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The Effect of Changing in Material and Details in Precast Column Socket Foundation on Bending Capacity: A State of the Art Review

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Abstract: In this study, the behaviour of the column-foundation connection in the precast reinforced concrete structures was observed and studied. Two different type of precast columns with same socket foundation were chosen and based on previous studies that were carried out by Canha in 2004 and Ebeling in 2006. This observation will be based on the compression of ultimate load between experimental models in term of comparison, assumptions, recommendation and aspects in changing the materials and details in the column part.

Key words: Precast column, connection, socket foundation, experimental investigation, bending capacity, embedded length

INTRODUCTION

The column-socket foundation connection used in precast concrete structures is constructed by embedding a column portion (embedded length) into a cavity of the foundation. The space between the cavity and the column is filled-up with cast-in-place concrete. Although, column-socket foundation connection in precast constructions has been used widely locally and internationally, the behaviour of column base connections is not fully understood. There are few experimental investigations related to socket foundation connections that have been carried out by other researchers such as Canha (2004), Ebeling (2006), Jaguaribe (2005), Leonhardt and Monnig (1973), Elliott (1996), Willert and Kesser (1983), Olin *et al.* (1985) and Osanai *et al.* (1996) but the behaviour of models in term of different materials and design of column part with same socket foundation has not been investigated.

In this study, the observation study has been carried out to investigate the behaviour of column-foundation connection with different material properties and design. The comparison was made between two types of precast column with same socket foundation that has been tested by other researchers.

Until now, various studies have been carried out on theoretical and experimental investigation of column to foundation connections. In this study, two different design of column in the same socket foundation were chosen. The first model which is PL80 was from Ebeling (2006) and the second one was from Canha (2004). Both models have the same properties as shown in Table 1 as well as the concrete compressive strength for socket base, whilst for column and joint part, the concrete properties are shown in Table 3 and 4. In term of modulus of elasticity, both models of Canha (2004) and Ebeling (2006) are having the save values for socket as shown in Table 2 but having different values for column and joint part as shown in Table 3 and 4. Both Table 3 and 4 also shown that model IL3 has bigger concrete compressive strength and concrete tensile strength in column and

Table 1: Model properties of IL3 (Canha, 2004) and PL80 (Ebeling, 2006)

Model	Interface	e (cm)	l_{emb} (cm)
PL80	Smooth	120	80
IL3	Smooth	120	80

Table 2: Results of concrete material in socket base of IL3 (Canha, 2004) and PL80 (Ebeling, 2006)

Model	Days	f_{cm} (MPα)	$f_{ctm,sp}$ (MPα)	E_{cm} (Gpα)
PL80	124	35.44	2.29	29.1
IL3	124	35.44	2.29	29.1

Table 3: Results of concrete material in column of IL3 (Canha, 2004) and PL80 (Ebeling, 2006)

Model	Days	f_{cm} (MPα)	$f_{ctm,sp}$ (MPα)	E_{cm} (Gpα)
PL80	123	54.40	2.95	45.0
IL3	123	59.37	3.71	36.8

Table 4: Results of concrete material in joint of IL3 (Canha, 2004) and PL80 (Ebeling, 2006)

Model	Days	f_{cm} (MPα)	$f_{ctm,sp}$ (MPα)	E_{cm} (Gpα)
PL80	10	53.1	2.37	35.1
IL3	10	65.01	4.09	40.7

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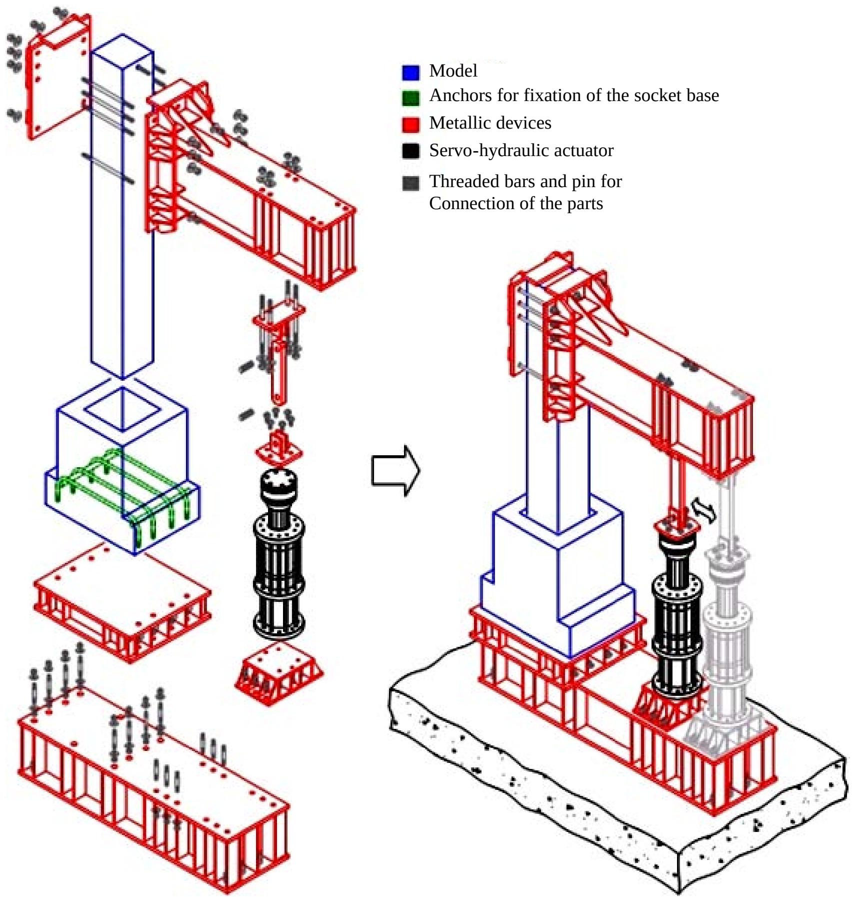

Fig. 1: Schematic of test models (Canha, 2004)

Table 5: Compression of ultimate load and ultimate moment of IL3 (Canha, 2004) and PL80 (Ebeling, 2006)

Model	Ultimate load (KN)	Ultimate moment (KN.m)
PL80	242	290
IL3	336	403

joint. In term of modulus of elasticity, model PL80 is bigger in column's part but is smaller than IL3 in joint's part as shown in Table 3 and 4 for the column and joint's material but they are same in base concrete material as shown in Table 2. The experimental results for both models are shown in Table 5 and it can be observed that model IL3 has bigger ultimate load of as 336 KN compared to model PL80 with 242 KN and as well as the ultimate moment for model IL3 which is 403 KN compared to PL80 with 290 KN.

Both models were subjected to the action of normal force with a large eccentricity in the order of e = 1850 mm for model IL3 and e = 1200 mm for model PL3. This eccentricity is justified by the fact that it is ordinary, not physically but in relation of M_d/N_d is provided in frames of precast concrete structures. Applying the load is same for both models in which the column part is connected to a servo-hydraulic actuator by a metallic device to apply the normal force as shown in Fig. 1.

From Fig. 2 and 3, it can be noticed that the reinforcement used in column model IL3 is stronger than model PL80 with diameter bars of 32 mm in compression and 12.5 mm in diameter for tension side, compared to model PL80 with diameter bars of 20 mm in compression and 10 mm in tension side. In the other hand, there were more reinforcements used in embedded length of model IL 3. Finally, Fig. 4 shows the points of transducers for having a good compression between the two models. In evaluating the displacement of the column closed to region of embedded length, two transducers were arranged in which one on the tensioned side and the other on the compressed side. Figure 5-7 show the diagrams of applied force-displacement at point TD-1, TD-2 and TD-3.

Due to the place of transducers of TD-2 and TD-3 which are fixed on top of transverse walls of 1 and 2 in region of connection between joint and socket base

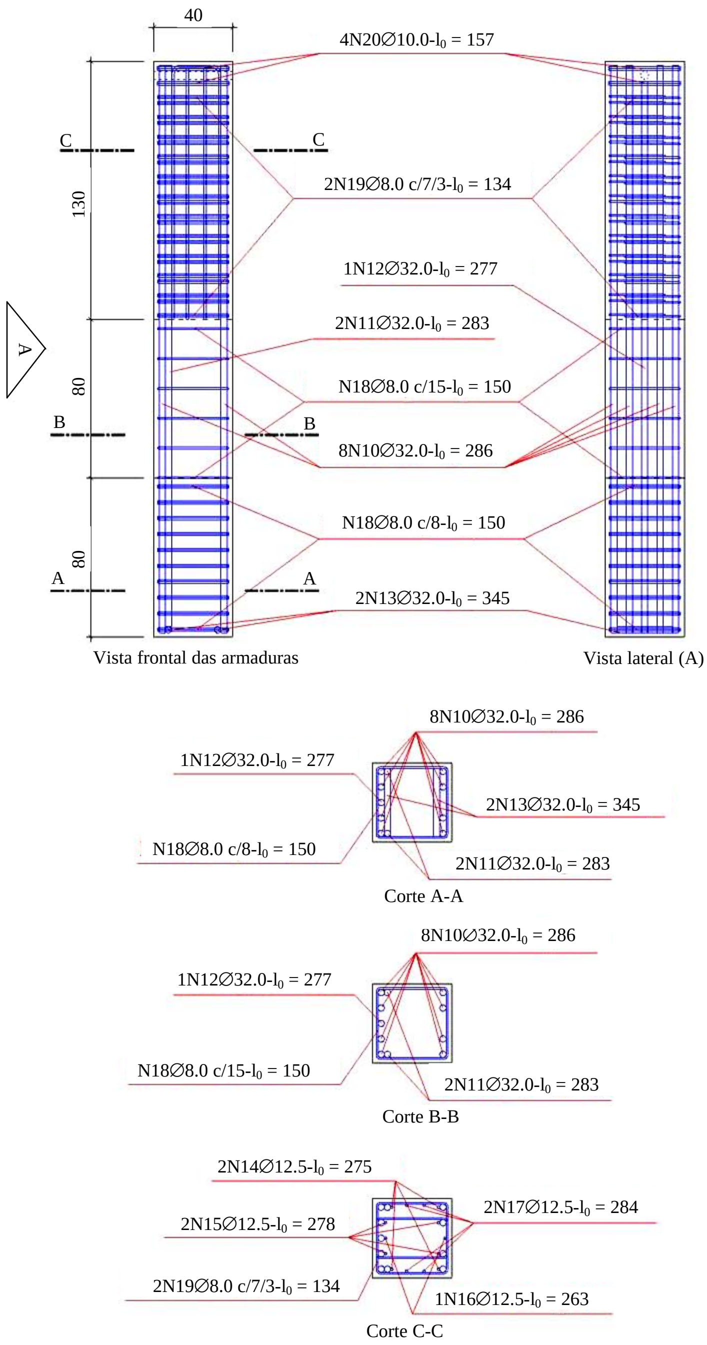

Fig. 2: Details of the column in model of IL3 (Canha, 2004)

concrete and due to detachment between the joint and socket base concrete, there is a little separation in this region. Therefore, displacement of the tension side of column has been larger than the compressed side in model PL80. The connection in tension side can be classified as rigid in model IL3. As the starting of the separation and sliding between the joint and socket base concrete which occurred since the beginning of loading, the curve of transducer in tension side shows different rigidities along the loading resulting from the progressive increase of the separation in region between joint of the socket base concrete.

As shown in Fig. 5, the results of transducer TD-1 in model PL80 was around 70 mm for horizontal displacement, whilst model IL3 was around 60 mm. Although, the horizontal displacement of model of

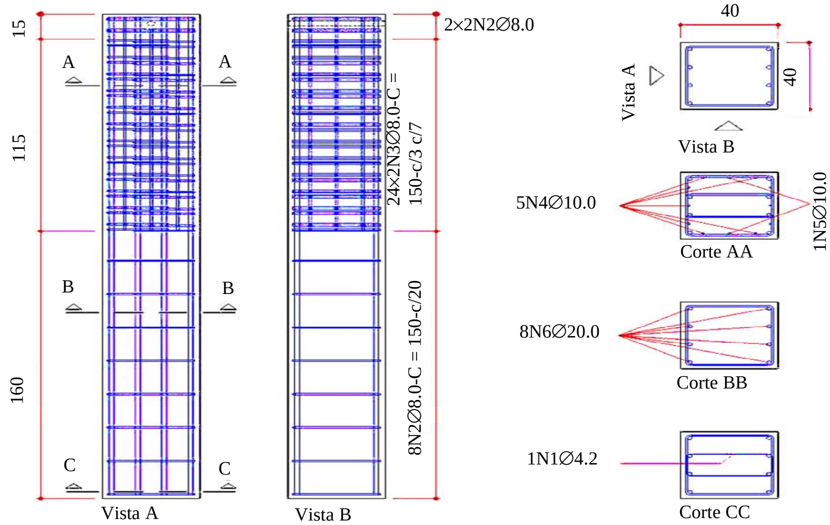

Fig. 3: Details of the column in model of PL80 (Ebeling, 2006)

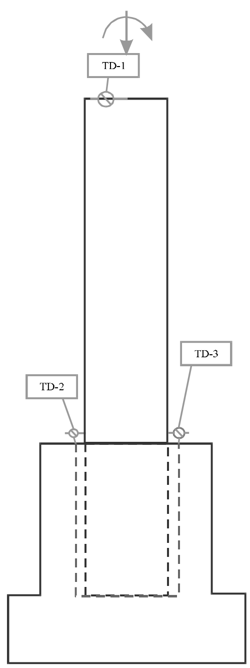

Fig. 4: Points of the transducers in the column to socket foundation connection in two models of IL3 (Canha, 2004) and PL80 (Ebeling, 2006)

IL 3 was around 60 mm but it is observed that this model has higher applied force of 336 KN in relation to PL 80 with 242 KN (Fig. 5).

For transducer TD-2 shown in Fig. 6, depicted the separation of the column and joint on top of the embedded length and presented an opening about 3.0 mm for model PL80 and 8.0 mm for model IL3 (Fig. 6).

Figure 7 shows the experimental results of transducer TD-3 with very small displacements around 0.2 mm for

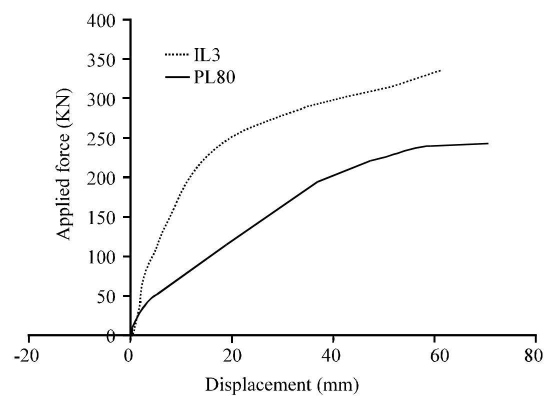

Fig. 5: Diagrams of applied force displacement of the point of TD-1 in models of IL3 (Canha, 2004) and PL80 (Ebeling, 2006)

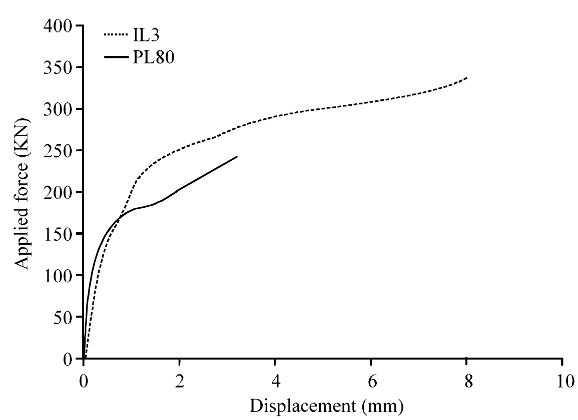

Fig. 6: Diagrams of applied force displacement of the point of TD-2 in models of IL 3 (Canha, 2004) and PL 80 (Ebeling, 2006)

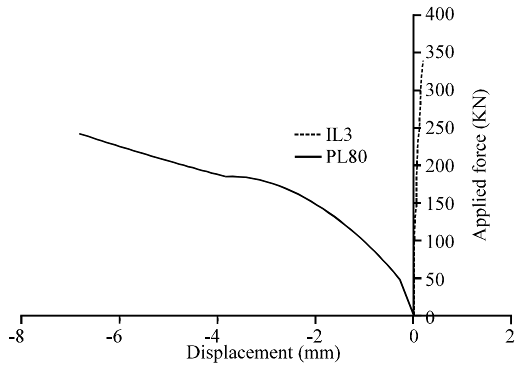

Fig. 7: Diagrams of applied force displacement of the point of TD-3 in models of IL3 (Canha, 2004) and PL80 (Ebeling, 2006)

model IL3, showing that movement in these sections is negligible. Therefore, the connection can be classified as substantially rigid. This transducer also clearly shows the separation of the column and joint on top of the embedded length with an opening about 7.0 mm for model PL80 (Fig. 7).

CONCLUSION

Based on the experimental results of both models, the following conclusions can be drawn:

- The models represent the behaviour concerning the base of precast column in the socket foundation connections with smooth interfaces. It is valid for the cases of loads with large eccentricities with a section partially compressed and for embedded lengths as 2 h, values used in the experimental investigation
- For column with socket base connection, failures have occurred outside of the embedded region with yielding of the longitudinal reinforcement in the tension side of the column base connection
- The amount of the transverse and longitudinal reinforcement calculated by Ebeling (2006) was less than Canha (2004)
- The increasing strength of materials and reinforcements used for compression side between this two different model of column and same socket base with same embedded lengths, it can be observed that the increasing can effect on the ultimate load directly. However, it does not effect on the displacements at the specific points. Displacement can also decrease with increasing the strength of materials and size of reinforcements

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NOMENCLATURE

e = Eccentricity of axial load
E_{cm} = Average concrete modulus of elasticity
f_{cm} = Average concrete compressive strength
$f_{ctm,sp}$ = Average concrete tensile strength determined by split cylinder tests
l_{emb} = Embedded length

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