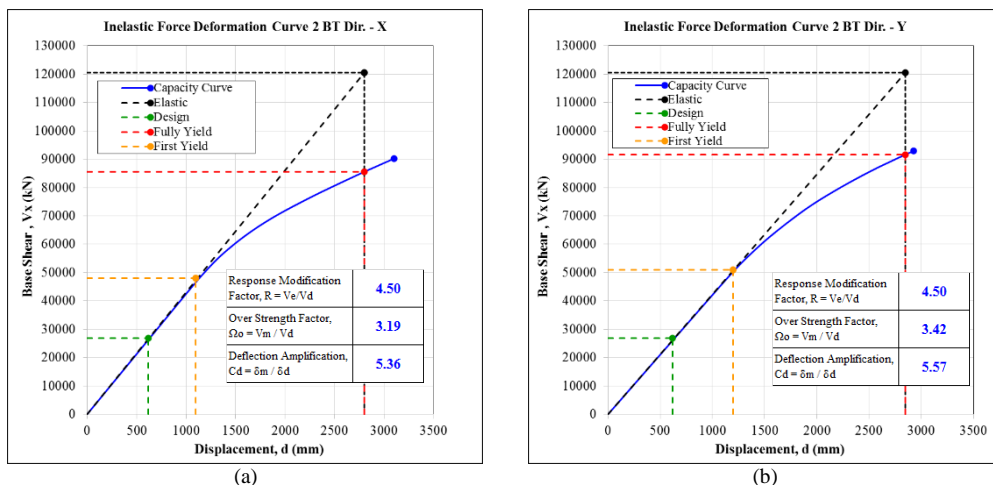


Fig. 10. Earthquake Resistant Structure Parameters 2 BT, (a) Dir - X and (b) Dir - Y.

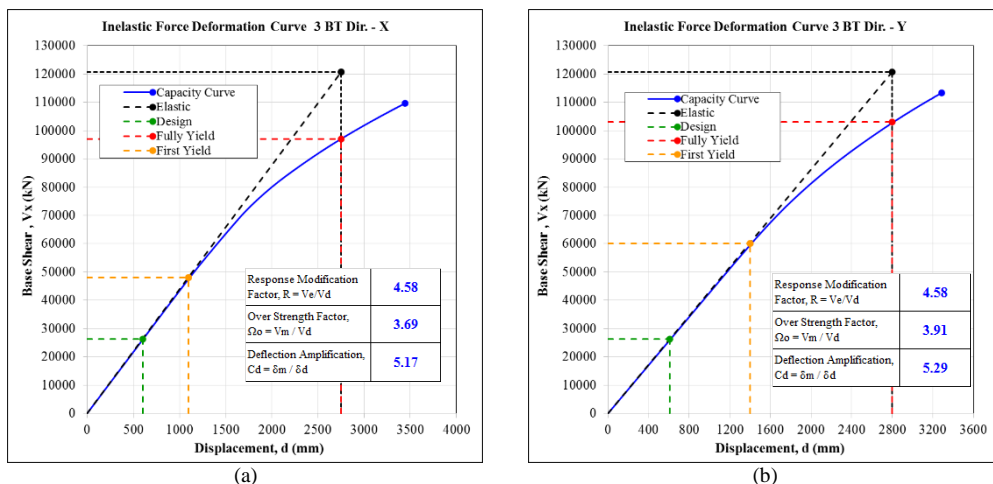


Fig. 11. Earthquake Resistant Structure Parameters 3 BT, (a) Dir - X and (b) Dir - Y.

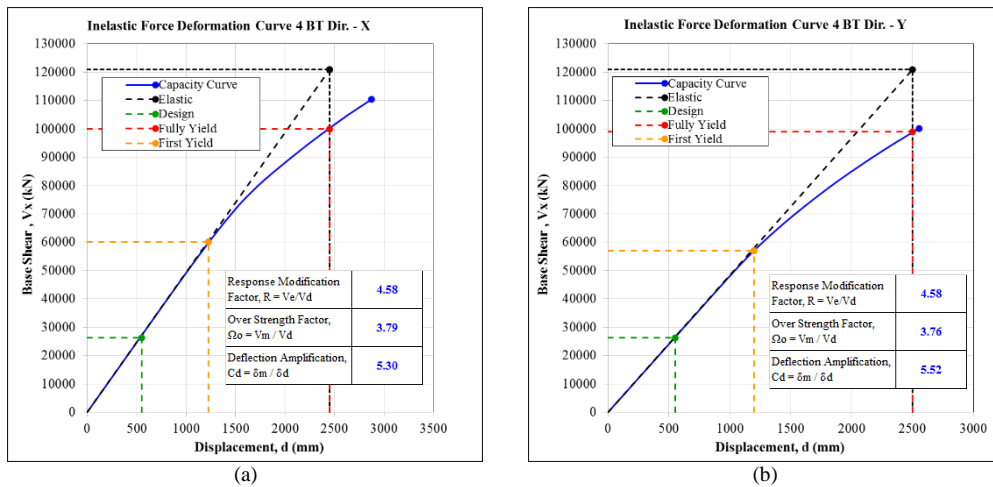


Fig.12 Earthquake Resistant Structure Parameters 4 BT,(a) Dir - X and (b) Dir - Y.

V. CONCLUSION

Based on performance evaluation results ATC-40 and FEMA 356 and analysis of earthquake resistant building parameters ASCE 7-16M [6] in this study the following conclusions can be drawn:

- The performance level of the dual system structure with Belt Truss has an Immediate Occupancy performance level because the total drift of the building has been reduced due to the addition of the Belt Truss structure.
- Response Modification Coefficient (R) is between 4.5 - 5.0.
- Deflection Amplification Factor (Cd) is between 5.0 - 6.0.
- Over Strength Factor (Ω_o) is between 3.0 - 4.0.

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