©2016 Published in 4th International Symposium on Innovative Technologies in Engineering and Science 3-5 November 2016 (ISITES2016 Alanya/Antalya - Turkey)

Numerical Investigation of Effect of Dowels on the Slip Interface of RC Jacketed Columns

[1]Ahmed Farah, *[2]Naci Caglar, [2]Aydin Demir

[1]Institute of Natural Sciences, Sakarya University, Sakarya, Turkey
[2]Faculty of Engineering, Department of Civil Engineering, Sakarya University, Sakarya, Turkey

Abstract

Several factors can lead to affect the effectiveness of RC jacketing if a proper procedures will not be taken into account. A certain consideration has to be paid to interface between old-new concrete, which could reduce the flexural capacity. In accordance to that, the aim of the present work is to find a frictional coefficient representing the monolithic surface interaction between core and jacket of an experiment conducted by Vandoros and Dritsos in terms of load capacity. Later on a model is proposed for a minimum space limit of dowels to supply necessary friction between core and jacket surfaces to capture well roughness behavior. For that purpose, a parametrical numeric simulation analysis is conducted in a commercial FE analysis ABAQUS/Standard. Results obtained from the study shows that the friction between old-new surfaces of the experiment is well captured at 38%. Moreover, the specimen posing the maximum space limit showed to behave well with well roughness behavior in terms of displacement capacity.

Key words: Dowel, finite element analysis, ABAQUS, RC jacketed columns.

1. Introduction

Strengthening of Reinforced Concrete (RC) members mainly columns is vital due to several reasons including deficient in concrete production, damages due to earthquake, design errors and accidents such as explosions and some other situations involves changes in the functionality of the structure [1].

One of the best ways to mitigate damages to existing buildings once encountered with above stated natural and induced hazards is to retrofit the members of these structures to improve their shear strength and ductility. Common practices for retrofitting an existing concrete columns may include external post-tensioning and steel or carbon fiber reinforced polymer (CFRP) jacketing, textile reinforced mortar (TRM) jacketing and reinforced concrete (RC) jacketing. All just mentioned methods have showed improving column behavior primarily by increasing ductility of the concrete section [2].

Reinforced concrete jacketing is a common technique of retrofitting existing concrete columns. This technique comprises of casting a concrete layer around the existing member, and reinforcing the concrete layer with a properly designed amount of longitudinal and transverse reinforcement [3].

*Corresponding author: Address: Faculty of Engineering, Department of Civil Engineering, Sakarya University, 54187, Sakarya, TURKEY. E-mail addresses: caglar@sakarya.edu.tr

There are many studies proposing that finite element (FE) analysis comprising an appropriate numerical modeling technique and accurate constitutive material models is a quite reliable and robust tool to model and observe nonlinear behavior of RC members [4]. Due to the fact that, "FE analysis is widely preferred tool by researchers" [5].

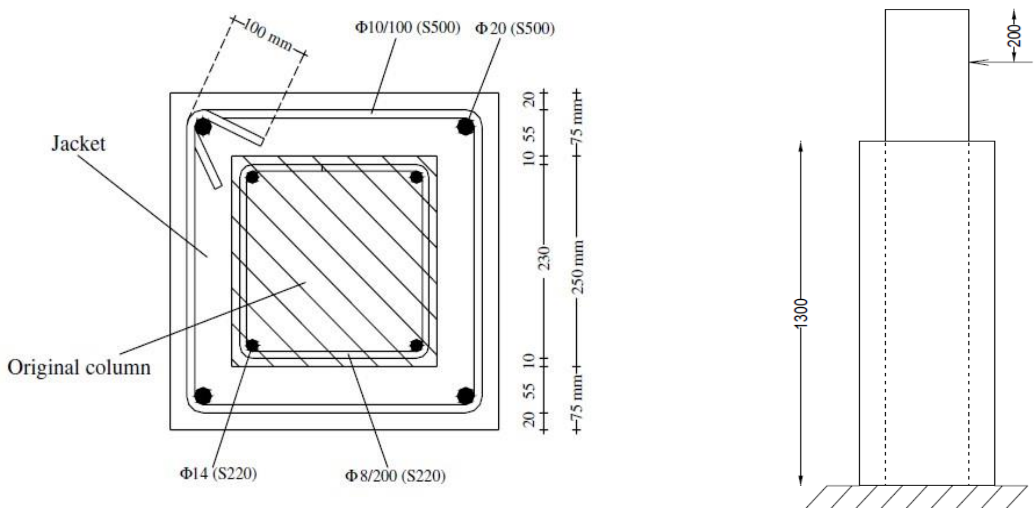
Additionally, in order to make a numerical simulation, first FE model should be verified sufficiently with experimental test results and later on a parametric study should be performed computationally by numerical analysis. During a numerical verification of a test result to create a FE model, a lot of parameters should be defined and calibrated into the model, e.g., constitutive material models, part (member) sections, mesh and assembly properties etc. [6].

Prakash et al. [7] conducted a finite element study on numerical modeling of nonlinear behavior of stud connected steed – concrete composite girder. A 3D finite element model study was developed and validated with an experimental test developed by the authors. Validation of the numerical model is done in terms of comparing the predicted energy absorption capacity, slip at interface, cracking and crushing of the concrete, yielding and local buckling of steel beam flanges with the corresponding values obtained in the experiments. Analysis results deduce that the FE model predicts a conservative value for ultimate load.

Several factors can lead to affect the effectiveness of RC jacketing if a proper procedures will not be taken into account. A certain consideration has to be paid to interface between old-new concrete, which could reduce the flexural capacity [8]. In accordance to that, the first aim of the present work is to find a frictional coefficient representing the monolithic surface interaction between core and jacket of an experiment conducted by Vandoros and Dritsos [9] in terms of load capacity. Later on a model is proposed for a minimum space limit of dowels to supply necessary friction between core and jacket surfaces to capture well roughness behavior. In response to that, a parametrical numeric simulation analysis is conducted in a commercial FE analysis ABAQUS/Standard.

2. Experimental study

As a reference study, an experimental study performed by Vandoros and Dritsos [9] has been selected in order to create a numerical model of an RC jacketed column. Two out of the three specimen in the reference study is selected as a reference verification specimens. These two reference verification specimens were namely N and E. More details about test setup, loading procedure and material properties can be reached in the reference study. Also, another four numerical specimens have been created named as **N_S – 1**, **N_S – 2**, **N_S – 3** and **N_S – 4**. The specimen geometry, reinforcement, loading procedure and material properties of the four proposed models are same with the two reference specimen except they have different configuration of dowels. The specimen geometry and reinforcement are demonstrated in Fig. 1. Moreover, configuration of dowels of the proposed models are given in Table 1.



a) Cross Section b) side view

Figure 1. Specimen geometry, reinforcement, and side view [10]

4. Numerical modeling

In this paper study, a commercial FE analysis software named ABAQUS/Standard [10] is used to generate a numerical simulation. Inelastic behavior of core and jacket concrete is defined for all FE specimens of the proposed model by using concrete damaged plasticity (CDP) model. A numerical FE modelling technique and material definitions have been utilized to perform the present numerical simulations that is similar with the study of Demir et al. [5]. Therefore the numerical FE modeling procure is not explained here and all details can be found in the related study. Additionally, the meshed model is displayed in Fig. 2.

Verification of load-displacement result of the test and the model in ABAQUS is figured in Fig. 3. In the experimental study, the tests results were obtained in terms of cyclic load-displacement behavior. In the study however that behavior is presented as positive part of back bone cure of that cyclic behavior. Therefore numerical and test results have been compared by considering that behavior. Moreover, since any tabular data representing the load-deflection graph of the reference study were not supplied, loads and corresponding displacement values are specified manually. It can be clearly seen from the graphs that the numerical models can successfully represent the actual nonlinear behavior of specimens tested in the experimental study.

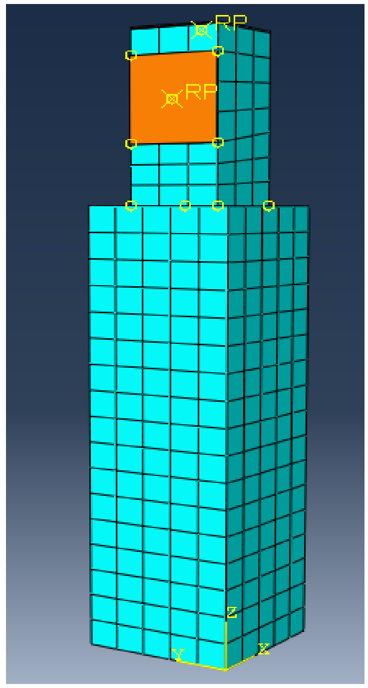
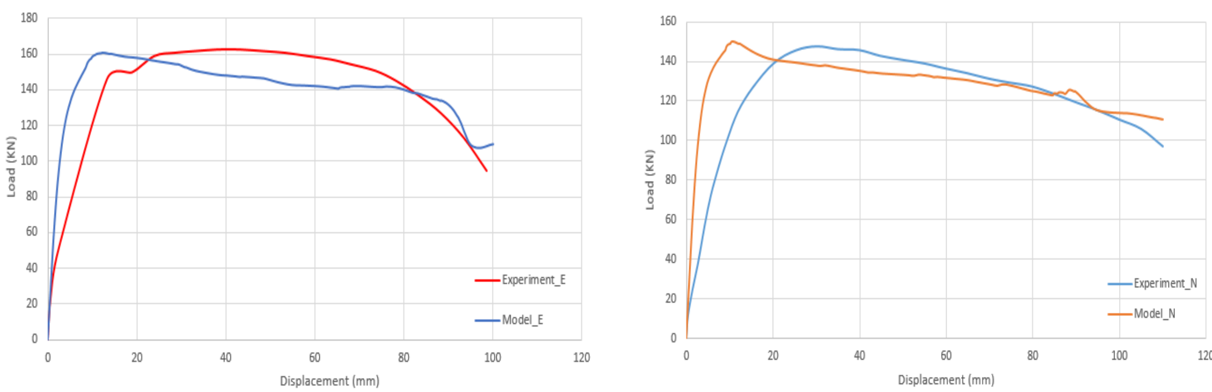


Figure 2. Meshed ABAQUS FE model [10]



a) Experiment – E vs. Model – E   b) Experiment – N vs. Model – N

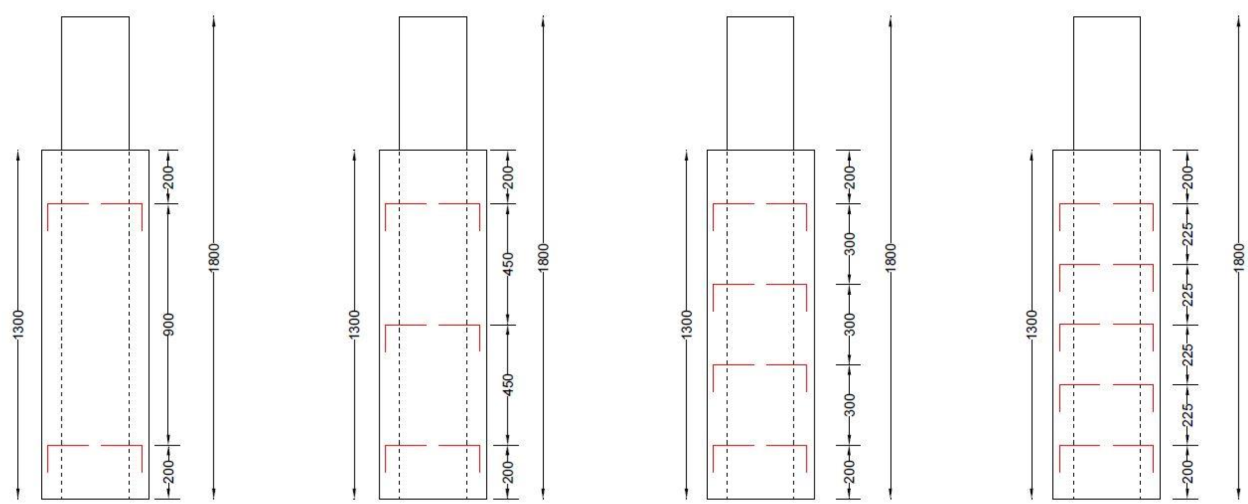
Figure 3. Load-deflection result of the experiment and the model

5. Parametric study

In order to investigate the behavior of an RC jacketed column with well roughened core to jacket interface and non-well roughened interfaces, a numerical simulation study is conducted. For that purpose, 4 different numerical models are created with varied configuration of dowels for all sides as tabulated in Table 1, also a sketch cross – section is depicted in Fig.4. Results of the numerical studies of Model _ N and Model _ E are compared with the experiment results in terms of load-displacement behavior and as can see from Fig. 3. The accurate load – carrying capacity has been obtained with the friction coefficient of 38% at the interface.

Specimen	No. of dowels at each side	Distance of first dowel from bottom	Space of internal dowels	Distance of last dowel from top
N_S-1	2	200	900	200
N_S-2	3	200	450	200
N_S-3	4	200	300	200
N_S-4	5	200	225	200

Table 1. Dowel configuration of the proposed Model



a) N_S-1 b) N_S-2 c) N_S-3 d) N_S-4

Figure 4. Varied configuration of dowels for all proposed models (units in mm)

6. Results and discussion

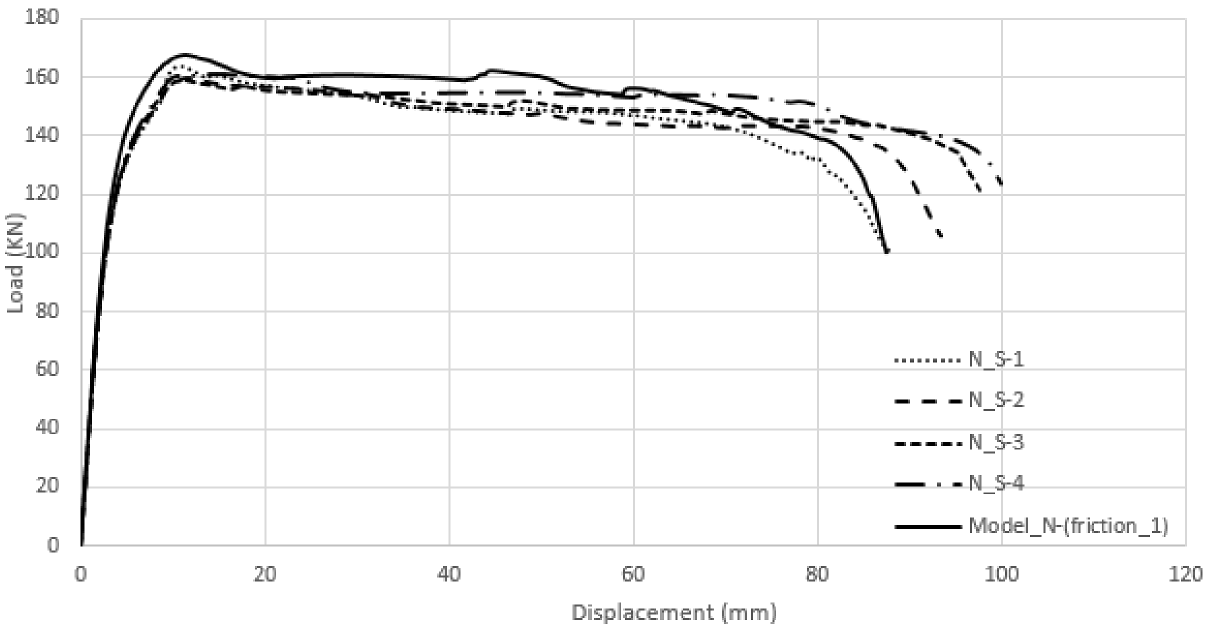


Figure 5. Comparison of load-displacement results of the proposed models

The numerical study results are demonstrated in Fig. 5. It is obvious from Fig. 5 that the dowels play an important role on increasing ductility of the four proposed specimens. Moreover they change slightly the numerical load carrying capacity of a RC jacketed columns. The numerical model N_S – 1, assigned with a friction coefficient 0.38 as evaluated previously seems to match with the FE model of Model _ N with a friction coefficient 1.0 in terms of displacement ductility. Therefore adding additional dowels to specimens provides further ductility to the members.

Conclusions

In this study, a parametric FE study was performed in order to evaluate numerical simulation of RC jacketed column with experimental test gathered from literature. In the sake of this; a numerical verification of an existing experimental study of a jacketed column is created by using ABAQUS software with a value of η equal to 38% defined to the FE models, (Model _ N) and (Model _E). Results of the experimental and numerical studies are compared in terms of load-displacement behaviors, and showed quite likeness in accordance to that.

The numerical results also developed by the authors deduce that dowels plays very important role on numerical simulation of RC jacketed columns. A FE model of an RC jacketed column assigned with very small amount of dowels (N_S – 1) match with the FE model of Model _ N with a friction coefficient 1.0 in terms of displacement capacity. Along with increase in dowel amount in simulations, not only a slightly increase in ultimate load capacity is experienced but also a more ductile behavior of displacement is achieved for RC jacketed columns.

References

[1] Sachin S. Raval, Urmil V. Dave "Effectiveness of Various Methods of Jacketing for RC Beams" Chemical, Civil and Mechanical Tracks of the 3rd Nirma University International Conference on Engineering

[2] Setzler_MSc2005_ "Modeling the behavior of light reinforced concrete columns subjected to lateral loads".

[3] Giovanni Minafò, Università degli Studi di Enna ''Kore'', Facoltà di Ingegneria e Architettura, Cittadella Universitaria, "*A practical approach for the strength evaluation of RC columns reinforced with RC jackets*". 94100 Enna, Italy.

[4] ACI 318-14, *Building Code Requirements for Structural Concrete*. American Concrete Institute, 2014.

[5] A. Demir, H. Ozturk, and G. Dok, "3D Numerical Modeling of RC Deep Beam Behavior by Nonlinear Finite Element Analysis," *Disaster Sci. Eng.*, vol. 2, no. 1, pp. 13–18, 2016.

[6] A. Demir, N. Caglar, H. Ozturk, and Y. Sumer, "Nonlinear finite element study on the improvement of shear capacity in reinforced concrete T-Section beams by an alternative diagonal shear reinforcement," *Eng. Struct.*, vol. 120, pp. 158–165, 2016.

[7] Amar Prakash, N. Anandavalli, C. K. Madheswaran, J. Rajasankar*, N. Lakshmanan, "*Three Dimensional FE Model of Stud Connected Steel-Concrete Composite Girders Subjected to Monotonic Loading*" International Journal of Mechanics and Applications. 2011; 1(1): 1-11

[8] G. Campione • M. Fossetti, C. Giacchino • G. Minafo', "*RC columns externally strengthened with RC jackets".* Materials and Structures (2014) 47:1715–1728.

[9] Konstantinos G. Vandoros, Stephanos E. Dritsos "*Concrete jacket construction detail* effectiveness *when strengthening RC columns"* Construction and Building Materials 22 (2008) 264–276

[10] "ABAQUS/CAE 6.13-2 SE." Dassault Systèmes Simulia Corp., Providence, RI.