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BEHAVIOR OF PRECAST COLUMN CONNECTIONS FOR SEISMIC-RESISTANT HOUSES UNDER CYCLIC LOADING

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ABSTRACT

Connections of structural members are very important elements in the design and construction of seismic-resistant buildings. The quality of the connection governs the failure or collapse of a building. Idealization of the design and behavior of Column Connections (CC) in precast buildings is very crucial in providing a sound and ductile structure. Precast concrete system has several advantages for its construction quality particularly in terms of material due to its manufacturing process with better quality assurance and control in the making process. Other advantages are faster installation, and more practical in construction process.

One of the structural members in a building structure is a column. The column is mainly intended to resist the internal bending moments which may cause tension failure and the internal shear forces that can lead to abrupt brittle failure. Hence, this study concentrated on the behavior of column's precast connection in seismic-resistant houses. The connection was a dry connection. The advantages of using dry connection are very quick and simple in installation without any casting during construction process. The dry connection system uses bolted steel rods to connect between column members and column stubs.

Specimen KP 2 (two-story house) produced good ductility. From the experimental testing, this specimen has provided full ductility. On the other hand, Specimen KP 1 (single-story house) produced limited ductility and the specimen can be considered to have limited ductility.

Keywords: column, cyclic loading, dry connections, precast concrete, seismic-resistant houses.

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1. INTRODUCTION

In recent years the Indonesian government preoccupied with the problem of prevention of disaster victims, especially due to the earthquake that causes most material losses and casualties. Carrying more than 5 large earthquakes occurred in less than 6 years has caused many families lost their homes or place of residence as the main support its activities. This makes the government needs to immediately relocate the victims into a new residential location is feasible for them to immediately return to normal activities. This means they need to rebuild homes for residents in quick time and in large numbers.

As an innovation to overcome this then propose a model of seismic-resistant houses of precast concrete. Advantages using precast, among others, his strength is assured (as printed in the factory), can speed execution time (easy installation), to beautify the structure and can be mass produced (in large numbers) that can be applied to build a house in large quantities (David, Philips & Wiliam, 1978). Because it can accelerate implementation time, it certainly will directly influence the cost savings (Alfred, 2001).

Planning a column as the main support structures need to be considered carefully to ensure the stability of the structure when an earthquake happens again. Although the beams and plates on it are very strong and stiff, but if the column is not strongly support the weight of the whole structure will collapse (Wiryanto, 2005).

In this research will be conducted experimental tests of a dry joint connection system that uses a bolt steel rods, which are used as joints between precast concrete columns. Excess dry joint was to accelerate implementation time, about 25%-40% when compared with in situ concrete joint (Noorhidana, 2002). The columns connection had an important role in determining the performance of structures, especially in the aspect of ductility that is needed in the design of earthquake resistant buildings.

2. RESEARCH SIGNIFICANCE

In this research, the experimental behavior of precast column connection for earthquake-resistant house single-story house and two-story house under cyclic loading. The objectives of this research are to observe the behavior of the connection, including crack pattern/damage at the specimens, plastic hinge location, load-displacement relationship and ductility.

3. EXPERIMENTAL PROGRAM

In the test program, the parameters investigated are dimension, longitudinal bars and anchor bolt. Two precast column connection for single-story house and two-story house were designed and tested.

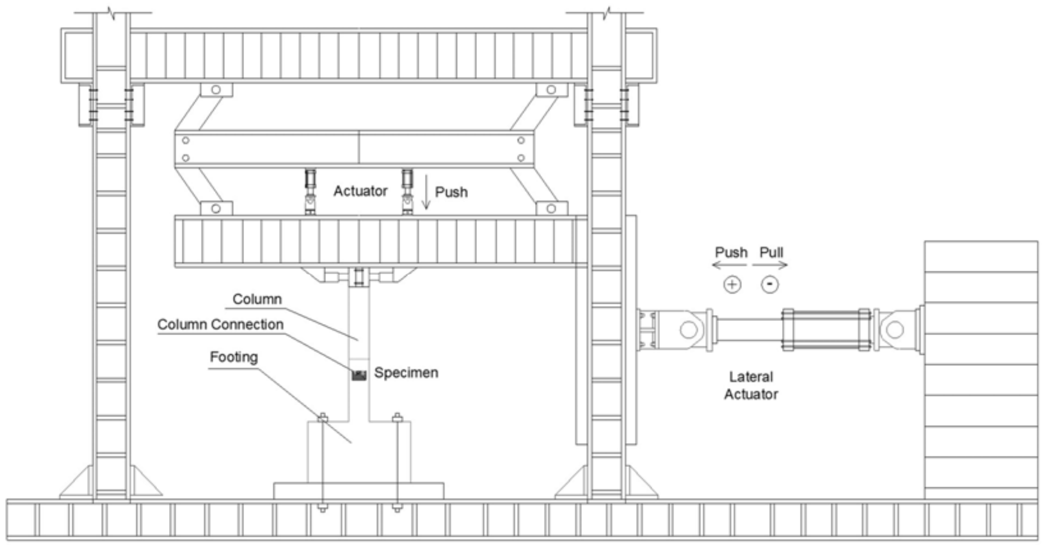


Figure 1. Test Setup for Experimental Study

3.1. Test Setup

Figure 1 shows a schematic view of the setup. Loading frame with axial capacity 1000 KN and lateral capacity of 2000 KN. Data logger recorded measurement from load cell, strain gauges and LVDT. Linier Variable Displacement Transducers (LVDT), to measure displacement occurred at the specimens and at the loading frame during experiment. Strain gauges installed on column longitudinal rebar, column transverse rebar and anchor bolt.

Quasi static reserved cyclic loading was applied to the specimens in increment, downward for compression and upward for tension, using displacement control system. The displacement sequence for each specimen is given in Figure 2.

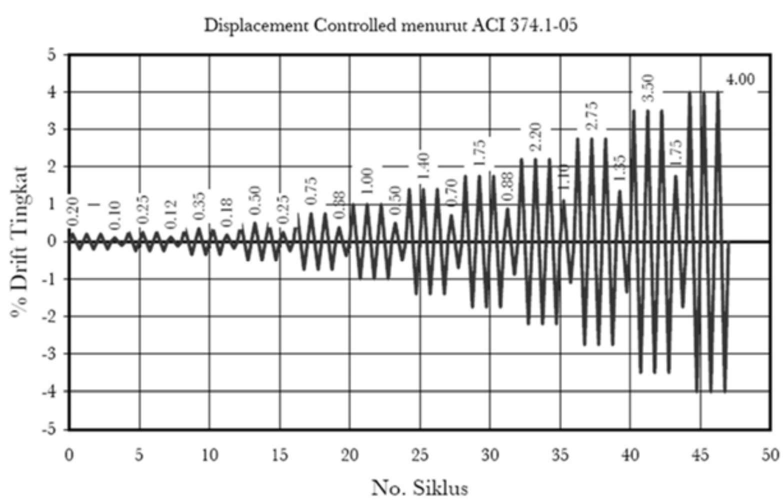


Figure 2. Cyclic Loading

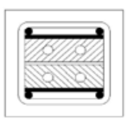
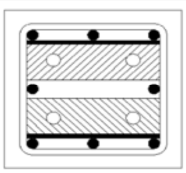
3.2. Specimens

Two specimens were used in this experimental. These specimens differed in column type and anchor bolt connection. Specimen 1 (KP1) is a column for single-story house and Specimen 2 (KP2) is a column for two-story house. The structural dimensions of the specimens are presented in Table 1.

3.3. Material Properties

The average compressive strength of at least 13 concrete cylinders is 24.6 MPa. The steel reinforcement, anchor bolt and steel profile used in this study have modulus of elasticity (E_s) of 200.000 MPa. The steel reinforcement used are plain rebar of ∅8 mm with f_y = 350 MPa, plain rebar of ∅10 mm with f_y = 384 MPa and deform rebar of 13 mm with f_y = 416 MPa. The anchor bolt use 13 mm and 16 mm with f_y = 594 MPa.

Table 1 : Details of test specimens

Specimen	Configuration	Axial Force	Dimension	Concrete Cover	Long. reinforcement	Trans. reinforcement	Anchor Bolt	L Plate
		(kN)	(mm)	(mm)	Size and number	Size and spacing	Size and number	(mm)
KP 1		15.696	150 x 150	25	10 No. 4	8 at 50	13 No. 4	L 40x40x4
KP 2		117.72	200 x 200	25	13 No. 8	8 at 50	16 No. 4	L 50x50x5

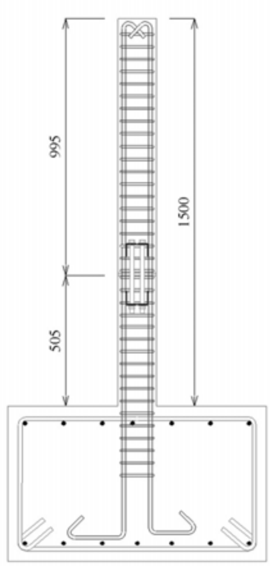


Figure 3. Specimen KP1

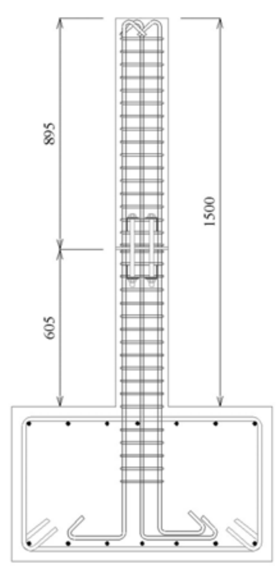


Figure 4. Specimen KP2

4. TEST RESULT

4.1. General behavior

The behavior of the column can be presented by lateral load versus lateral displacement Δ curve. Typical lateral load-displacement curves are shown in Figs. 7 and 8. In all specimens, first crack occurred around column connection.

4.2. Crack pattern

First crack in the specimen KP 1 occurs when pull load at 3.679 KN that occurred in the area 9A column and the first crack of the push load when the load at 3.848 KN that occurred in the area 9D column. The crack pattern of specimen KP 1 at the end of the loading can be seen in Figure 5.

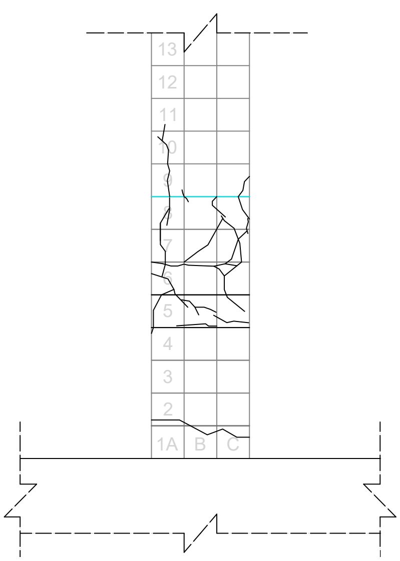


Figure 5. Crack pattern for KP 1

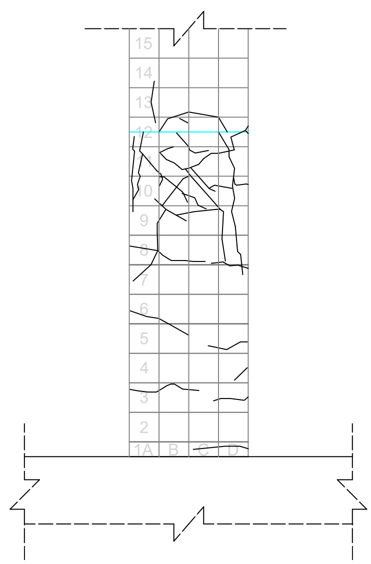


Figure 6. Crack pattern for KP 2

First crack in the specimen KP 2 occurs when pull load at 12.26 KN that occurred in the area 12D column and the first crack of the push load when the load at 12.65 KN that occurred in the area 12A column. The crack pattern of specimen KP 2 at the end of the loading can be seen in Figure 6.

4.3. Load-displacement relationship

Maximum load for specimen KP 1 while push load is 10.3 KN occurred at Δ = 67.54 mm (drift 5%) and maximum load while pull load is 10.98 KN occurred at Δ = 92.1 mm (drift 6,8%)

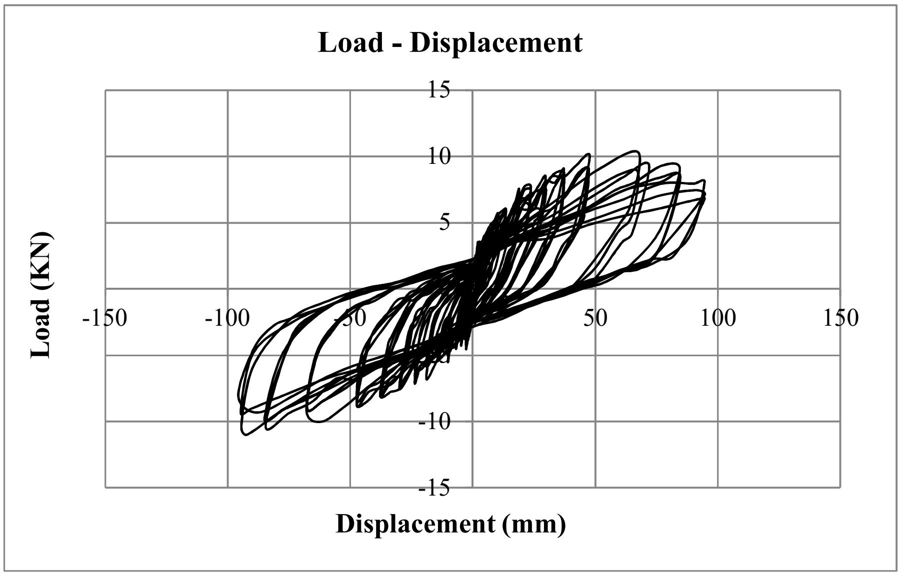


Figure 7. Hysteretic Curve Load-Displacement relationship specimen KP 1

Maximum load for specimen KP 2 while push load is 28.47 KN occurred at Δ = 67.78 mm (drift 5%) and maximum load while pull load is 33.06 KN occurred at Δ = 73.58 mm (drift 5.4%)

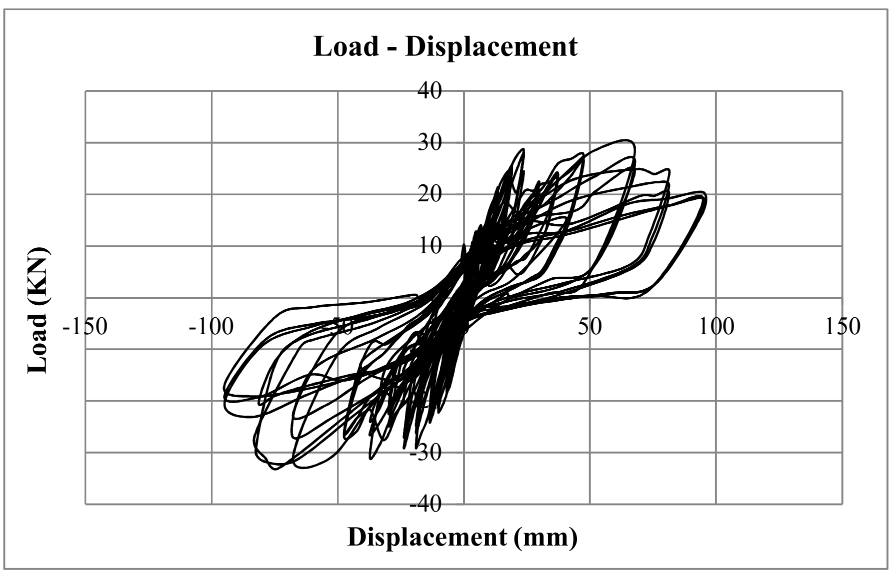


Figure 8. Hysteretic Curve Load-Displacement relationship specimen KP 2

4.4. Displacement Ductility

Deflection value of reinforcement is taken as the first yielding of reinforcement experienced when the load 6.475 KN for pushing load with deflection value of Δy = 17.24 mm and 6.769 KN of pulling load with a deflection value of Δy = 18.94 mm. For ultimate displacement while push load is taken from 80 % of peak push load that is 8.24 KN with displacement Δu = 91.92 mm, the obtained value displacement ductility amounted Δμ = 5.33. For ultimate displacement while pull load is taken from 80 % of peak pull load that is 8.79 KN with displacement Δu = 94.74 mm, the obtained value displacement ductility amounted Δμ = 5.00. (shown in Figure 9)

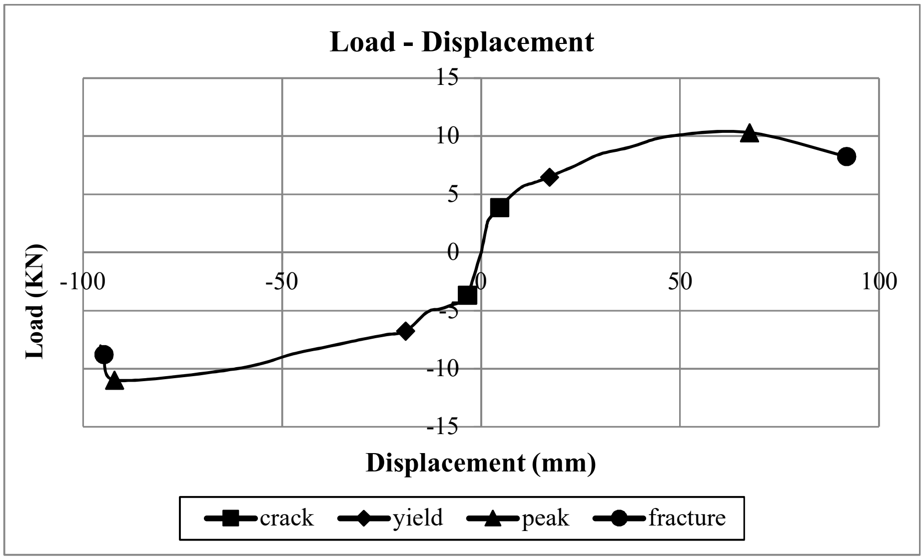


Figure 9. Envelope Curve Load-Displacement relationship specimen KP 1

Deflection value of reinforcement is taken as the first yielding of reinforcement experienced when the load 15.892 KN for push load with deflection value of Δy = 10.16 mm and 22.073 KN of pull load with a deflection value of Δy = 10,16 mm. For ultimate displacement while push load is taken from 80 % of peak push load that is 22.838 KN with displacement Δu = 86.84 mm, the obtained value displacement ductility amounted Δμ = 8.55. For ultimate displacement while pull load is taken from 80 % of peak pull load that is 26.44 KN with displacement Δu = 79.83 mm, the obtained value displacement ductility amounted Δμ = 7.86. (shown in Figure 10)

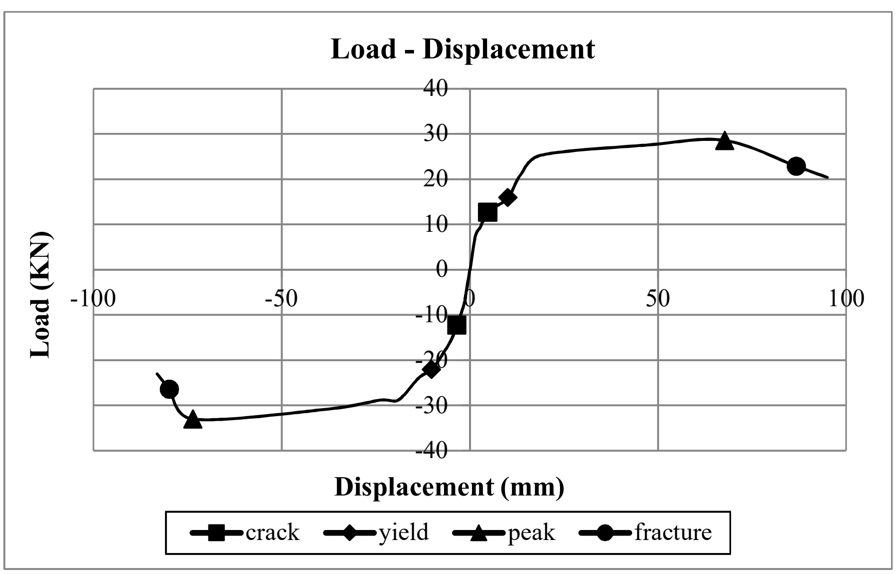


Figure 10. Envelope Curve Load-Displacement relationship specimen KP 2

5. CONCLUSIONS

Based on the experimental result, the following conclusions can be made for specimens KP 1 (single-story house). For push load displacement ductility amounted $\Delta\mu = 5.33$, for pull load displacement ductility amounted $\Delta\mu = 5.00$. From the test, it can be concluded that the connection to have full ductility. Result of specimens KP 2 (two-story house), for push load displacement ductility amounted $\Delta\mu = 8.55$ and pull load displacement ductility amounted $\Delta\mu = 7.86$. The specimen can be considered to have full ductility. For all specimens, first crack occur around the beam-column joint.

6. ACKNOWLEDGMENTS

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7. REFERENCES

B.S. Smith (1963), Infilled Frames, Tesis Ph.D., University of Bristol.

D.V. Mallick, dan R.T. Severn (1967), "The Behaviour of Infilled Frames Under Static Loading", Institution of Civil Engineering, Vol. 38, hal. 639-956.

Mulyanto, (2007), Pedoman Membangun Rumah Sederhana Tahan Gempa, Universitas Gadjah Mada, Jogjakarta.

Noorhidana, V.A., Sugiri, S.M. dan Soemardi, B.W., "Analisis Eksperimental Kolom Pracetak Dry Joint Akibat Beban Siklik Lateral," Jurnal Teknik Sipil, Vol. 8, Juni 2002, hal. 40-50.

Purwono, Rachmat (2005), Perencanaan Struktur Beton Bertulang Tahan Gempa (Sesuai SNI-1726 dan SNI-2847 Terbaru), ITS Press, Surabaya.

Tirtajaya, R., Tavio dan Suprapto, K. 2010. "Perilaku dan Perancangan Kolom Pracetak untuk Rumah Sederhana Cepat Bangun Tahan Gempa dengan Sistem Rangka Berdinding Pengisi (Infilled- Frame)", Surabaya. Institut Teknologi Sepuluh Nopember.

SNI 03-1726-2002, Tata Cara Perencanaan Ketahanan Gempa untuk Bangunan Gedung, Badan Standarisasi Nasional, Bandung.

SNI 03-2847-2002, Tata Cara Perhitungan Struktur Beton untuk Bangunan Gedung, Badan Standarisasi Nasional, Bandung.

Wiryanto Dewobroto, (2005), Aplikasi Rekayasa Konstruksi dengan Visual Basic 6.0 (Analisis dan Desain Penampang Beton Bertulang sesuai SNI 03-2847-2002), PT. Elex Media Komputindo, Jakarta.

Yee, Alfred A., "Structural and Economic Benefits of Precast/Prestressed Concrete Construction," PCI Journal, Vol. 46, No.4, Juli 2001, hal. 34-42.

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