

DUCTILITY AND DISTRIBUTION OF STRAINS ON COLUMN REINFORCEMENT RETROFIT WITH WIRE MESH

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Abstract

A lot of damage to building structures due to earthquakes is damage to column components that serve as vertical elements to pass the load to the foundation. Ductility is one of the parameters that must be owned by the column and as part of the column, longitudinal reinforcement is part of the column element that is quite vital and one of the parameters that can be studied is the distribution of strains that occur in longitudinal reinforcement when burdened with cyclic loads. In this study, a study of the ductility and distribution of strain values occurred in the reinforcement of control columns and retrofit columns with wire mesh size M6. From the test results it can be seen that on the column that is retrofitted with wire mesh and SCC experienced an increase in the value of ductility. While the strain value on the reinforcement of the control column and retrofit column tends to enlarge when it is in the plastic hinge area of the column. In the control column the strain value that occurs in the plastic hinge area is greater than the strain value in the retrofit column, so that in the control column the plastic hinge mechanism has begun to form, while in the retrofit column the plastic hinge mechanism has not been formed due to higher stiffness.

Keywords:

Concentric load;
Multiple mixes;
Eccentric load;
Fine aggregate replacement;
Reinforced concrete.

1 Introduction

Earthquakes are natural disasters that can cause damage even failure to building structures that are not designed against earthquake loads [1-4]. In general, damage to building structures caused by earthquakes can be from minor damage to severe damage, where severe damage to the structure can occur in the event of a failure in the column that causes total wrinkles on the structure [5-8].

As part of the portal, the column structure must have sufficient strength, stability and ductility, in order to be able to channel the working load to the foundation, where the ductility that occurs in the column is determined by the mechanism of plastic hinge that are likely to form at the ends of the column due to earthquake loads and one of the efforts to reduce possible failures in the column plastic hinge area by installing jacketing [9-11]. In general, efforts made to restore and improve the capabilities of the structure are called retrofit [12-14] and based on the material used consists of the installation of concrete jackets, steel jackets, ferrocement laminated jackets, Fiber Reinforced Polymer (FRP) restraints and other material combinations [15, 16].

Reinforced concrete column is a structural component consisting of longitudinal reinforcement, transversal reinforcement and concrete [17-19]. As part of the column, the built-in reinforcement will determine the behavior and strength of the column, so one of the parameters that can be studied is the distribution of strains that occur in the column reinforcement. In this study, a study of the ductility

and distribution of strains that occurred in reinforced concrete columns that were retrofitted along the column body using wire mesh size M6 and Self Compacting Concrete (SCC).

2 Experimental method

The test specimens used in this study are square columns of reinforced concrete as many as 2 specimens, where specimen 1 is the control column and specimen 2 is a retrofitted column with wire mesh along the body of the column as presented in Fig. 1. For column reinforcement using 8D13 deformed steel bar as longitudinal reinforcement and plain reinforcement Ø8 as a transverse reinforcement, where the results of strong tensile steel reinforcement test are presented in Table 1.

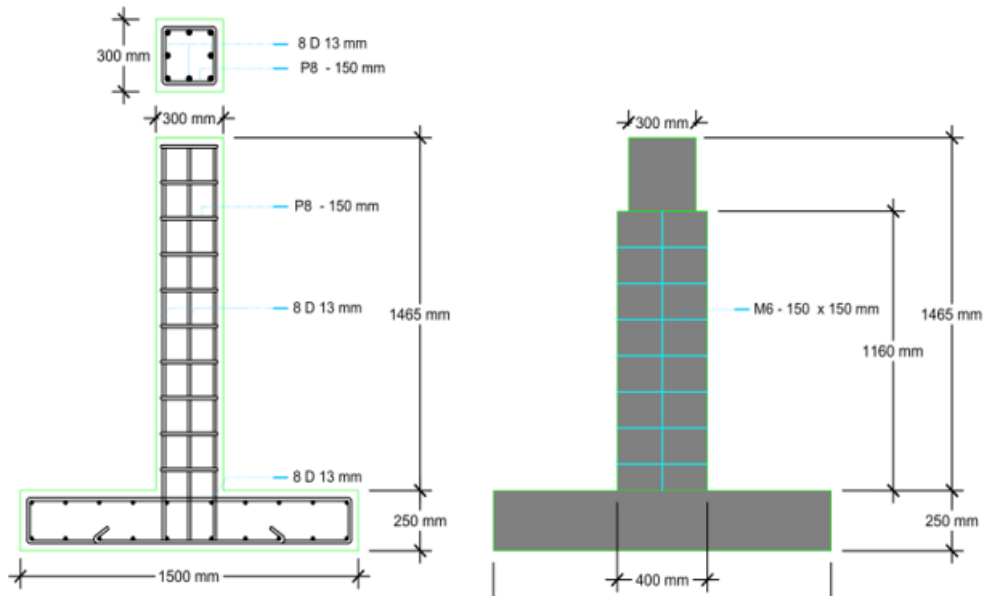


Fig. 1: Specimen dimensions.

Table 1: Test results of tensile steel reinforcement.

Diameter	Tensile stress	
	f_y [MPa]	f_u [MPa]
D13 (BJTS 520)	473.744	643.150
Ø8 (BJTP 280)	377.868	420.964

Initially Specimens 1 and 2 were made with the same dimensions and reinforcement using normal concrete with a quality of $f'_c = 25$ MPa. After the specimen is 14 days old, in specimen 2 then retrofit using wire mesh size M6 mm and Self Compacting Concrete (SCC) with quality $f'_c = 25$ MPa. To examine the behavior of strains that occur in the reinforcement then in both specimens are installed strain gauge before the specimen is cast at the same point as presented in Fig. 2.

Specimen testing is performed when the specimen is 28 days old, where the setting up of the test is shown in Fig. 3. Specimens were tested with cyclic load using displacement control method based on loading pattern required in SNI 7834:2012 [20], as shown in Fig. 4. During testing, each drift ratio must go through three full cycles, with phase 1 being the primary cycle and phases 2 and 3 being stabilizing cycles. During the test, data from loggers and computers were collected, as well as ocular observations of cracks in the specimen.

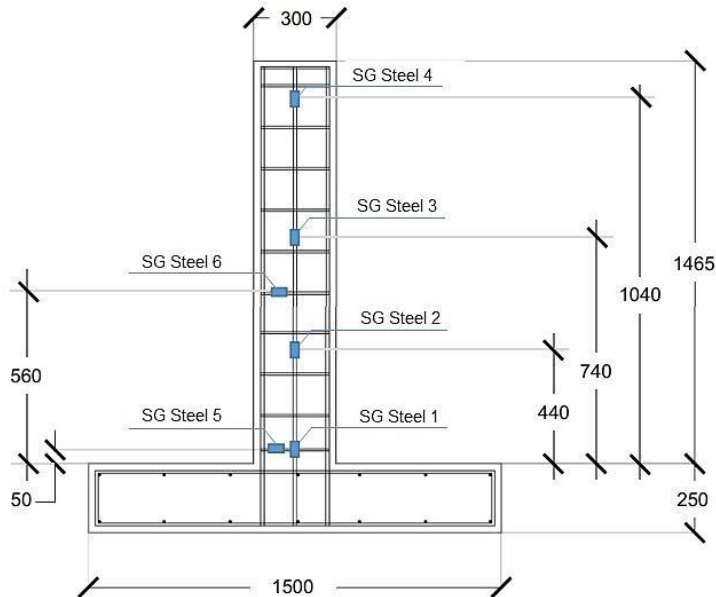


Fig. 2: Placement of strain gauges (SG) in specimens.

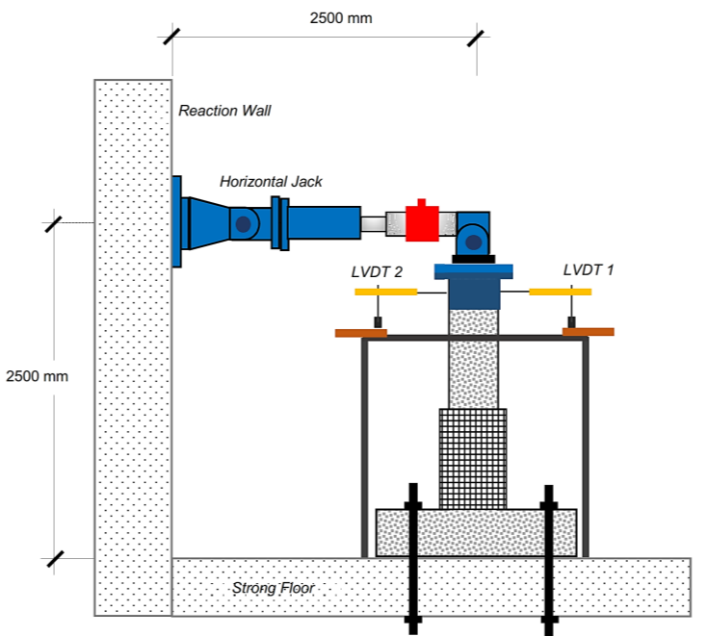


Fig. 3: Testing setting up.

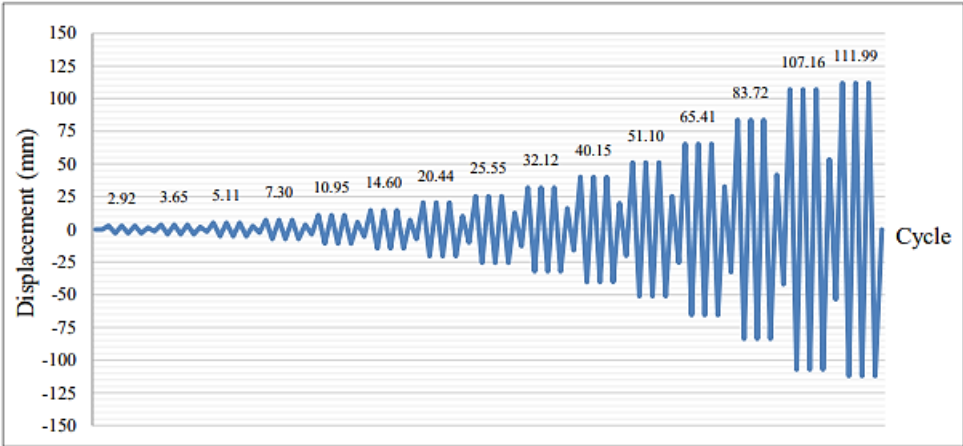


Fig. 4: Loading pattern on specimen.

3 Results and discussion

The test specimens used in this study are square columns of reinforced concrete as many as 2 specimens, where specimen 1 is the control column and specimen 2 is a retrofitted column with wire mesh along the body of the column as presented in Fig. 1.

3.1 Ductility

For the analysis of the ductility value that occurs in each specimen, refers to the values of load and displacement in the condition of the occurrence of the first crack, yield and ultimate as presented in Table 2 and Table 3. Based on the results of the analysis, the value of ductility in specimens 01 in push condition was 2.074 and tensile condition was 2.077. While in specimen 02, in push condition of 3.165 and in tensile condition of 3.144, as presented in Fig. 4.

Based on the average value, the value of ductility in specimen 01 is 2.076 and the value ductility in specimen 02 is 3.154, which according to the provisions in SNI 1726 for the value of ductility more than 1.5 is included in the performance level of the partial ductility structure. When compared to the value of ductility in specimen 01, the value of ductility in specimen 02 increased by 52.6 % in push load and 51.4% in tensile load. The increase in ductility occurred in specimen 02 due to the use of wire mesh as a retrofit material in the form of a series of longitudinal and transversal reinforcements that make specimen 02 get additional tighter shear reinforcements, by installing wire mesh that has a grid distance of 150 mm between transverse reinforcements installed with a distance of 150 mm.

Table 2: Load on the specimen at the time of the first crack, yield and ultimate.

Specimen Test	Load [kN]					
	P_{cr}		P_y		P_u	
	Push	Pull	Push	Pull	Push	Pull
01	9.890	-8.550	20.00	-23.00	24.98	-27.20
02	17.850	-11.01	30.00	-26.40	34.90	-37.00

Table 3: Displacement on the specimen at the time of the first crack, yield and ultimate.

Specimen Test	Displacement [mm]					
	Δ_{cr}		Δ_y		Δ_u	
	Push	Pull	Push	Pull	Push	Pull
01	4.850	-5.100	12.400	-13.000	25.720	-27.000
02	5.480	-5.480	12.750	-12.760	40.350	-40.120

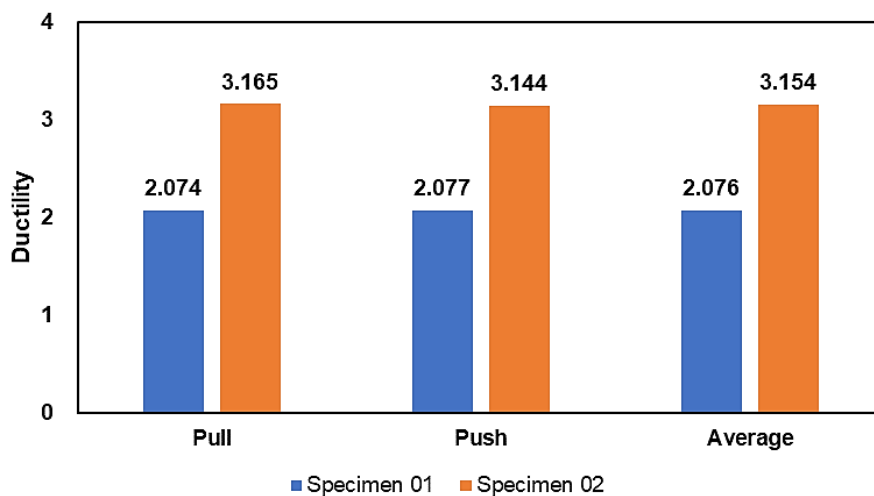


Fig. 4: Ductility in specimens.

3.2 Strain distribution

From the test results on specimen 01 which is the control column, the strain value on the longitudinal reinforcement mounted at a distance of 50 mm from the bottom edge of the column is

2200.90, at a distance of 440 mm by 866.038, at a distance of 740 mm of 707.574 and at a distance of 1040 mm of 586.792. The distribution of strains on longitudinal reinforcement specimen 1 is presented in Fig. 5.

Based on these conditions, longitudinal reinforcement at a distance of 50 mm or in the approximate area of the column plastic hinge has yielded and the mechanism of plastic hinge has been formed, while longitudinal reinforcement at a distance of 440 mm, 740 mm and 1040 mm is not yielded. In addition, the distribution of longitudinal reinforcement strain values read in Fig. 5 forms an increasing pattern when in the plastic hinge area of the column.

From the test results on specimen 2, which is a retrofitted column with wire mesh along the column body, the longitudinal reinforcement strain value mounted at a distance of 50 mm from the bottom edge of the column is 928.302, at a distance of 440 mm by 135,849, at a distance of 740 mm of 130.634 and at a distance of 1040 mm of 34.230 mm. The graph of strain distribution on longitudinal reinforcement of specimen 2 is presented in Fig. 6.

Based on these conditions, longitudinal reinforcement in specimen 2 does not melt and the distribution of the readable strain value in longitudinal reinforcement forms an increasing pattern when in the plastic joint area of the column.

In specimen 02, the strain value that occurs in longitudinal reinforcement is relatively smaller when compared to the strain value that occurs in specimen 01. This is due to the effect of retrofit installation of M6 wire mesh along the column cross section, resulting in the addition of dimensions in the original cross section from 300 x 300 mm to 350 x 350 mm. In addition, due to the installation of retrofit with wire mesh the rigidity value in specimen 02 becomes larger and stiffer when compared to specimen 01, so in the same condition has not formed the mechanism of plastic joints in the column legs in specimen 02.

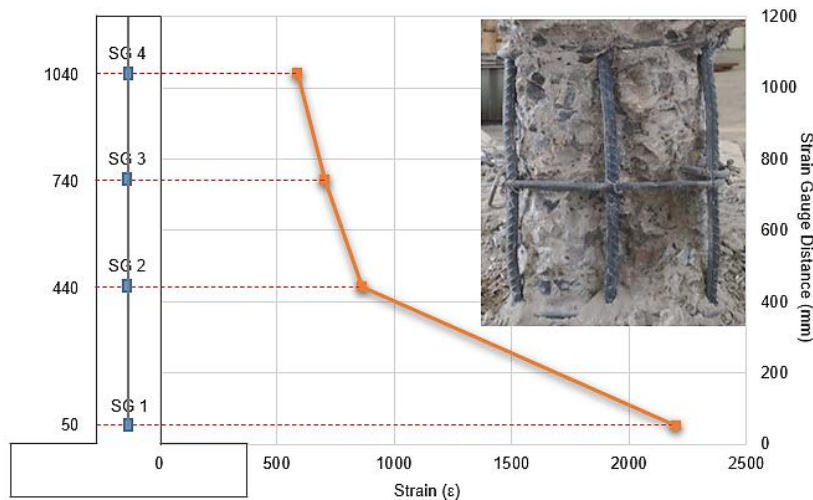


Fig. 5: Distribution of strain on longitudinal reinforcement of specimen 01.

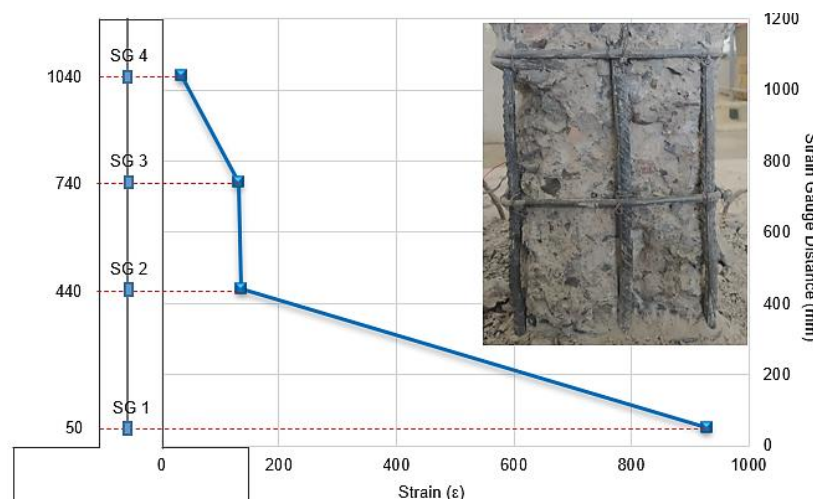


Fig. 6: Distribution of strain on longitudinal reinforcement of specimen 02.

3 Conclusion

The value of the ductility in the fully retrofitted column model with wire mesh along the column body increased by 53 % in push loading and 51 % in tensile loading, when compared to the value of the ductility in the column model that was not retrofitted with wire mesh.

From the test results, it was found that the strain value on the column reinforcement tends to be enlarged in the plastic hinget area of the column both on the control column and the retrofitted column with wire mesh along the column body. In addition, a retrofitted column with wire mesh along the column body produces a smaller strain value compared to the control column.

For future research opportunities can be conducted a study of the ductility and distribution of strains on column reinforcement retrofitted with wire mesh in the area of plastic hinge with variations in the size of wire mesh, thick retrofit layer with normal concrete or other materials.

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