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ANALYSIS OF REINFORCED CONCRETE COLUMNS FITTED INSIDE STEEL CASINGS

Dr. Amjad Hameed Abd Al-Razaq
Civil Engineering Department
College of Engineering, University of Kufa
amjad881980@yahoo.com

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Abstract

Due to construction costs and operational issues have been in this study to discuss how to strengthen the concrete columns. The results of previous studies on the construction of some structures earthquake-prone weakness reinforced concrete columns. The inside steel casings surrounding the columns is a modern technique used in many countries today for columns of rectangular and circular concrete. The advantages of this method is convenient, economical and easy. Reference model in this study is a column concrete without casing steel and the others concrete columns were wrapped casings steel to study the amount of retrofitting, and which has been approved changing the thickness of the cover steel are the main variable in this research. Were analyzed columns under the effect of axial force using the finite element method by using the program **ANSYS (version 11).** The results showed that increase the susceptibility of the inside steel casings bearing concrete columns of force inflicted by the largest of the main form without the steel casing, as well as to increase the thickness of the cover leads to increased endurance.

Keywords: Reinforced Concrete, Columns, Retrofitting, Coated Steel, Enclosed Punctures.

دراسة سلوك الأعمدة الخرسانية المسلحة المغلفة بالفولاذ

م.د.امجد حميد عبد الرزاق/جامعة الكوفة/كلية الهندسة

الخلاصة

بسبب تكاليف البناء والمسائل التنفيذية فقد تم في هذه الدراسة مناقشة كيفية تقوية الأعمدة الخراسانية. أظهرت نتائج الدراسات السابقة على بعض الهياكل الإنشائية المعرضة للزلازل ضعف الأعمدة الخرسانية المسلحة. ان استخدام الأغلفة الفولاذية المحيطة بالأعمدة الخرسانية المستطيلة و الدائرية تمثل تقنية حديثة تستخدم في كثير من البلدان. ومزايا هذه الطريقة اقتصادية وسهلة التنفيذ. النموذج المرجعي في هذه الدراسة هو عمود خرساني بدون غلاف فولاذي اما باقي الأعمدة الخرسانية فقد تم تغليفها بأغلفة فولاذية لدراسة مقدار التقوية فيها, وقد تم اعتماد تغيير سمك الغلاف الفولاذي المتغير الرئيسي في هذا البحث.تم تحليل الأعمدة تحت تأثير قوة محورية باستخدام طريقة العناصر المحددة من خلال برنامج **ANSYS (الإصدار 11).** أظهرت النتائج أن الاغلفة تزيد من قابلية تحمل أعمدة الخرسانية للقوة المسلطة عليها أكبر من النموذج الرئيسي بدون غلاف الفولاذي، وكذلك ان زيادة سمك الغلاف يؤدي إلى زيادة التحمل حيث تزداد قوة التحمل تقريبا 1.16 من قوة التحمل بالنسبة لسمك الاغلفة 3 سم و الى 3.4 من قوة التحمل بالنسبة لسمك الاغلفة 5 سم بالنسبة الى النماذج الاصلية.

الكلمات الدالة: أعمدة ,الخرسانة المسلحة، غلاف فولاذي، تقوية، قوة محورية

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1.Introduction

The main problem of failure of reinforced concrete columns (RC) subjected to earthquakes load is the lack of ductility and strength..

Generally concrete columns with steel bars were made up in order to increase the bending strength of the longitudinal reinforcement in the column. However, rarely transverse reinforcement was used. During an earthquake, reinforced concrete columns in axial and lateral loads reciprocating with three main modes of failure include shear, flexural and plastic joint connecting patches failures. Due to the sudden shear failure (brittle behavior) is the more dangerous of the three mentioned failure mode, so special measures should be taken to prevent this failure. The failure in the area of the damaged concrete columns, longitudinal reinforcement of the column buckling and no early warning loses in its strength. Example of this type of failure can be seen in **Figure 1 (The earthquake Northridge 1994).**

In short columns shear strength are inadequate with compared to stiffness and resistance to the applied load. The crack shear transfer across cracks which caused by expansion of the transverse reinforcement strain is associated with a significant reduction in the transfer of shear transverse reinforcement surrender occurs. Columns of buildings that have been conducted in the past have often contain small amounts of transverse reinforcement, when the strain to the yield strain or even most of it is rapidly decreasing in strength and stiffness of the column occurs. The last earthquake happens to be vulnerable to such members have clearly shown **(J. F. Hall et al, 1994, C. D. Comartin et al , 1995, Fung, G. G. et al, 1971)**

Several researchers have stated that columns without jacket are more likely to be damaged under earthquake- related crushing than those with jacket. These methods can be listed in three categories including: coated steel, concrete and composite (FRP) are studies on the technique of using coated steel compared to other techniques, particularly the use of composite coatings is negligible. The inside steel casings technique given two main advantage is considerable:

1- The overall height of the confining concrete columns and also avoid packing.
2- Ease of implementation and is not available to the other two methods.

According to the relevant literature, there are many techniques that have been employed to retrofitting reinforced concrete columns. This research presents several studies that used the steel coating technique as one of the most common methods in reinforced concrete retrofitting.

Aboutaha et al (1996 and 1999) using a clad steel for rectangular pillars which are connected by bolts to the column suggested that the inhibitory **(R. S. Aboutaha et al, 1999 and R. S. Aboutaha et al,1996). Priestley et al (1994)** have proposed the use of coated steel circular or elliptical **(M. J. N. Priestley et al, 1994).**Also **Xiao (2003)** conducted studies throughout the coating thickness is less recommended for retrofitting **(Y. Xiao et al, 2003)**

In the present study steel plates with a thickness of 3 and 5 mm are coated and the reinforced concrete columns with dimensions of 1500*350*350 millimeters. The compressive strength of concrete of 12, 15 and 20 MPa are used in the present study. The ANSYS software will be used to compare the analytical model results with ensure the

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experimental results of samples without coating reinforced concrete columns with dimensions 750*150*150 mm.

Fig. 1: Northridge (1994) Shear failure at the Base of the Bridge due to Confining (Fung, G. G. et al, 1971).

2. The Finite Element Model

2.1 Concrete

The ANSYS software is used to model the concrete by element SOLID65. This element is a three-dimensional elements to model concrete with (or without) rebar is used. This element is able to model concrete cracking in the tensile and compressive regions it is crunch. The SOLID65 content eight points is integrated with the control condition in which cracks or comminution takes place and each node has three degrees of freedom in order x, y and z criterion is based on the triaxial behavior is Willam-Warnke behavior. The **Figure 2** shows a general view of the element. Note that this element is able to model the behavior of nonlinear geometric and material **(ANSYS, 2011).**

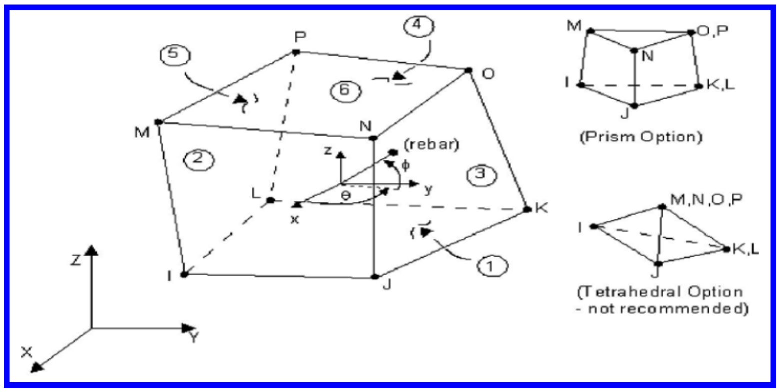

Fig. 2: The placement of Nodes and Others, the Element SOLID65 (ANSYS Program (Ver. 11.0)).

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3. Longitudinal and Transverse Reinforcement

Longitudinal and transverse reinforcement element LINK8 modeling of concrete elements at the nodal points are used. This type of truss element has two nodes **(Figure 3)**, each node has three degrees of freedom of motion is non-elastic deformation of these elements has ability to handle **(ANSYS, 2011)** and material properties for the steel reinforcement for all columns are shown in **Table 1**.

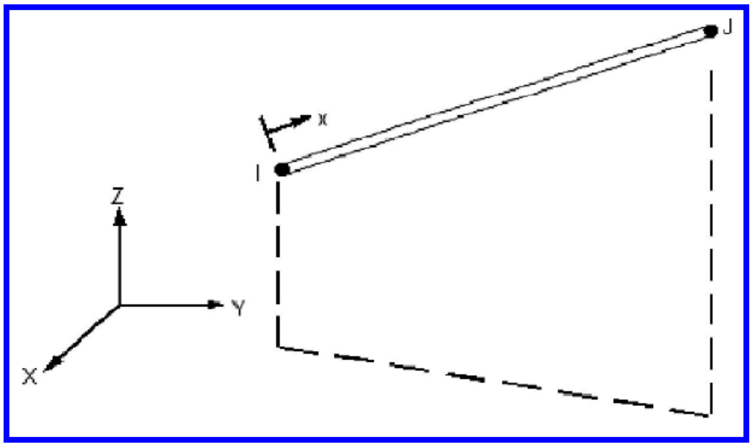

Fig. 3: The nodes of the element LINK 8
(ANSYS Program (Ver. 11.0))

Table 1: Material properties for the steel reinforcement

Elastic modulus MPa	Stress yield MPa	Poisson's ratio
200000	420	0.3

Coated Steel

The element **SHELL43** is used to model the steel jacket **(ANSYS, 2011)** and material properties for the steel coated for columns are shown in **Table 2.**

Table 2 :Material Properties for the Steel Coated

Tensile Strength Ultimate MPa	Tensile Strength Yield MPa	Modulus of Elasticity MPa	Poisson's Ratio	Shear Modulus MPa
500	250	200000	0.26	80000

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4. Description of the Experimental Sample

To compare the model with experimental results, a review of the literature and research results by **Seangatith in 2009** conducted on 36 reinforced concrete columns **(Seangatith, S. et al, 2009),** a reinforced concrete column was selected as the simulation is performed. The column dimensions are 750*150*150 mm. The compressive strength of cylinder of column is 18 MPa. They are four longitudinal reinforcement has diameter 12 mm and transverse reinforcement has diameter ϕ 6 @ 150mm. **Figure 4** shows the both theoretical (Ver-18-0-150) and experimental (C-18-0-150) results.The different between the theoretical and experimental results is that experimental sample is more stiff than theoretical. This is because of the theoretical models does not take into consideration the crashing, cracking, etc. and using Newton-Raphson method in analysis. Due to the gain curve of load - displacement based numerical model to the curve of load - displacement laboratory work is relatively time consuming, regardless of the chart is bearish, and has tried to carefully add up zone.

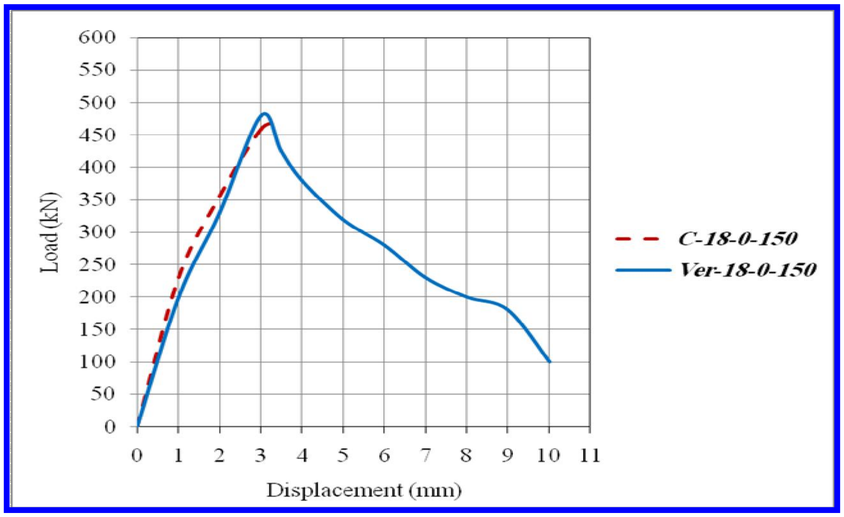

Fig. 4: Results of validation

4.1Analytical Samples

Studies have been conducted on three groups in each column dimensions 1500*350*350 mm with four longitudinal reinforcement at corners is 12 mm diameter and reinforcement of stirrup is 8 mm diameter with a distance is 10 mm was used. The first, second and third respectively in the columns with concrete compressive strength of cylinder of 12, 15, 18 and 20 MPa for the three groups of retrofitted steel cladding thickness of 3 and 5 mm is used.

In **Figure 5 , 6 and 7** for instance, the finite element model for reinforced concrete columns. In these models, for example, the model RC-12 reinforced concrete column with compressive strength of 12 MPa and not retrofitted columns, the model RC-12-3 shows the previous model, but enhanced by coating steel with thickness 3 mm are full contact between coating steel and reinforced concrete column.

Retrofitting the samples was applied axial load and no load is only the column does not apply to steel cladding. The software for the measurement of friction between concrete and steel plated contacts automatically with the friction coefficient 0.3 is used.

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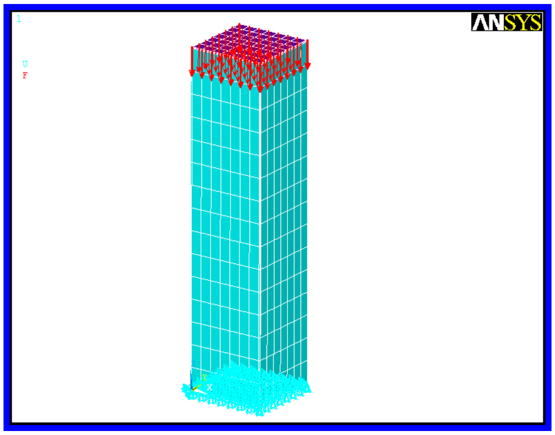

Fig. 5 : Finite Element Model of the First Group.

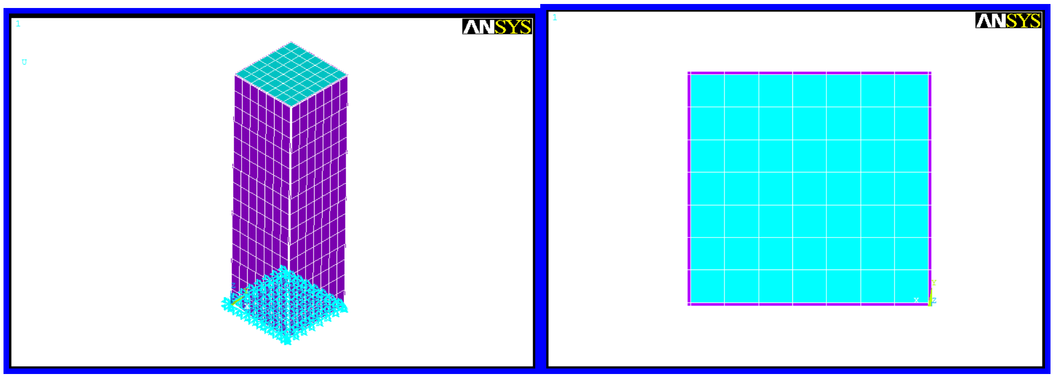

Fig. 6: Finite Element Model with Steel Jacet.

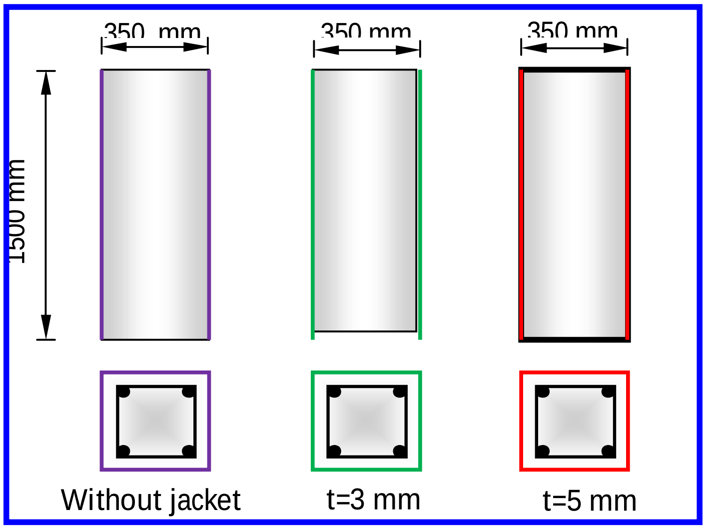

Fig. 7: A view of the Columns without Crowns and Reinforced

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Analysis of Samples

The First Group

A group of three columns was used to study the effect of strengthening. All columns have compressive strength 12 MPa. One column was tested without strengthening while, the other two columns were strengthened with steel plate of thickness 3 mm and 5 mm. Figure 9 illustrates the variation of axial load with displacement for the three columns mentioned above. It can be noted that steel plate increased the ductility by 38.71 % and 56.45 % for columns 3mm and 5 mm steel plate respectively. Hence, the column resistance was increased by 51 % and 70.34 % respectively.

The Second Group

A group of three columns was used to study the effect of strengthening. All columns have compressive strength 15 MPa. One column was tested without strengthening while, the other two columns were strengthened with steel plate of thickness 3 mm and 5 mm. **Figure 10** illustrates the variation of axial load with displacement for the three columns mentioned above. It can be noted that steel plate increased the ductility by 33.8 % and 51.3 % for columns 3mm and 5 mm steel plate respectively. Hence, the column resistance was increased by 49.5 % and 67 % respectively.

The Third Group

A group of three columns was used to study the effect of strengthening. All columns have compressive strength 18 MPa. One column was tested without strengthening while, the other two columns were strengthened with steel plate of thickness 3 mm and 5 mm. **Figure 11** illustrates the variation of axial load with displacement for the three columns mentioned above. It can be noted that steel plate increased the ductility by 29.3 % and 50.65 % for columns 3mm and 5 mm steel plate respectively. Hence, the column resistance was increased by 37.3 % and 53% respectively.

The Fourth Group

A group of three columns was used to study the effect of strengthening. All columns have compressive strength 20 MPa. One column was tested without strengthening while, the other two columns were strengthened with steel plate of thickness 3 mm and 5 mm. **Figure 12** illustrates the variation of axial load with displacement for the three columns mentioned above. It can be noted that steel plate increased the ductility by 24.7 % and 50 % for columns 3mm and 5 mm steel plate respectively. Hence, the column resistance was increased by 25 % and 40 % respectively.

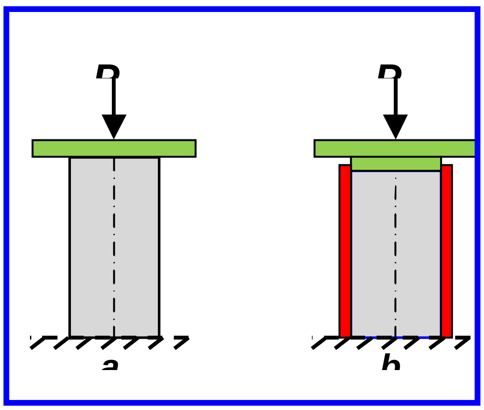

Fig. 8: a) Uncoated Non-Reinforced Concrete Column , b) Coated Reinforced Concrete Columns

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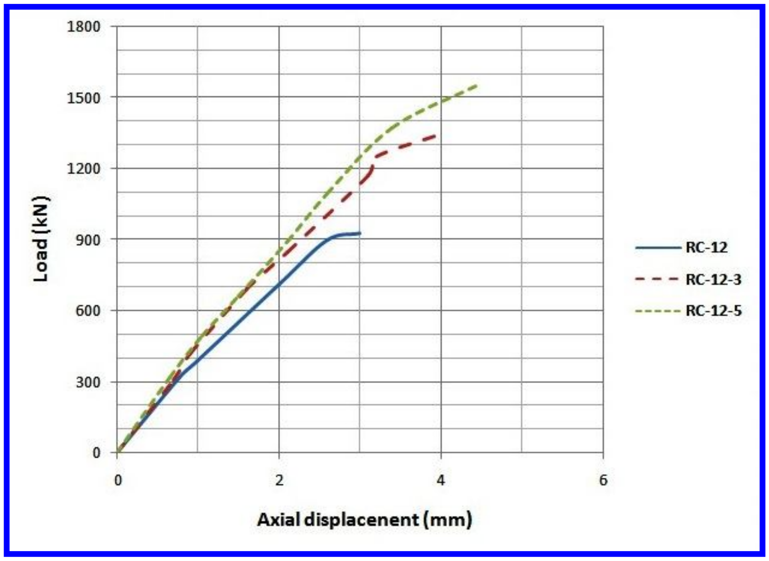

Fig. 9: Comparison of Numerical Results for the First Group of Reinforced Concrete Columns (Concrete with Compressive Strength of 12 MPa)

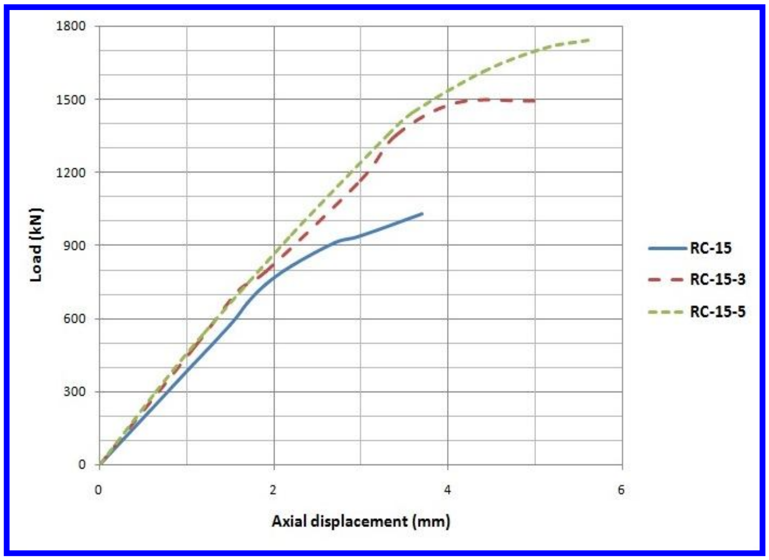

Fig. 10: Comparison of Numerical Results for the Second Group of Reinforced Concrete Columns (Concrete with Compressive Strength of 15 MPa)

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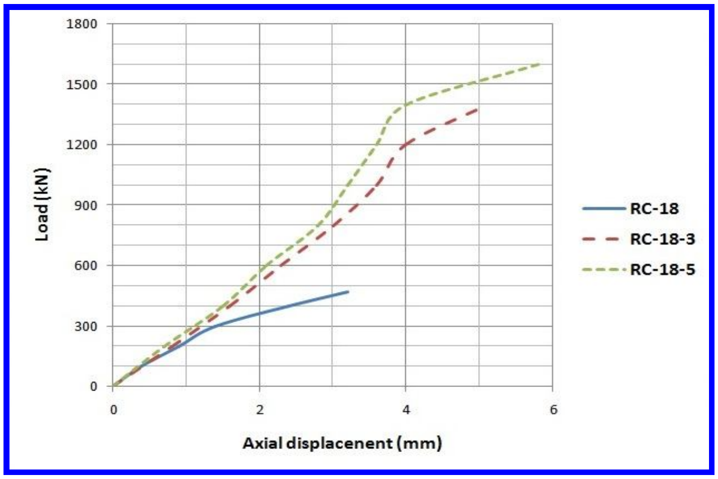

Fig. 11: Comparison of Numerical Results for the Third Group of Reinforced Concrete Columns (Concrete with Compressive Strength of 18 MPa)

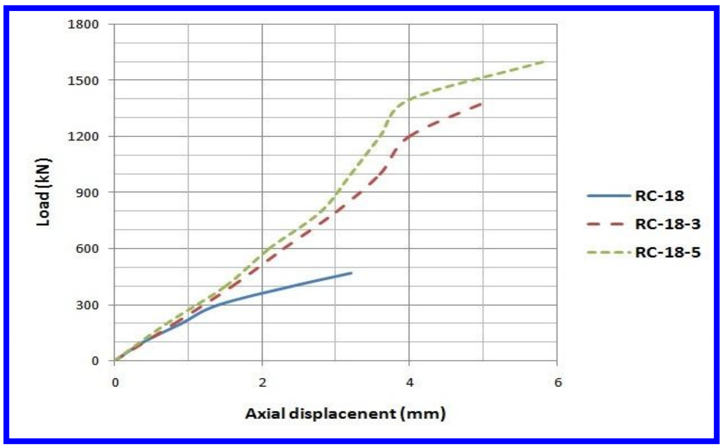

Fig. 12. Comparison of Numerical Results for the Third Group of Reinforced Concrete Columns (Concrete with Compressive Strength of 20 MPa).

1. Conclusion

1. Retrofitting technique by using coated steel and rubble packing the punch of concrete is prevented by increasing phenomenon (**confinement**), columns ductility and resistance dramatically increases. However, the coated columns behavior prevent shear failure of the softening tenderness transfer.
2. Most effective in improving behavior in the first groups (column compressive strength of concrete 12 MPa) is visible in the groups with cover 5 mm thickness and 3 mm thick coating shows higher efficiency, but also will cost more. The elastic behavior of columns retrofitted with increasing thickness is greater.
3. Due to the considerable impact of steel, cladding can be considered the beginning of the design of composite columns. It is expected that with the right combination of concrete

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and steel member strength, stiffness and ductility could be desired, since the characteristics of these two elements together is used.

4. Using steel pate thickness of 3 mm to coat the reinforced concrete columns of the present study tend to increase the axial compressive strength of coated columns which have cylinder compressive strength of 12, 15, 18 and 20 MPa by 1.15, 1.166, 1.14 and 1.115 respectively.
5. Using steel pate thickness of 5 mm to coat the reinforced concrete columns of the present study tend to increase the axial compressive strength of coated columns which have cylinder compressive strength of 12, 15, 18 and 20 MPa by 1.67, 1.7, 3.4 and 1.43 respectively.

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