Research Article

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Assessment for behavior of axially loaded reinforced concrete columns strengthened by different patterns of steel-framed jacket

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Abstract: Rehabilitation, upgrading, or strengthening of structural members, especially columns, has become the target of many researchers because columns are the most important members in a building and the failure of columns causes direct collapse in the building. This study aims to get an assessment of the best pattern of steel-framed jacket used for strengthening axially loaded concrete columns by numerically studying the behavior of the column for different cases of the same amount of steel jacket. The jacket consists of four angles and/or battens, lacings, or battens with lacings. The nonlinear analysis program designated as ARCC-SSJ (Analysis of Reinforced Concrete Columns Strengthened by Steel Jacket) is used to compare different patterns with the same and different cross-sections of battens and single lacing, as well as battens and lacing with battens taken into account. It is found that lacing with battens is the best pattern for the same amount of steel jacket with different cross-sectional areas. It is observed that the load-carrying capacity of the column increased by approximately 1.8 and 1.15% over that of battens alone in the case of a lacing angle of 60.832° and 74.407° with the vertical axis of the column, respectively.

Keywords: concrete column, numerical assessment, steel jacket, strengthening columns

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1 Introduction

Columns are the primary structural elements of a building. The need for periodic strengthening of columns is required to increase load-carrying capacity. This strengthening may be needed because of the use of additional live loads, deterioration of the load-bearing elements, structural problems, construction problems during building, or because the building is getting old or needs to be renovated to meet current standards and requirements [1]. The strengthening or rehabilitation of structural elements of a building requires studying performance of building and defining techniques to improve it, which is usually designer's responsibility [2]. Many techniques are used for increasing the load-carrying capacity of columns, such as concrete jacketing, ferrocement jacketing, external prestressing, steel collars, fiber-reinforced polymer wrapping, and steel-framed jackets [3]. A steel-framed jacket is manufactured by four steel angles in the corners of a column with discrete steel straps welded horizontally, called battens, or welded in an inclined direction, called lacings, or using both of them, battens and lacings [4]. Figure 1 shows different patterns of steel-framed jackets. The steel-framed jacket method is considered economic, efficient, and easy to execute [3]. Moreover, it is a safe method through increasing the ductility due to confinement, so the member gives an indication before failure [5]. Besides that, this method improves the behavior of the structural member by increasing the shear resistance, axial, and flexure load capacities [6,7].

Extensive studies are available that were performed in this area of strengthening reinforced concrete (RC) columns; most of them studied the column behavior experimentally [7–10]. The results of these studies were based on using one pattern of strengthening steel jacket. Khalifa and Al-Tersawy [7] established an experimental program to evaluate the improvement in stiffness, ductility, and load-carrying capacity of RC columns surrounded by steel jackets. To simulate the old local structures that needed to be strengthened in regional countries, the experimental test results had

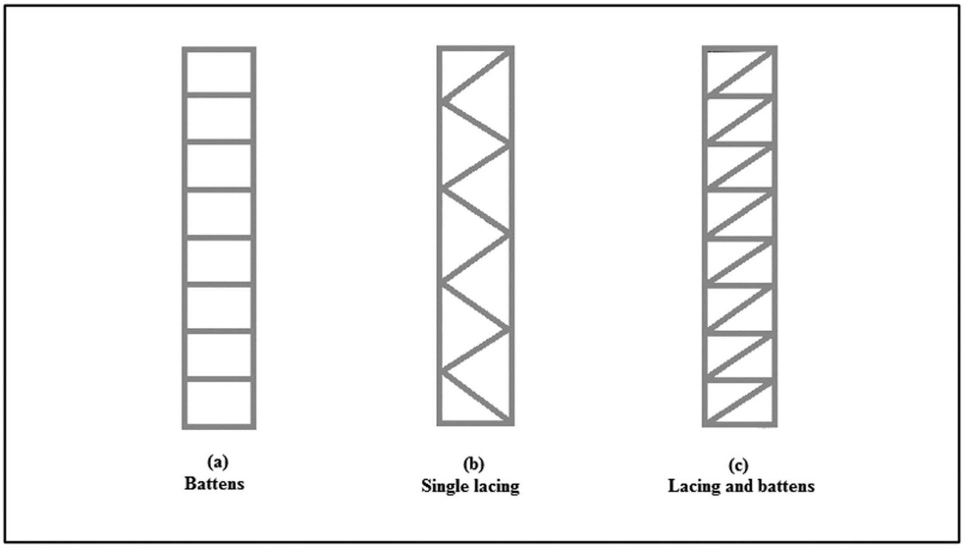

Figure 1: Different patterns of steel-framed jackets [4]. (a) Battens, (b) single lacing, and (c) lacing and battens.

to have a low value of concrete strength. Jackets were created using steel plates that covered the entire column surface area; alternatively, they were made by connecting individual steel strips to steel angles at the corners of columns. The authors observed that the stiffening action of steel strips and angles enhances the confined concrete strength and therefore delays the sudden compression failure of the columns. It was also observed that increasing the strip thickness leads to increased confinement strength, so the strip in this case can achieve extra strain. Makki and Nimnim [8] investigated the behavior of RC columns with the same cross-section and height that were externally strengthened with a steel jacket when subjected to axial loads. The steel jacket was made up of four different-sized vertical steel angles attached to the column corners via horizontal battens, or it was made up of four vertical steel angles of constant size at the column corners, connected by varying sizes of steel plates at the top and bottom of the columns, in addition to horizontal battens. The authors found that the strengthening technique using steel jackets is applicable and can increase the ultimate load for all cases of strengthening by approximately 42–122% compared with the unstrengthened columns. Ezz-Eldeen [9] proved that the use of steel jacket technology with variable vertical angle sizes coupled with horizontal steel straps is valid to upgrade the load-carrying capacity of eccentrically loaded rectangular RC columns. The author found that increasing the covered area of the steel jacket by increasing the angle dimensions leads to an increase in the load-carrying capacity of the strengthened columns. Landovic and Besevic [10] presented experimental research on axially loaded RC columns with a square cross-section that are reinforced with a steel tube jacket and additional fill concrete. Failure modes of the specimens, as well as the load versus deformation and strain development relationships, were all recorded. The authors found that at all load levels, all three cross-sectional components (steel jacket, core column, and fill concrete) cooperated in the force-carrying processing. They also found that the steel tube and the infill concrete are engaged for load-carrying, even if the load is only applied to the core RC column. The load distribution on all three parts of the cross-section is achieved over the bond layer through the friction of adjacent materials. A new simple and efficient model that can control the behavior of short rectangular RC columns strengthened by a steel lattice-framed jacket was provided by Alwash and Al-Zahid [3]. They proposed a stress–strain diagram for confined concrete with internal reinforcement and an outside steel jacket. The authors concluded that the model can be used to study the interface nonlinearity between concrete and steel jacket. Depending on confinement properties, Campione et al. [11] assessed the dependability and effectiveness of various available analytical models for determining the load-bearing capacity of steel-jacketed RC columns under sustained loads. Within the analytical models, some of the strengthened column specimens are preloaded to a certain compressive stress and strain level before strengthening. According to the authors, the compressive behavior of preloaded specimens differs from that of non-preloaded specimens, with an increasing preloading level resulting in a lower load-bearing capacity. Kafel et al. [12] used the multi-criteria analysis method to select the appropriate solution method for strengthening columns constituting structural elements of historical buildings using strengthening jackets. Depending on the material, two types of strengthening jackets were proposed as reinforcement options: a mortar clamp reinforced with stirrups and a steel clamp made of steel angles and flat bars (battens). The results indicated that the multi-criteria analysis method was successfully applied to the reinforcement options for columns. However, assessing the priorities in the decision-making process related to the necessity of strengthening should take into account the archaeological, economic, social, and historical features of the buildings. In this study, an optimal pattern is determined by comparing and numerically evaluating the behavior of reinforced axially loaded concrete columns strengthened with three different patterns of steel-framed jackets. The jacket consists of four angles and/or battens, lacings, or battens with lacings. The results of this study are based on using the same amount of steel for battens, lacings, and battens with lacing with different cross-section areas and comparing in between. Also, an empirical model for the spring stiffness of the concrete-steel jacket interface is considered in the analysis due to a lack of information in this field.

2 Method of analysis

This section provides a synopsis of the approach that was used to conduct an analytical analysis of RC columns strengthened with steel lattice jackets. The analysis method is based on the exact stiffness matrix of an axially loaded, RC column strengthened with a steel jacket. Three different patterns of strengthening jackets are used in the analysis, in which the jacket is made by four steel angles in the corners of a column with horizontally welded discrete steel straps (battens), welded in an inclined direction (lacings), or using both of them, battens and lacings. This method is suggested to make a major comparison between different patterns of strengthening jackets by converting the pattern of jacket from single lacing or battens with single lacing to equivalent battens using the same amount of steel with different cross-sectional areas of lacings and battens. The numerical analysis of the strengthened columns by steel jacket, according to the present suggested method, is achieved using a nonlinear finite element visual basic language program designated as ARCC-SSJ [3] (Analysis of Reinforced Concrete Columns Strengthened by Steel Jacket). The program is dependent on the exact solution of the finite elements for columns supplemented with a steel lattice frame jacket. The displacement field is exactly determined in accordance with the concept of minimum strain energy. The analysis of the strengthened columns by steel jacket, according to the present suggested method, assumed that the bottom of the columns is a fixed end, and there are three degrees of freedom at the top, namely longitudinal displacement in the concrete, longitudinal displacement in the steel jacket, and longitudinal displacement in the reinforcement. The confinement of internal reinforcement and the external steel-framed jacket have been taken into consideration. The nonlinearity of materials and interface between the concrete column face and the steel-framed jacket have been included. The main equations that have been used for analysis are presented as follows:

(1) The displacement field equation that has been adopted to drive the stiffness matrix [13]:

$$U = \left[\frac{1}{2}\int_0^L u'^2 E_c A_c + \frac{1}{2}\int_0^L u'^2 E_{rs} A_{rs} + \frac{1}{2}\int_0^L u'^2 E_{sj} A_{sj} + \frac{1}{2}\int_0^L k_{scr}(u(x)_{rs} - u(x)_c)^2 + \frac{1}{2}\int_0^L k_{scj}(u(x)_{sj} - u(x)_c)^2\right] dx, \quad (1)$$

where A_c, A_{rs}, and A_{sj} are the concrete cross-sectional area, reinforcement area, and steel jacket area, respectively. k_{scr} is the spring stiffness at the interface between concrete and reinforcement. k_{scj} is the spring stiffness of the interface between the concrete and the steel jackets. E_c, E_{rs}, and E_{sj} are the elasticity modulus of concrete, reinforcing steel, and steel jacket, respectively (MPa).

(2) As stated by Campione [6], the equation for confined pressures induced by stirrups and internal longitudinal bars is as follows:

$$\text{CP reinforcement} = \frac{2\pi f_y \Phi_{st}^2}{4 s_{st} b} + n_b \frac{384}{3 s_{st}^4} E_r \frac{\pi \Phi_l^3}{64} * \frac{b}{2}(\nu\varepsilon_{sp} - \varepsilon_{yst}), \quad (2)$$

where Φ_{st} is the transversal stirrup diameter (mm). Φ_l is the longitudinal reinforcement diameter (mm). s_{st} is the distance between two consecutive stirrups (mm). n_b is the number of side bars. E_r is the elastic modulus for reinforcement (MPa). ν is the ratio of Poisson's. ε_{sp} is the strain associated with concrete cover spalling. ε_{yst} is the stirrups yield strain.

(3) The equation of confining pressure (CP) due to the steel jacket is as follows [6]:

$$\text{CP steel jacket} = 1.33 f_{yb} e^{-\frac{1.5s}{b}} s^{-1}\left(\frac{Ls}{st_a} + \frac{L2}{S2t_b}\right)^{-1}, \quad (3)$$

where f_{yb} is the batten yield stress (MPa). s is the distance between two consecutive battens (mm). L_s is the length of the angle side (mm). t_a, and t_b are the steel angle and steel batten thicknesses, respectively (mm). S_2 and b are the batten and column widths, respectively (mm). $L_2 = (b - 2L_s)/2$ (mm). The overall confinement of the system is as follows:

$$\text{CP} = \text{CP reinforcement} + \text{CP steel jacket}. \tag{4}$$

(4) Empirical model for the spring stiffness of the concrete-steel jacket interface.
Chemical adhesion, friction, and mechanical interlock between reinforcement and concrete all contribute to the bond strength between rebar and surrounding concrete. The steel jacket and concrete interface spring stiffness do not include chemical adhesion or mechanical interlock. Furthermore, the parameters of any formula used to evaluate such stiffness for the axially loaded columns do not account the transverse expansion due to Poisson's ratio. Hence, the stiffness was determined practically. The empirical equation of the interface spring stiffness between concrete and steel jacket becomes [3]

$$K_{sc} = \frac{1.83}{L_{sj}}(E_s + E_c) * L_s * \text{CP}_{\text{steel jacket}}, \tag{5}$$

where K_{sc} is the concrete and steel jacket stiffness of interface spring (N/mm^2). L_s is the angle side length (mm). L_{sj} is the longitudinal length of angles, which is equal to the length of column (mm). L_s and L_{sj} are illustrated in Figure 2. E_s and E_c are the elastic modulus of steel and concrete, respectively (MPa).

(5) A stress–strain curve for confined concrete that has been proposed is shown in Figure 3.
At a certain level of strain, the corresponding stress value will be greater in confined concrete; the ultimate strength of confined concrete can be found from equation (6) according to the provisions of Euro code 8 [14]:

$$f_{cc} = f'_c\left[1 + 3.7\left(\frac{\text{CP}}{f'_c}\right)^{0.87}\right]. \tag{6}$$

The ultimate strain of confined concrete can be evaluated from equation (7), adopted by Mander et al. [15].

$$\varepsilon_{cc} = \varepsilon_o\left[1 + 5\left(\frac{f_{cc}}{f'_c} - 1\right)\right], \tag{7}$$

where f_{cc} and ε_{cc} are the strength and strain of confined concrete, respectively. CP is the total confining pressure for the system. fc' and ε_o are the strength and strain of unconfined concrete, respectively.

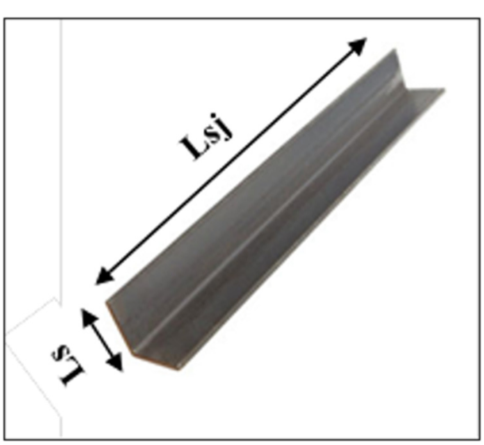

Figure 2: Dimension details of steel angle.

3 Comparison between experimental and analytical results

The efficiency and validity of the method of analysis used in this study are validated via comparison with other experimental results. Two verification case studies are performed in this section to compare the results of the analytical analysis of this study using the ARCC-SSJ program to the experimentally tested data used by Campoine [6,16] and Adam et al. [17] for axially loaded RC columns strengthened with steel frame jackets. In those cases, the need for strengthening is due to problems with strength caused by substandard concrete used in construction (real strength below design) or to replicate the situation of old local structures that needed to be strengthened [7,17]. In the first case, an RC column with a 215 × 215 mm square cross-sectional area and a length of 1,200 mm was used by Campoine [16] with the following properties: concrete has a compressive strength of 10 MPa. Four longitudinal reinforcement bars are used; each one has a diameter of 12 mm, while the yield stress is 461 MPa. The diameter of the stirrups is 6 mm, with 200 mm center-to-center as the spacing in between; the yield stress is 400 MPa.

The strengthening jacket consisted of angles and battens welded together around the column. Four angles are used at the corners of the column. The side length of each one is 30 mm, and the thickness is 3 mm, while the yield stress is 239 MPa. The battens were 30 mm in width and 3 mm in thickness. The spacing between battens equals 200 mm from center to center. The yield stress is 239 MPa. Figure 4 shows the main form of input data for the program

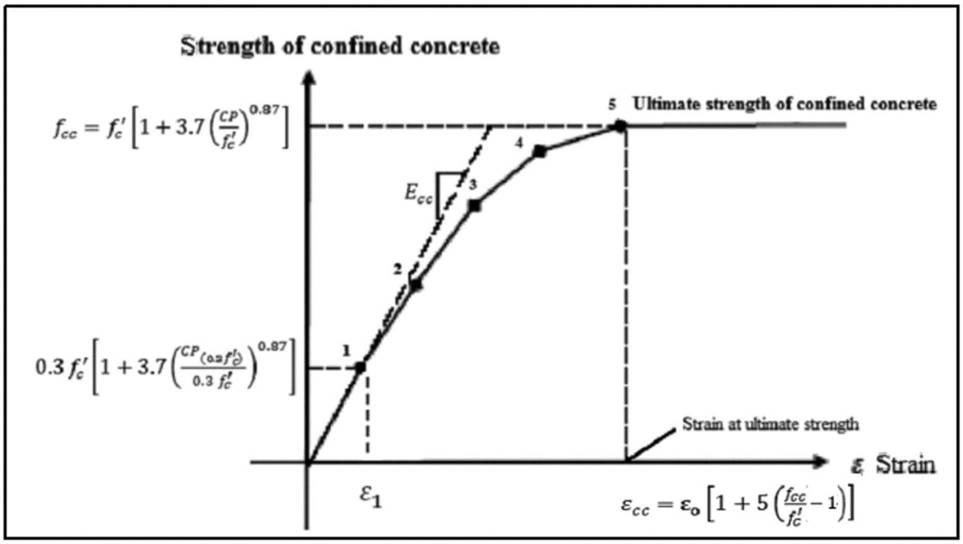

Figure 3: Stress–strain curve for confined concrete [3].

to analyze the strengthened column. Figure 5 shows the relationship between applied load and concrete longitudinal strain. A good agreement is found between Campione's [16] experimental work and this study.

In the second case, a comparison of the experimental results of Adam et al. [17] and this study with and without including the effect of interface spring stiffness between concrete and steel is presented. In the analysis, an RC column with a 300 × 300 mm square cross-sectional area and a length of 2,500 mm was used. Concrete has a compressive strength of 8.3 MPa. Four 12 mm longitudinal reinforcement bars were used and had a yield stress of 400 MPa. The stirrups are 6 mm in diameter, with 200 mm center-to-center as the spacing in between was used; the yield stress is 400 MPa. The columns were strengthened with four steel angles with length dimensions of 80 mm × 80 mm and a

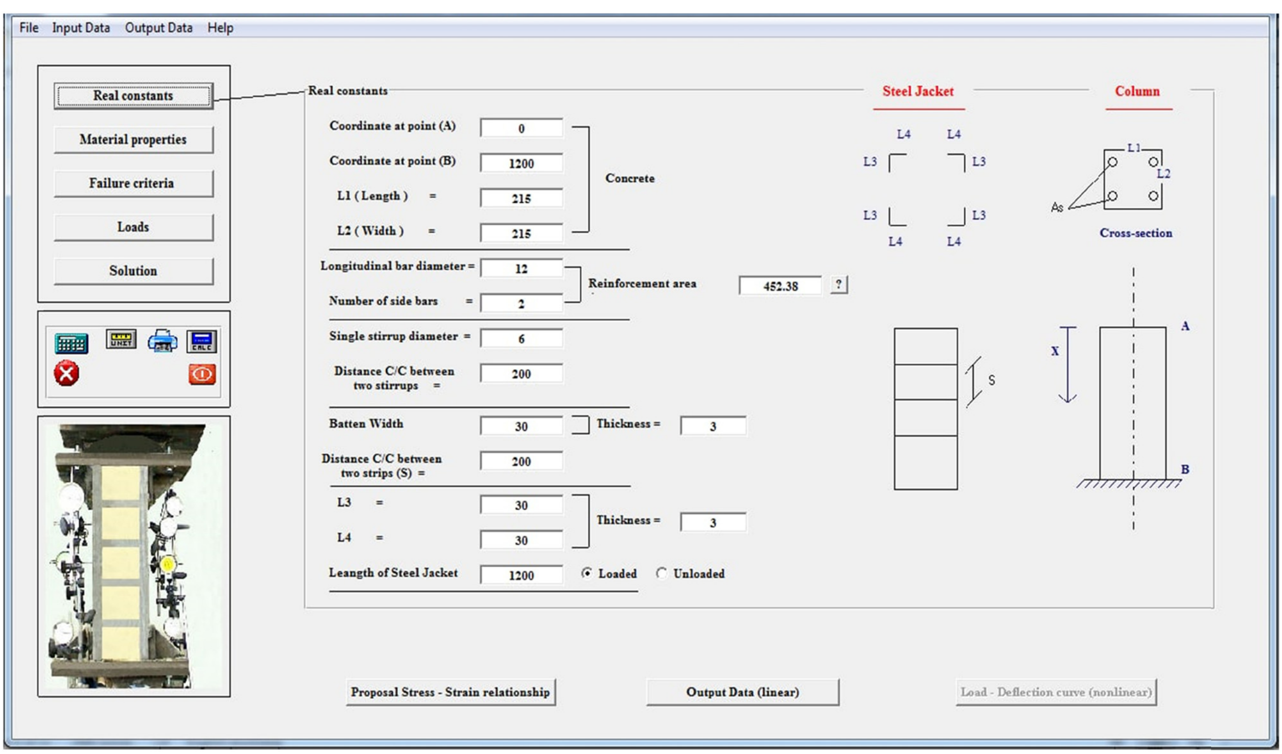

Figure 4: ARCC-SSJ program.

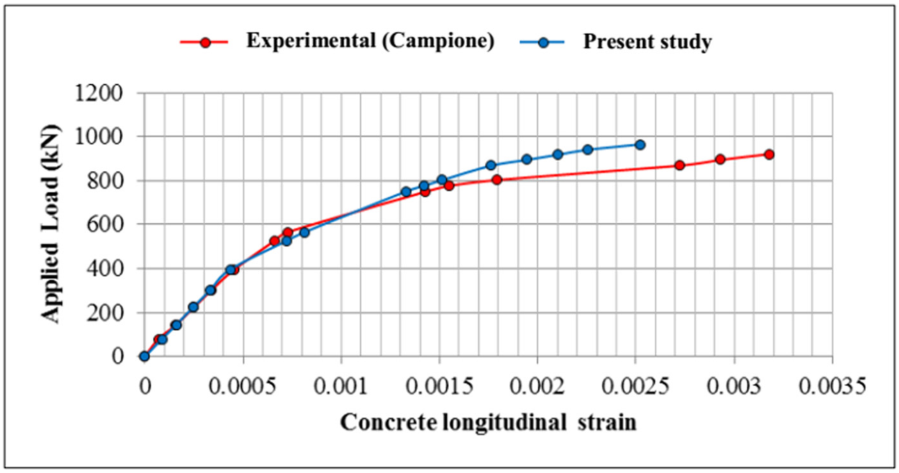

Figure 5: Load–strain curve of column for this study and experimental work.

thickness of 8 mm, as well as rectangular strips (battens) with dimensions of 270 mm × 160 mm × 8 mm. The yield stress of angle and strip steel is 275 MPa.

The analysis revealed that there is a normal pressure from the concrete to the steel angle due to the expansion of the concrete due to the effect of Poisson's ratio; this pressure will increase the friction between the concrete and the steel angle. On the other hand, the interface element between the concrete and the steel jacket takes into consideration this effect, and equation (5) presents a one-dimensional interface that includes the effect of normal pressure. So, the results of this study (load versus concrete strain), including the effect of an interface spring, have been very close to Adam's [17] experimental work, while the stiffness matrix without an interface spring shows inappropriate results as shown in Figure 6.

Both cases of verification compare the results of the adopted analytical model with experimental work to get good confidence in the results, but the difference between the two cases (Campoine et al. [16] and Adam et al. [17]) was the behavior of columns at 1,000 kN. The concrete strain in the Campoine specimen was extremely higher than the concrete strain for the Adam et al. specimen, so the adopted analytical model has good results for both types of failure, brittle or ductile.

4 Analysis results and discussions

This section includes the results of the comparison between battens and single lacing and the comparison between battens and battens with lacing. The dimensions and properties of the concrete column and steel jacket mentioned in the

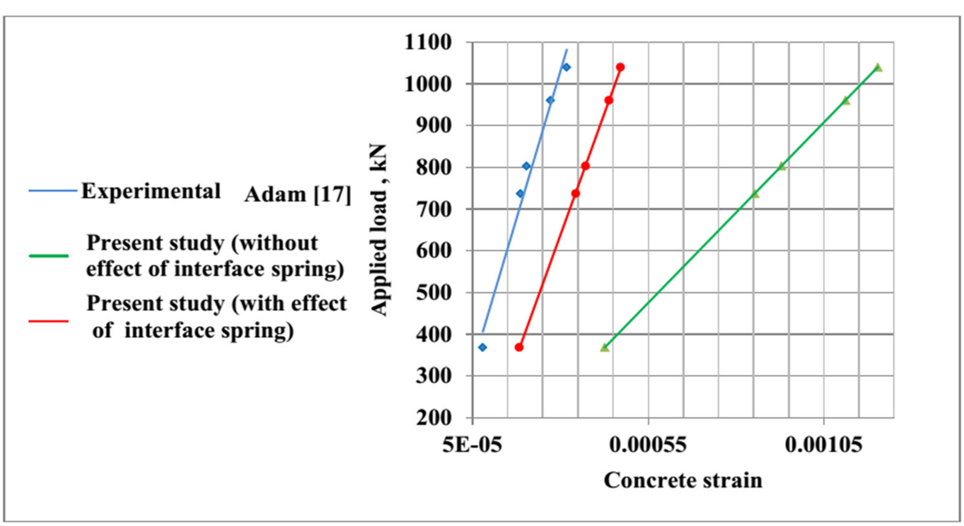

Figure 6: Comparison of experimental results by Adam et al. [17] with this study (with and without the effect of interface spring stiffness).

first verification case are adopted in the analysis. The load capacity for eight case studies is found through the results of the ARCC-SSJ program and compared with each other to obtain the best pattern for strengthening. The results have been discussed to find the best pattern of steel frame jacket using the same amount of steel with the same or different cross-section area of lacing and battens. In the research case studies, the angle of the lacing with respect to the longitudinal axis of the column was taken as 60.832° or 74.407°, as shown in Figure 7, depending on the cross-sectional area of the lacing, to obtain the same amount of steel in the jacket for all strengthening patterns.

4.1 Comparison between battens and single lacings

This comparison is between battens (Figure 7(a)) and single lacings (Figure 7(b)). The comparison includes two cases. The first case included the same amount of steel with different cross-sectional areas of battens and lacings, while the second case uses the same cross-sectional areas of battens and lacings.

4.1.1 Same amount of steel with different cross-sectional areas of lacings and battens

The ARCC-SSJ program has been used to get the load-carrying capacity. To convert the lacing form into the batten form, an equivalent calculation is performed. The following steps show the procedure for replacing the lacing with equivalent battens:

Lacing with angle 60.832°,

$$\sin 60.832^\circ = \frac{215}{\text{Length of lacing}}.$$

Length of lacing = 246.22 mm,

$$\cos 60.832^\circ = \frac{\text{Equivalent spacing}/2}{246.22}.$$

Equivalent spacing = 240.

Length of column = 1,200 mm, so the number of lacing equal to 10 with the same density, depend on the volume of lacing to find the same amount of steel jacket. Therefore, the equivalent area of angle will be

$$A_{\text{equivalent}} = A_{\text{angle}} + A_{\text{lacing}} \times \cos(60.832).$$

Equivalent area of angle = 180 + 43.86 = 223.86 mm^2.

Equivalent thickness of angle = 3.73 mm.

Battens' equivalent cross-sectional area = 2 × A_{lacing} × sin(60.832).

Battens' equivalent cross-sectional area = 157.17 mm^2.

Therefore, the required equivalent details in battens form are as follows: Length of batten = 215 mm.

Number of battens = 9.

Width of batten =

$$\frac{246.22 \times 3 \times 30 \times 10}{215 \times 3 \times 9} = 38.17 \text{ mm}.$$

Spacing of battens = 120 mm.

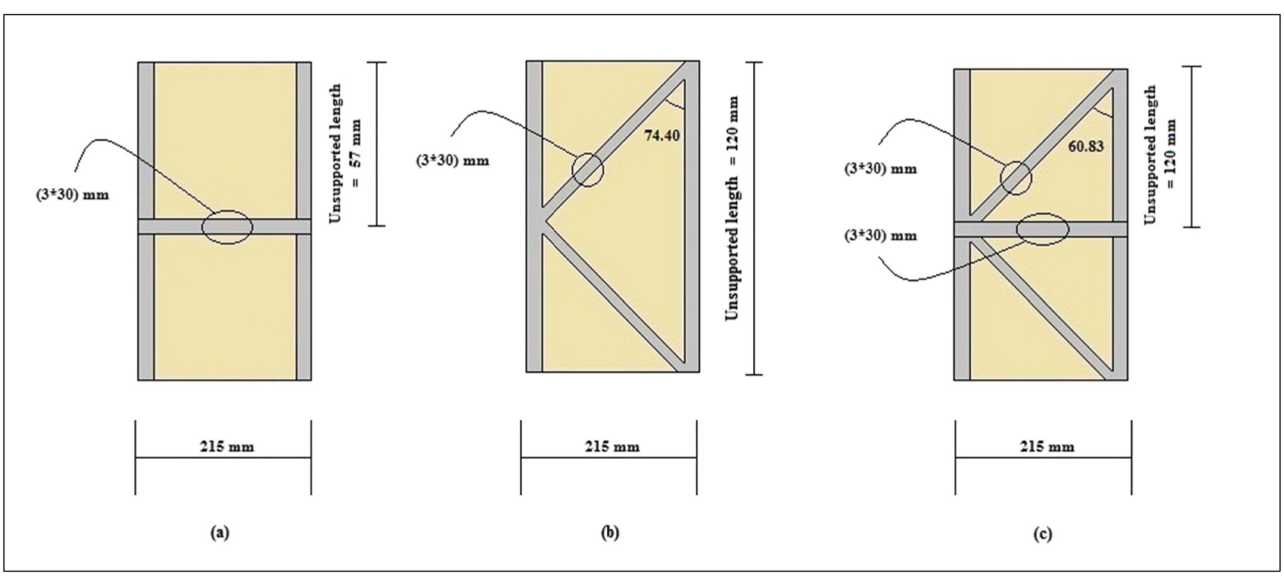

Figure 7: Details of battens and lacings for different case patterns of steel jacket. (a) Battens, (b) single lacing, and (c) lacing and battens.

Lacing with angle 74.407°,

$$\sin 74.407 = \frac{215}{\text{Length of lacing}}.$$

Length of lacing = 223.21 mm.

$$\cos 74.407^\circ = \frac{\text{Equivalent spacing}/2}{223.21}.$$

where equivalent spacing = 120.

Length of column = 1,200 mm. So, the number of lacings is equal to 20.

With the same density, based on volume of lacing the same amount of steel is found. Therefore, equivalent area of angle will be:

$$A_{\text{equivalent}} = A_{\text{angle}} + A_{\text{lacing}} \times \cos(74.407),$$

where equivalent area of angle = 180 + 24.19 = 204.19 mm^2.

Equivalent thickness of angle = 3.4 mm.

Battens' equivalent cross-sectional area = 2 × A_{lacing} × sin(74.407).

Battens' equivalent cross-sectional area = 2 × 86.68 = 173.37 mm^2.

So, the required equivalent details in battens form are as follows:

Length of batten = 215 mm.

Number of battens = 19.

Width of batten =

$$\frac{223.21 \times 3 \times 30 \times 20}{215 \times 3 \times 19} = 32.78 \text{ mm}.$$

Spacing of battens = 60 mm. The details and maximum load-carrying capacity are summarized in Table 1.

4.1.2 Same amount of steel with the same cross-section dimensions of lacings and battens

As shown in the following steps, an equivalent calculation is performed to convert the lacing form into battens with the same cross-section area:

Volume of lacing (60.832) = (length × thickness × width × No.$_{\text{lacing}}$).

Volume of lacing = 246.22 × 3 × 30 × 10 = 221,598 mm^3.

For the same volume of steel jacket, (221,598 = 30 × 3 × 215 × No.$_{\text{battens}}$).

No. of battens = 11.45, use (11), Spacing of battens = 100 mm.

Volume of lacing (74.407) = (length × thickness × width × No.$_{\text{lacing}}$).

Volume of lacing = 223.21 × 3 × 30 × 20 = 401,778 mm^3.

For the same volume of steel jacket (401,778 = 30 × 3 × 215 × No.$_{\text{battens}}$).

No. of battens = 20.76; using (20), spacing of battens = 57 mm. Table 2 summarizes the details and maximum load-carrying capability.

4.2 Comparison between only battens and lacings with battens

This comparison is between battens shown in Figure 7(a) and lacing with battens shown in Figure 7(c). The comparison includes two cases: one with the same amount of steel but a different cross-section area of lacings and battens, and the other with the same cross-section of lacings and battens.

4.2.1 Same amount of steel with different cross-sectional areas of lacings and battens

The equivalent calculations and maximum load capacity are summarized in Table 3.

4.2.2 Same amount of steel with the same cross-sectional area of lacings and battens

The equivalent calculations and maximum load capacity are summarized in Table 4.

Table 1: Comparison of battens and single lacing (same amount of steel jacket, different cross-section area)

Details	First case		Second case	
	Battens	Single lacing 60.832° in battens form	Battens	Single lacing 74.407° in battens form
Spacing of battens (mm)	120	240	60	120
Width of battens (mm)	38.17	52.39	32.78	57.79
Angle thickness (mm)	3	3.73	3	3.34
Maximum load capacity (kN)	1,044	936	1,263	1,123

Table 2: Comparison of battens and single lacing (same amount of steel jacket, same cross-sectional area)

Details	First case		Second case	
	Battens	Single lacing 60.832° in battens form	Battens	Single lacing 74.407° in battens form
Spacing of battens (mm)	100	240	57	120
Width of battens (mm)	30	52.39	30	57.79
Angle thickness (mm)	3	3.73	3	3.34
Maximum load capacity (kN)	1,067	936	1,261	1,123

Table 3: Comparison between battens and lacings with battens (same amount of steel jacket, different cross-sectional area)

Details	First case		Second case	
	Battens	Battens with lacing 60.832° in battens form	Battens	Battens with lacing 74.407° in battens form
Spacing of battens (mm)	120	120	60	60
Width of battens (mm)	68.17	56.193	62.78	58.893
Angle thickness (mm)	3	3.73	3	3.4
Maximum load capacity (kN)	1,120	1,141	1,462	1,479

Table 4: Comparison between battens and lacings with battens (same amount of steel jacket, same cross-sectional area)

Details	First case		Second case	
	Battens	Battens with lacing 60.832° in battens form	Battens	Battens with lacing 74.407° in battens form
Spacing of battens (mm)	57	120	30	60
Width of battens (mm)	30	56.193	30	58.893
Angle thickness (mm)	3	3.73	3	3.4
Maximum load capacity (kN)	1,261	1,141	1,578	1,479

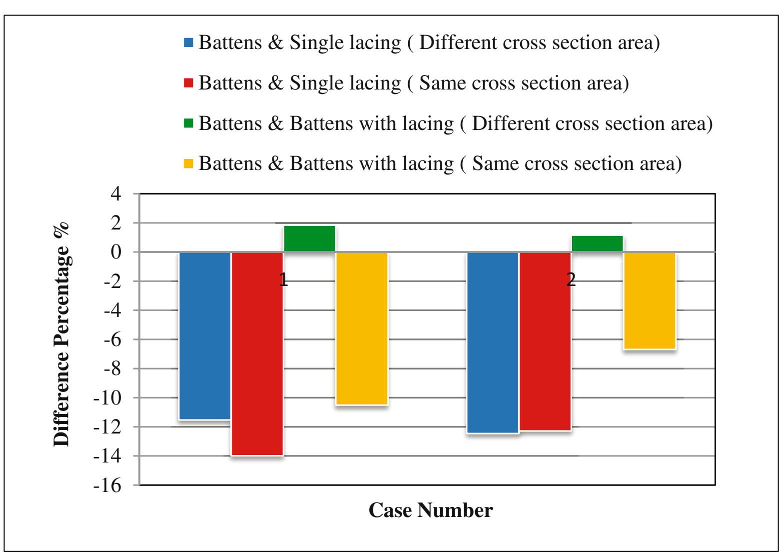

Figure 8: Different percentages of maximum load-carrying capacity for different patterns.

4.3 Discussion of the results

The primary structural principle is that axial strain in concrete causes lateral strain due to Poisson's ratio, which is caused by the fact that confined concrete resists more axial load, and the lateral strain increases the value of the interface spring stiffness between concrete and steel jackets. So, the results of battens without lacing are considered good patterns. According to the results shown in Tables 1–4, decreasing the spacing between battens by about 1% causes an increase in maximum load-carrying capacity of about 0.5%. As a result, when battens and lacing are used with varying cross-sections, the maximum load-carrying capacity is increased by about 1.8 and 1.15%, respectively, over battens without lacing in the first and second cases (lacing: 60.832°; lacing: 74.407°). Figure 8 shows the different percentages of maximum load-carrying capacity among different patterns.

Even though using battens alone produces good results in terms of the maximum load-carrying capacity, using battens and lacings is still necessary to upgrade the results of load-carrying capacity and get improvements in the behavior of the strengthened columns because the lacing has double action in terms of a steel jacket, axial resistance, and confining.

5 Conclusion

(1) For the same amount of steel jacket with the same or different cross-sectional area of lacing and battens, the lacing pattern is considered the worst compared with battens alone.
(2) Battens without lacing are considered a good pattern for the same amount of steel in a jacket with the same cross-sectional area of lacings and battens. By reducing the spacing between battens by about 1%, the maximum load-carrying capacity increases by about 0.5%.
(3) The pattern of lacing with battens improves the behavior of the column and increases the maximum load-carrying capacity by about 1.8 and 1.15% more than that of battens without lacing for lacing 60.832° and lacing 74.407°, respectively, for the same amount of steel jacket with varying lacing and batten cross-sections.

Conflict of interest: The authors state no conflict of interest.

Data availability statement: Most datasets generated and analyzed in this study are comprised in this submitted manuscript. The other datasets are available upon a reasonable request from the corresponding author with the attached information.

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