Behavoir of Precast Concrete Columns with Steel Dowels H Profile on Cyclic Testing

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ABSTRACT

In the development of today's development, concrete is the most widely used material in development in the field of civil engineering, for buildings, bridges, dams, and other constructions. The use of precast concrete building structure systems can reduce the negative impact on environmental pollution. Precast concrete structure systems are also very effective for reducing labor requirements and as a relatively high labor wage solution. Precast concrete structures are generally planned by the emulsion method, which involves considering the structure to be monolithic, so that the precast concrete structure is planned and adjusted to the regulations that apply to monolithic concrete frames. The use of precast concrete in building construction is more efficient when compared to monolith concrete. However, there are major problems in the installation of precast concrete systems that use a wet connection system. Inaccuracies or deviations that do not correspond to the planned dimensional tolerances can affect the stress distribution in the structure to be built. Therefore, the joints on the precast columns must be designed to withstand the force of the earthquake. In a study related to the precast concrete column joint system using an H profile, the number of test specimens to be studied is 2, with an axial compression variation of 0.4. The research method used in this study related to the test object is part of a prototype of a 5-storey building that functions as a simple rental apartment (rusunawa) located on Karimunjawa Street, Gedanganak Village, West Ungaran Regency. Buildings with a column distance of 500 cm, height of each floor 350 cm, reinforced concrete floor slabs 13 cm thick. The materials and tools used are Concrete with K-350 quality, 420 MPa fy rebar steel, H fy 240 MPa steel profile, and fy 240 MPa steel plate. Loading process: The precast concrete column joint test object will be cyclically loaded back and forth under axial compression. The provisions of the charging used are regulated in SNI 7834:2012.

Keywords: column, preprint, dowel, steel, cyclic testing.

INTRODUCTION

In the current development, concrete is the most widely used material in the field of civil engineering, both for buildings, bridges, dams, and other constructions [1].

[2] said that the use of precast concrete has a long history, so the research on concrete structures never stops, especially related to concrete beams, columns, walls, and slabs. However, with the increasing awareness of the importance of maintaining the environment and relatively high labor wages, conventional concrete can be used with more efficient and effective construction systems in any way. The use of precast concrete building structure systems can reduce the negative impact on environmental pollution. Precast concrete structure systems are also very effective for reducing labor requirements and as a relatively high labor wage solution.

[3] researched that the precast concrete structure system is one of the alternative construction technologies that can be done in a more controlled, more economical manner, and supports time and energy efficiency and can support environmental conservation. This precast system is very suitable for use in modular buildings, such as flats, dormitories, shophouses, or offices. Precast concrete has advantages compared to conventional concrete, including quality control, shorter implementation time, more economical costs, and the influence of weather can be minimized.

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[4] analyzed that in building planning with a precast system, it is very important to determine the precast method, because one of the weaknesses of the precast system is the connection between elements. One of the main aspects of the design of the building structure is the implementation of the "Strong Column Weak Beam" system. According to this planning concept, column elements must be designed to be stronger than the beam elements so that if the structure is overloaded, the beam elements will be damaged before the column elements [5].

Precast concrete structures are generally planned by the emulsion method, which is by considering the structure to be monolith, so that the precast concrete structure is planned and adjusted to the regulations that apply to monolith concrete frames. The joint is the most important part of precast concrete in transferring force and behaves as a link of energy dissipation between the precast components that are joined [6].

The types of joints between the components of precast concrete that are commonly used can be categorized into 2 groups [7], namely dry connections and wet connections. Dry joints are joints between components of precast concrete using iron plates as connectors, which are then welded or bolted, while wet joints are joints between precast concrete that are characterized by the exit of reinforcing iron from precast concrete. This reinforcing iron is connected with a rebar iron from precast concrete, which will be connected by casting on site.

The use of precast concrete in building construction is more efficient when compared to monolith concrete. However, there are major problems in the installation of precast concrete systems that use a wet connection system. The connection in the precast system must have a strength that can withstand the loads that occur. Inaccuracies or deviations that do not correspond to the planned dimensional tolerances can affect the stress distribution in the structure to be built. Therefore, the joints on the precast columns must be designed to withstand earthquake forces [8].

One of the systems used in precast concrete joints is by using the dry connection method. Dry joints are commonly used in the connection between precast concrete components. Dry joints are joints between concrete components that use the help of steel plates placed in one or both components of a concrete structure, by connecting them using welds or bolts/anchors [8].

Based on the above explanation, the researcher is interested in being able to develop science related to precast concrete using a dry connection system. The research became a thesis scientific paper with the research title "Behavior of Precast Concrete Columns with H Profile Steel Dowels in Cyclic Testing" [10].

RESEARCH METHODS

The precast portal system of the research stage begins with a literature study to identify precast connections on columns. Furthermore, a test object is planned based on SNI 1726 of 2019 concerning Earthquake Resilience Planning Procedures for Building and Non-Building Structures, with a prototype of a 3-storey building using a column spacing of 500 cm and a height of 350 cm on each floor. The prototype was analyzed as a 3-dimensional building model with ETABS V 18 to obtain the inner styles [14].

The connection on the test specimen is planned based on SNI 2847 of 2019 concerning Structural Concrete Requirements for Buildings, SNI 7833 of 2012 concerning Planning Procedures for Precast Concrete and Prestressed Concrete for Buildings, and SNI 1729 of 2015 concerning Specifications for Structural Steel Buildings [11]-[13].

The test specimen in the form of a precast column connection with H-profile steel is tested by providing an alternating cyclic load. Furthermore, the effect of the connection model on strength, rigidity, ductility, energy dissipation, cracking patterns, and column collapse patterns was studied. As for the flow chart as shown in Figure 1 below.

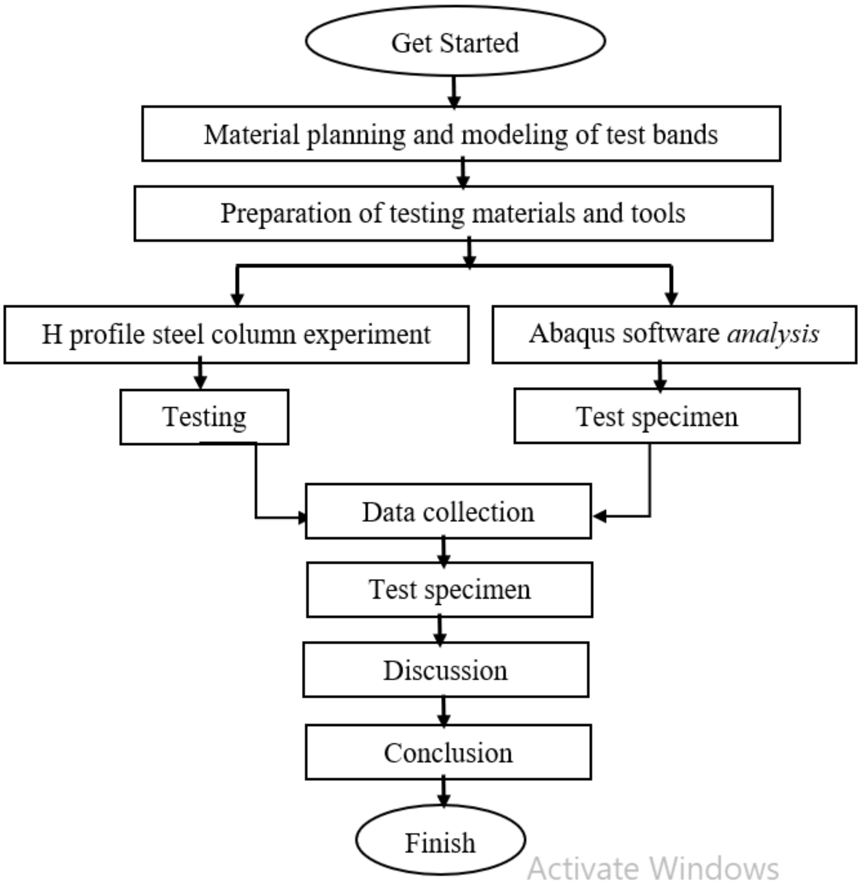

Figure 1. Flow chart

In the study related to the precast concrete column connection system using the H profile, the number of test specimens to be studied is 2 pieces, varied, the axial compression is 0.4 for the two test specimens based on their displacement values, and then hysterical curves are obtained. The details of the test and repetition pieces are shown in Figures 2 and 3 below.

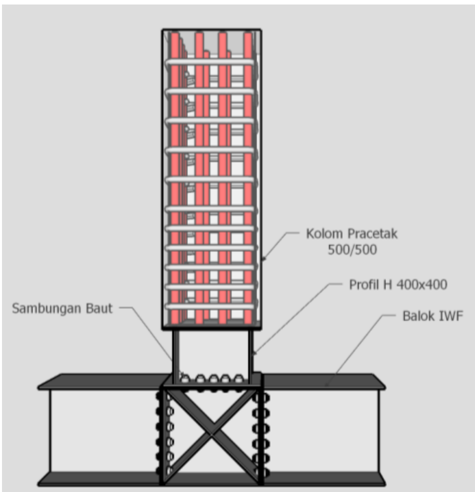

Figure 2. Precast concrete column joint details

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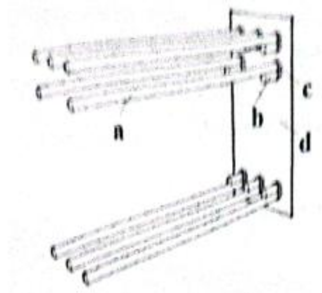

Figure 3 Connection between reinforcing steel and steel plate [9]

Component a is longitudinal reinforcing steel, component b is a piece of reinforcing steel, component c is a weld joint, and component d is the steel plate at the end of a precast concrete beam. Component a is reinforced with component b, which is the same diameter as component a and 2.5 times the diameter of component a. The pieces of reinforcing steel that serve as reinforcement are welded to the longitudinal reinforcing steel and further jointly connected to the steel plate by the welded joint.

Test setup and instrumentation of test specimens

The test specimen is placed in the position of a vertical column on a rigid floor. The lateral load is exerted by the hydraulic actuator mounted on the loading frame. The plan and results of the successive test setups can be seen in Figure 4 below.

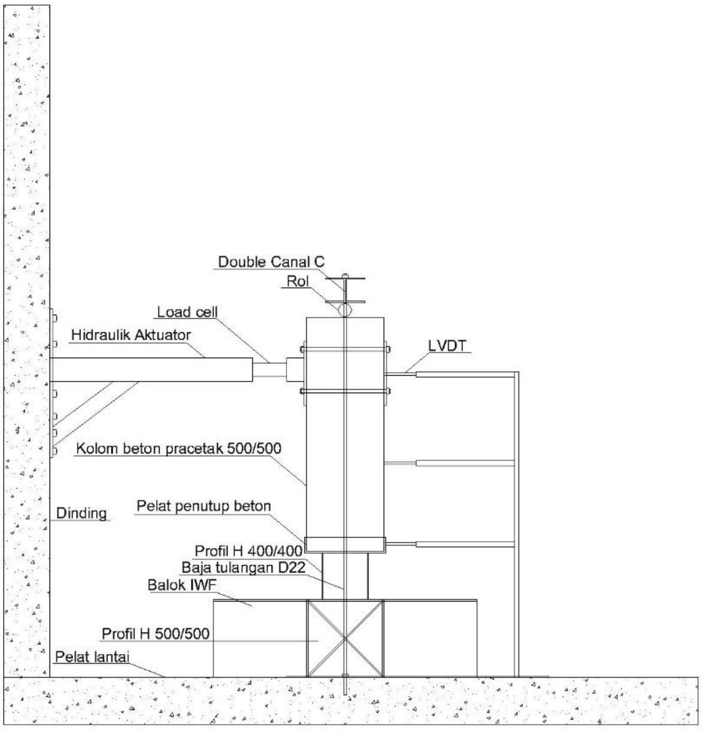

Figure 4 Prototype details of the test method

Loading Process

The joint test piece between the steel beam and the precast concrete beam will be cyclically loaded back and forth. The loading provisions used are as stipulated in SNI 7834 of 2012 Test Methods and Acceptance Criteria for Precast Reinforced Concrete Moment Bearing Frames for Buildings that adopt ACI-374-1-05, with the loading program as shown in Figure 5 [15]. Some of the things that are regulated include:

1 The test specimen must be weighted by a series of displacement control cycle sequences that represent the expected drift at the connection during an earthquake.
2 Three full cycles must be applied to each drift ratio.
3 The initial drift ratio should be within the linear elastic behavior range of the test object. The next drift ratio must be worth no less than the times, and no more than the times, of $1\frac{1}{4}1\frac{1}{2}$The previous drift ratio.
4 The test must be carried out by gradually increasing the drift ratio until a minimum drift ratio value of 0.035 is achieved.
5 The data required to qualitatively interpret the performance of the test specimen must be recorded. The data of the test specimen drift ratio versus the column shear force must be recorded continuously.

The cyclic load graph is according to Figure 5 below.

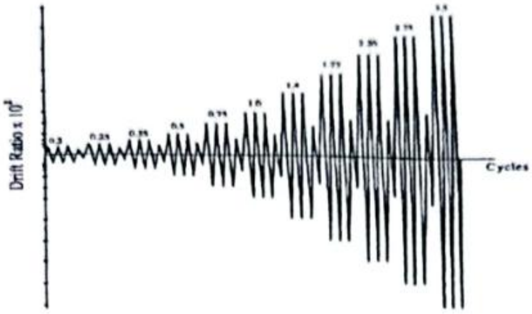

Figure 5 Charging program (10)

RESULT AND DISCUSSION

The test results indicate that ductility in Graph 1 begins to develop when the displacement reaches 20–25 mm, as evidenced by the onset of significant nonlinear behavior during cycles 3–4. The maximum displacement achieved was approximately 45 mm. According to SNI 2847:2019, the Special Moment Resisting Frame (SMRF) system requires a minimum ductility of 2.0; therefore, the tested precast concrete element satisfies the minimum ductility requirement. The energy dissipation behavior, as represented by the hysteresis loops in Graph 1, exhibits wide and stable loops, particularly during cycles 5–10. No snap-back phenomenon or sudden strength loss was observed. This behavior is consistent with the provisions of SNI 2847:2019, Clause 18.2.3, which require structural elements to dissipate seismic energy through stable inelastic behavior. The maximum peak forces recorded in Graph 1 were approximately –90 kN in compression and +60 kN in tension. A strength degradation of about 15–20% occurred during the final cycles (cycles 11–14), which remains within acceptable limits according to SNI 2847:2019. Overall, the cyclic test results of Specimen 1 demonstrate stable hysteretic behavior, with a displacement ductility of approximately 2.0 and strength degradation of less than 20% in the final cycles. Based on the seismic performance criteria stipulated in SNI 2847:2019, the tested element is capable of adequate energy dissipation and exhibits a ductile failure mechanism. Therefore, it can be classified as a structurally sound and seismically viable element.

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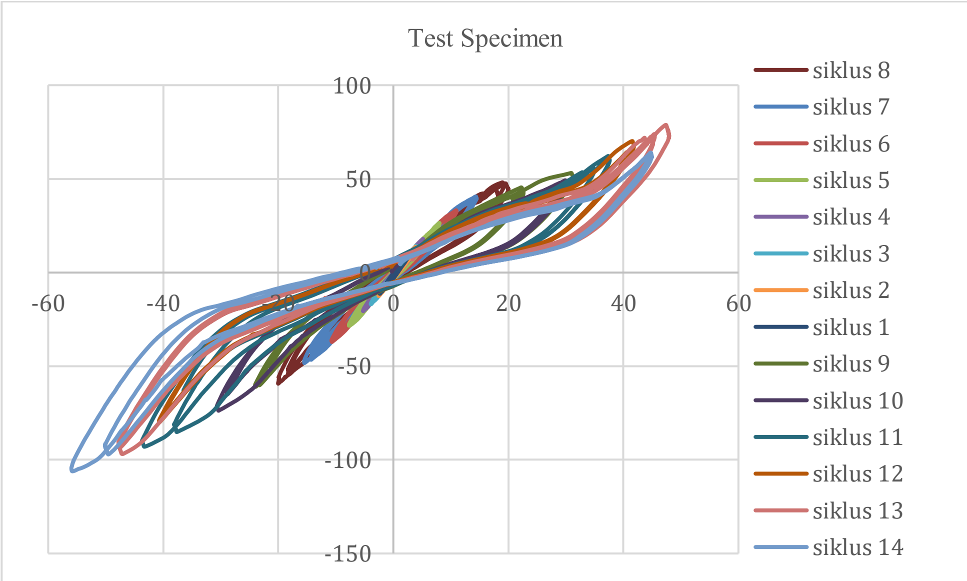

Figure 6. Results of cyclic and axial load testing.

CONCLUSION

Based on the interpretation of the hysteresis curve of Specimen 1 (Figure 6), a change in structural behavior begins to occur during cycles 3–4, as indicated by a reduction in stiffness and an increase in the hysteresis loop area at a displacement of approximately ±25–30 mm, with a corresponding lateral force of about ±50 kN. Strength degradation becomes evident after cycle 8, where further increases in displacement up to ±45 mm are no longer accompanied by an increase in peak force; instead, a reduction in capacity of up to approximately 20% is observed in the final cycles. Research on precast concrete structures needs to be further developed, particularly with respect to connection behavior, which requires special attention. This study is highly beneficial for construction technology, as it has the potential to accelerate construction time and, most importantly, minimize construction waste, especially formwork debris generated during construction projects.

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