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Probabilistic Evaluation of a Local Retrofitted RCC Structures: A review

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Abstract: Seismic retrofitting resembles modification to existing structures or to strengthen existing structures as per the current seismic demand or codal provisions. Different retrofitting techniques have been adopted worldwide to strengthen damaged structures owing to natural disasters like earthquake, wind, Tsunamis etc. From last decades, several improvements were taken into account for more suitable methods/techniques to repair/strengthening/retrofit a damaged structure. In case of seismically vulnerable structural elements such as reinforced beam-column or beam column joint, jacketing is observed as the most common type of retrofitting technique for strengthening of deficient or damaged structural member from several years. Various researchers form the cited literature signifies, jacketing as a practical solution to recover and improve the load carrying capacity of damaged structural members due to earthquake or due to improper construction/supervision. In addition to this, there are lot of challenges in front of structural designer to consider the inherent strength of retrofitted element in terms of load carrying capacity as warranted in post retrofitting analysis, which barricades the widespread use of jacketing or retrofitting strategy as a whole. This paper presents an exhaustive review of literature on local retrofitting techniques align with recent investigations cited in literature on retrofitting of structures by using reinforced concrete jacketing. The review paper aims to identify grey areas/ a gap in implementation of jacketing techniques and a need to address key potential issues associated with the same to access interface bond strength of old new concrete, load transfer mechanism and load carrying capacity of retrofitted section into a measurable/ quantifiable parameter to be adopted in understanding post retrofitting behavior of retrofitted section that can lead to break through development in the field of retrofitting of structures.

Keywords: Seismic Retrofitting, Jacketing of beam/column, Post retrofitting.

1. Introduction

In past years, natural disasters like earthquake/ wind damaged many existing structures. The damaged structure portrayed that not only non-engineered structures but also engineered structures were damaged severely. After evaluation and assessment of damaged structure, a need to repair/strengthen/retrofit an existing structure was observed [6-10]. Retrofitting of old structures is indeed one of the most important activities in civil engineering industry. At the present, reinforced concrete jacketing is a common and widely used method of retrofitting to strengthen damaged structures especially in earthquake prone region. Jacketing of beam/column means construct a stiff jacket over a core beam/ column to increase a strength,

stiffness and ductility of existing beam/column. Jacketing is a simple method of strengthening a structural member [17-22]. The most important aids of jacketing method are to increase load carrying capacity of structural members [58]. Compressive strength of core concrete, ultimate concrete compression strain and ductility of the jacketed member increased considerably if design of longitudinal reinforcement and transverse reinforcement is proper [16].

This review paper presents an extensive historical literature survey on local retrofitting technique (Jacketing of Structural members), covering what has been published between 1972 to 2022 i.e in almost 50 years of study. Some research gaps are identified and study thoroughly for further advancement in the retrofitting industry. This review paper aims to help understanding the concept and feasibility of local retrofitting adopted in worldwide and also identifies a need of measurable parameters by virtue of which jacketing can lead to its desired place in retrofitting strategies.

2. Literature Review

Ensuing, an exhaustive literature review on local retrofitting technique is described. Experimental and analytical work on local retrofitting techniques studied and presented carried by various researchers. A chronological order is adopted to study and identify future scope of research in this area. Expressions and notations were used originally adopted by researchers for review but units considered as a SI unit for reference.

2.1. Hellesland J and Green R. (1972)

Hellesland J and Green R. [4] performed experimental tests on repaired reinforced column specimen. Experimental set up and tests were carried out to determine deflection and load carried by repaired section. Six column specimens were casted of dimension 127 mm X 177 mm and height of column was 1.37 m. The study was carried out to calculated data for eccentrically loaded reinforced concrete column to compare various characteristics of original column and repaired column. Column specimen were loaded through knife edges and load applied through stroke control by using MTS electro-hydraulic closed loop machine. Maximum load was applied for 20 to 30 minutes and calculate continuous record of load verses deformation (Mid-height deformation) for each test.

The result from this research was suggested that the repaired column specimen had a greater deflection under low loading. Original column specimen was carried out large load comparative repaired column specimen under cyclic loading. This research program was limited in size & scope. Researcher also conclude that response of repaired column section was similar to original column specimen.

2.2. Sugano S. (1981)

Sugano S. [5] was studied different existing buildings damaged due to earthquake in Japan. In this research general design procedure and application of strengthening techniques to existing buildings was described and brief review of some relevant experimental studies given. He developed a flowchart of design and construction of seismic strengthening. Researcher concludes that the analytical and experimental study must be used to assessment and evaluation of strengthening an existing building.

2.3. Rodriguez M and Park R. (1991)

Rodriguez M and Park R. [8] was done a review on repair and strengthening of reinforced concrete buildings, to study a seismic performance of a repaired and strengthened buildings located in seismic areas. In this review paper researcher described an experimental and analytical investigation which provide information regarding strength, ductility and seismic

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behaviour of reinforced concrete column as proposed by various researcher including Sugano S. [5]. Researcher mentioned that shear wall was a best retrofitting technique which has used 85% cases when existing structures need strengthening globally. Jacketing of column and beam has used in 35 % cases and steel bracing used 2 % cases. Researcher also enlisted different advantages and disadvantages of jacketing and state that new longitudinal reinforcement passing through slab while jacketing was more advantageous.

2.4. Vistasp M. Karbhari, Yanqiang Gao. (1997)

Vistasp M. Karbhari, Yanqiang Gao. [12] was proposed an expression for ultimate strength and strain of jacketed composite concrete specimen by comparing experimental data and phenomenological model for confined system. To compare the prediction and effectiveness of the different expression for ultimate stress and strain at failure mode, experimental data from sets of composite wrapped concrete cylinders were used. When study a failure modes and expressions comparison it has been shows that the prediction of ultimate strain is extremely sensitive to the input data, which required direct measurement of strain from both the concrete and the composite jacket. The proposed experimental model was restricted to hoop dominated architectures for the confining jacket. Finally, researcher conclude that the use of fiber reinforced composites was effective means of confinement of concrete for the purpose of strengthening and to increase ductility.

2.5. Tsonos AG. (1999)

Tsonos AG. [13] was performed experimental study on seven beam column joint specimen taking into account on study of Rodriguez M and Park R. [8] in Japan earthquake damages. Seven specimens casted as per original beam column joint as per the design consideration of existing structure and then applying cycling loading using Laboratory of Reinforced Concrete Structures at the Aristotle University of Thessaloniki to the beam while maintaining a constant axial load in the column of the specimens. Study failures modes of beam column joint and then retrofitted specimens using UNIDO techniques of local retrofitting and concluded that the ACI-ASCE Recommendations can be beneficial for designing a jacketing technique in the beam column joint regions

2.6. A. P. Lampropoulos, O. T. Tsioulou and S. E. Dritsos. (2003)

A. P. Lampropoulos, O. T. Tsioulou and S. E. Dritsos. [14] was used ANSYS computer program (Finite Element based Program) to study and examine the behaviour of the interface between old and new concrete in a jacketed column. In this research a reinforced concrete column strengthen/retrofitted using jacketing technique. The cross-sectional dimension of column taken as 250 mm X 250 mm and the height was considered as 1.8 m with reinforcement 4-14Ø of steel grade S220. Transverse reinforcement was 8Ø @ 200 mm spacing. Jacketed thickness of column was 75 mm up to height of 1.4 m with longitudinal and transverse reinforcement. The compressive strength and ultimate strain were assumed/considered. By using different value of cohesion, friction and thickness of jacket analytical study was carried out and conclude that friction plays and important role in interface bond than a cohesion and increases a thickness of jacket reduces a sliding.

2.7. Abdullah, Katsuki Takiguchi. (2003)

Abdullah, Katsuki Takiguchi. [15] presented a behaviour and strength of reinforced concrete columns retrofitted with ferrocement jackets. In this research six column specimen of circular and rectangular section were tested after jacketed with ferrocement. Researcher was elaborated a strengthening procedure and testing procedure with instrument. Test results shows that lateral displacement increased and flexural strength, shear strength was formed at the gap on the end

parts of the jacket. This research shows that if the size and thickness of jacket design properly then premature rupture of the longitudinal bar could be avoided.

2.8. Júlio E, Branco F and Silva V. (2003)

Júlio E, Branco F and Silva V. [16] presented a brief review on structural rehabilitation of columns [4-11]. In this review paper author specify the need of strengthening and rehabilitation and also mentioned when, why and how to rehabilitate a building. Author was reviewing an experimental and analytical study on RC jacketing of different damaged structures and concluded that repair/strengthening method influences due to surface preparation, chosen bonding agent, application of steel connectors and longitudinal/ transverse reinforcement. Hence there was a need to take into account while design and construction.

2.9. Júlio E, Branco F and Silva V. (2004)

Júlio E, Branco F and Silva V. [17] performed an experimental study to calculate bond strength between two concrete layers. In this research 25 slant shear specimen and 25 pull of test specimen was prepared by surface preparation through wire brushing, sand-blasting and chipping with light jack hammer. After performing a slant shear test and pull of test on different specimen an analysis result was indicate that the sand blasting had given a highest value of bond strength.

2.10. Ong KC, Kog Y, Yu CH and Sreekanth AP. (2004)

Ong KC, Kog Y, Yu CH and Sreekanth AP. [18] presented a parametric study of two existing experimental data and compare the experimental results of jacketed column. Two different types of RC jacketing (full length and partial) were studied. Existing experimental and analytical data of research shows that jacketing was increase a load carrying capacity of repaired column.

2.11. Júlio EN, Branco FA, and Silva VD. (2005)

Júlio EN, Branco FA, and Silva VD. [19] presented an experimental and theoretical study on monotonic loading response on jacketed column specimen. The main objective of this research was to attain a monotonic behaviour of the composite element. Experimental and theoretical study was performed by author Júlio E, Branco F and Silva V. [16], Rodriguez M and Park R. [8] and Stoppenhagen DR, Jirs JO and Wyllie LA. [11] considered for further study. Seven model were built for experimental study. All models built at same time with given dimension and design consideration. The seven models like Non strengthen column (M1), column with nonadherent jacket (M2), column with monolithic jacket (M3), column jacketed without surface preparation (M4), column jacketed after surface preparation with sandblasting (M5), column jacketed after surface preparation with sandblasting and application of steel connectors (M6) and column jacketed after surface preparation with sand blasting and after loading of axial force (M7) were built and estimate a compressive strength, axial load and yielding load of specimen. The result was analyzed with a several parameters like failure pattern, measured yielding load, maximum load, stiffness, axial load, strain analysis and computation of the column and added jacket contribution to the global strength. The conclusion of this research was the strength and stiffness of jacketed column was higher than the original column and the contribution of adherent jacket to lateral force resistance varied between 86 to 90%.

2.12. Júlio EN, Branco FA, Silva VD and Lourenço JF. (2006)

Júlio EN, Branco FA, Silva VD and Lourenço JF. [20] presented experimental and analytical (Finite element analysis) study of bond strength between jacketed concrete and existing core concrete followed by Hindo KR. [7]. Experimental investigation had started from mix designed of M30, M50 and M100 concrete. Three different situations considered for evaluation: core

concrete (30)/jacketed concrete (30), core concrete (30)/jacketed concrete (50) and core concrete (30)/jacketed concrete (100). Slant shear test was performed to quantify bond strength in shear. Sand blasting method used for surface preparation suggested by Júlio E, Branco F and Silva V. [16], [17]. Finite element analysis carried out to evaluate analytical results and the compare both results. It was concluded that through this research jacketed concrete compressive strength may have influence on concrete-to-concrete bond strength. Increasing difference of compressive strength from jacketed to core concrete was beneficial for repairing and strengthening process.

2.13. Alexander G. Tsonos. (2008)

Alexander G. Tsonos.[21] presented an experimental and analytical finding to evaluate retrofitting methods for older existing structure that have lack of sufficient flexural and shear reinforcement within column and joints. Four identical beam column subassemblage were constructed as per the 1960s and 1970s type existing construction and calculate flexural strength and joint shear stresses of subassemblage subjected to cyclic loading. After applying load researcher was study failure patterns of subassemblage and retrofitted existing subassemblage with different local retrofitting like jacketing and FRP jacketing. In this research researcher study different failure modes, strength, stiffness and energy dissipation of retrofitted subassemblage for pre-earthquake and post-earthquake. Researcher conclude that RC jacketing was more efficient in post-earthquake retrofitting of column and beam column joint than the high strength fiber jacket. In case of pre- earthquake retrofitting/strengthening both reinforced concrete jacket and high-strength fiber jacket were equally efficient.

2.14. Chris G. Karayannis, Constantin E. Chalioris and George M. Sirkelis. (2008)

Chris G. Karayannis, Constantin E. Chalioris and George M. Sirkelis Vandoros K and Dritsos S. [22] presented an experimental investigation of a new type of reinforced concrete jacket for exterior beam-column connections damaged due to earthquake considering summary of research by Tsonos AG. [13]. To investigate a RC jacketed sections 20 original and retrofitted exterior beam column joint subassemblage had been examined. Firstly, 10 joint subassemblage specimen were constructed. Specimen was tested and damaged under constantly increasing cyclic loading. Damaged subassemblage retrofitted using different reinforcement arrangements and made three different groups of retrofitted specimens for investigation. Test results and comparison was done by adopting hysteretic responses and asses the effectiveness of the applied jacketed method. After testing researcher was study a different damaged pattern of original and retrofitted specimen. Researcher was concluded that the proposed jacketing method seems to be easy, reliable and effective for rehabilitation of damaged exterior beam column joints.

2.15. Vandoros K and Dritsos S. (2008)

Vandoros K and Dritsos S. [23] presented an experimental investigation of the effectiveness of strengthening of reinforced columns. In this research three alternative methods of concrete jacketing were presented. The three techniques were adopted for jacketing: welding the jacket stirrup ends together, placing dowels and jacket stirrup end welding and placing bent down steel connector bars welded to the original columns. It was not possible to take proper supervision or construction practice of jacketing and hence in this research researcher study jacketing without surface treatment. Five original and jacketed specimens were constructed for experimental study. A hydraulic jack and an IPE 600 steel beam were used to apply constant load.

In this research Vandoros K and Dritsos S. developed an expression for normalized axial load ratio for the strengthened.

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$$V_i = \frac{Ni}{(A_{co}.f_{co})+(A_{cj}.f_{cj})} \quad \text{.....eq (1)}$$

Test results and failure patterns of each specimen studied and concluded that the behaviour of damaged structural member improved by strengthening significantly without surface preparation. Due to no surface preparation reduction in ductility and dissipated energy capacity can be expected. It was also concluded that CFRPs increases ductility, strength and stiffness.

2.16. Júlio EN and Branco FA. (2008)

Júlio EN and Branco FA. [24] presented an experimental and analytical (Finite Element analysis) study on RC jacketed column under cyclic loading. Research significance was to consider undamaged column with a bending moment/shear force ratio greater than 1. Seven column footing specimens casted for experimental investigation as per casted by Júlio EN, Branco FA, and Silva VD. [19] without preparing surface or using epoxy chemical material or steel connectors. This experimental research concludes that sound column with bending moment/shear force ratio 1 m or greater subjected to monolithic behaviour without surface preparation and numerical research concludes that sound column with bending moment/shear force ratio lower than 1 m debonding of jacket may occur without surface preparation.

2.17. Enuica C, Bob C, Dan S, Badea C, Gruin A. (2009)

Enuica C, Bob C, Dan S, Badea C, Gruin A. [25] was presented experimental program and its application to a structural repair/strengthening/retrofitting. Old and new concrete bond increasing methods was analyzed such as epoxy resin, mechanical anchored connectors, chemical anchored connectors prism class C 16/20 and chemical anchored connectors prism class C 20/25). Three specimens were considered and study old new concrete layers using pull of test. This research concludes that chemical anchors connectors prism from C16/20 and C20/25 increase the bond strength with 15%.

2.18. Ariel D. Espeche and Javier Leon. (2011)

Ariel D. Espeche and Javier Leon. [27] presented a method of estimation of failure envelops for old to new concrete interface based on plasticity theory. To study the behaviour of interface of old and new concrete shear stress and failure criteria of the interface were studied. Analytical model was constructed to study the failure criteria of interface using plasticity index. Tensile strength, friction, cohesion and friction angle were assessed through experimentally. Researcher was concluded that splitting tensile test (Brazilian Test) can be used to estimate failure envelop. This research presented a more rational and precise way of evaluating the cohesion parameter based on the tensile strength of the interface and the coral failure envelop was adopted as a numerical expression.

2.19. PMD santos and Eduardo N. B. S. Julio. (2011)

PMD santos and Eduardo N. B. S. Julio.[28] presented experimental and analytical study on interface bond between new and old concrete. In this research researcher study bond between concrete parts cast in different ages by using different surface preparation techniques. Three different time range were considered for study and six sets of specimens were casted in which three specimens were cured in laboratory and three specimens in exterior of laboratory. Slant shear test and splitting test were adopted to calculate bond strength of the surface in shear. This research focus on temperature, relative humidity, shrinkage and surface preparation parameters. From this research it was concluded that the bond strength of new and old concrete interface with increasing with increasing difference of age between concrete layers and surface roughness. Influence of young's modulus of each concrete layer should be investigated for future study.

2.20. Lampropoulos AP and Dritsos SE. (2011)

Lampropoulos AP and Dritsos SE. [29] examined a finite element analysis model of RC column by adopting experimental data of Júlio EN, Branco FA, Silva VD and Lourenço JF. [19],[20],[24], and predicted the effect of concrete shrinkage on the behaviour of RC column under monotonic and cyclic loading. For studying FE modelling of steel reinforcement and concrete author had cited different literature. The main aim of this research was to investigate the effect of shrinkage on behaviour of column, effect of dimensions of column and axial load. This research concludes that the effect of shrinkage influenced by amount of reinforcement i,e if amount of reinforcement was increased then it reduced a compressive strength due to biaxial stress state and also affected a load carrying capacity. The effect of shrinkage also influenced by dimensions of the RC column and it was found that in rectangular column concrete shrinkage was more critical than square column.

2.21. Lampropoulos AP and Dritsos SE. (2011)

Lampropoulos AP and Dritsos SE. [30] presented finite element analysis of RC column strengthening with RC jackets using ANTENA and ANSYS software [29]. In this research paper FE analysis was carried out to examined the behaviour of jacketed column using experimental data of Júlio EN, Branco FA, Silva VD and Lourenço JF. [19],[20],[24]. Validation was done to calculate percent deviation of experimental and analytical results and proposed a formula for coefficient of friction and adhesion. This research was concluded that an accurate prediction of behaviour of reinforced concrete jacket over a unstrengthen column under monotonic and cyclic loading can be obtained by using special contact element to stimulate interface between the old and the new concrete.

2.22. Lampropoulos A, Tsioulou O and Dritsos S. (2012)

Lampropoulos A, Tsioulou O and Dritsos S. [31] presented an analytical investigation to estimate a response of monolithic column (Original column) and jacketed column by using ANTENA and ANSYS software. Lampropoulos AP and Dritsos SE. [29], [30]. Finite element analysis was performed by considering different values of normalized axial load (Vandoros K and Dritsos S. [23]), jacketed thickness and jacketed concrete strength. Researcher was calculated monolithic coefficient values for the strength and conclude that concrete strength of jacket not significantly influence the monolithic coefficient.

2.23. PMD santos and Eduardo N. B. S. Julio. (2012)

PMD santos and Eduardo N. B. S. Julio. [32] presented research of various researcher on shear friction of concrete-to-concrete interface. The analysis of the design expression was obtained from published research which shows that the load transfer mechanism at concrete-to-concrete interface was due to cohesion friction and dowel action [14]. The summary of this paper was state that the roughness of the concrete substrate had a very significant influence on the bond strength of the concrete-to-concrete interface. From this research future scope identified was to study differential shrinkage and stiffness which was neglected in all described expression by various researcher.

2.24. Cho C, Kim Y, Feo L and Hui D. (2012)

Cho C, Kim Y, Feo L and Hui D. [33] presented experimental research on use of high-performance fiber reinforced cementitious composite mortar to strengthen a reinforced column under cyclic loading and developed a new method for seismic strengthening. Lack of strength and ductility in the plastic hinge region of reinforced column may be vulnerable or raises several concerns due to brittleness of concrete. Failure's modes of column and mixing properties of HPFRC was studied in this research. Three specimens were manufactured by changing PVA fiber volume fraction and one specimen with conventional method for

experimental study. Evaluate and asses hysteretic behaviour, displacement ductility and failure modes of specimen by applying cycling loading. This research concludes that if we placed HPFRC on plastic zone (1.5 -2 d from column base) then it improves a load carrying capacity, deformation capacity and also control bending and shear cracks comparatively conventional method.

2.25. Lampropoulos A, Tsioulou O and Dritsos S. (2013)

Lampropoulos A, Tsioulou O and Dritsos S. [34] proposed a finite element method which were justify and validated using the experimental data. In this present research the findings from the experimental work had been used and finite element analysis had been conducted in monolithic and strengthen reinforced column with and without concrete shrinkage on bridge pier. Numerical analysis and parametric study were carried out and presented a load deflection result of analysis for with and without shrinkage different values of normalized axial load. This research concludes that the strength and stiffness of the restrained jacked column was reduced due to shrinkage and reduction was found to be in range of 8 to 11 % for all specimen.

2.26. Campione G, Fossetti M, Giacchino C and Minafò G. (2013)

Campione G, Fossetti M, Giacchino C and Minafò G. [35] presented analytical study of behaviour in compression of RC columns strengthen with concrete jacketing considering effect of axial load and bending moment. In this paper, researcher cited literature of various researcher including Júlio E, Branco F and Silva V. [16-17-19-20-24] and Vandoros K and Dritsos S. [23] and neglected some important aspects such as shrinkage, creep, old to new concrete interface. According to researcher if concrete surface was not prepared or roughened then there will be 10% reduction occur in flexural strength and interface roughened properly then it will be negligible hence model was developed by neglecting these effects. Researcher developed model of jacketed section using SAP-2000 software and compare experimental results presented in literature for various parameters such as load shortening curves, moment axial-force domain and moment-curvature diagram and concludes that analytical results show good prediction of experimental results.

2.27. Marco Corradi, Antonio Borri, Giulio Castori and Romina Sisti. (2014)

Marco Corradi, Antonio Borri, Giulio Castori and Romina Sisti. [36] presented an experimental investigation of shear strength on three historic building wall panels situated in Italy. As stated by researcher seismic upgradation and consolidation of historic masonry was a recurring problem in most work done on existing buildings, hence there was a need of retrofitting of wall panel effectively and economically. In this research, researcher carried out in situ diagonal compression test and shear-compression test with existing confinement stress on wall panel model retrofitted with GFRP (Glass Fiber Reinforced Plastics). After experimental investigation researcher was carried out finite element analysis (Numerical simulation) based on laboratory results and conclude that the specimen retrofitted or repaired with GFRP grids behaved satisfactorily. Shear strength was increased by using GFRP with limited thickness. It also concludes that finite element modeling can be helpful tool to study exact behaviour of structures with GFRP grids.

2.28. PMD santos and Eduardo N. B. S. Julio. (2014)

PMD santos and Eduardo N. B. S. Julio. [37] presented succeeder research of past research of PMD santos and Eduardo N. B. S. Julio.[28] [32] on interface shear transfer of old new concrete (composite concrete). Researcher presented a design expression of past literature and design expression of design code of shear friction theory and developed a new measuring device 2D Laser Roughness Analyzer (Non-destructive method) to predict bond strength of old new concrete. Experimental study was carried out to investigate the effect of differential shrinkage

and differential stiffness on concrete interface and concludes that it plays significant role to transfer load from old to new concrete. Therefore, it was stated that by researcher design expression of current design code (ACI-318) should be improved to incorporate the consideration of these parameters thus increasing their accuracy.

2.29. Chang S, Chen T, Tran N and Liao W. (2014)

Chang S, Chen T, Tran N and Liao W. [38] presented experimental investigation on an original reinforced column and strengthen column using different strengthening way of RC jacketing and installed wing walls. Original column was a full-scale model of existing column of school building located at Taiwan as per there pre-1999 design standards. Original column failure behaviour was studied by applying cyclic loading on column and retrofitted 2 specimen column using jacketing and 2 specimens by installed wing walls. Researcher presented a comparison of both retrofitting results of RC jacketing and wing walls and conclude that strength and stiffness can effectively improve after both retrofitting method. RC jacketing was increase energy dissipation and ductility comparatively installing wing walls.

2.30. Kaliyaperumal G and Sengupta AK. (2014)

Kaliyaperumal G and Sengupta AK. [39] presented a method of analysis and guidelines for retrofitting of columns for earthquake forces. This paper was reported a study on the enhancement of flexural strength and behaviour of column by concrete jacketing and also study interface of old new concrete. Experimental test was carried out on reference and jacketed column specimen, to study the enhancement of strength of a retrofitted column section under interaction of axial load and bending moment. After experimental investigation it was conclude that the selected jacketing scheme by researcher was effective in enhancing the flexural strength as well as in retaining the ductility and energy dissipation in the behaviour.

2.31. Komathi M and Sengupta AK. (2015)

Komathi M and Sengupta AK. [40] presented an experimental study on strengthening of column for shear by concrete jacketing. After studying different literature including [6-8-10-23] researcher was state that Limited experimental data was available on parameters influencing shear strength of columns strengthened by RC jacketing. Beam column specimens were need to test to investigate the parameters and hence 38 rectangular beam column specimens were tested under monotonic single point lateral loading in the presence and absence of axial load. After studying experimental results researcher was conclude that the shear strength increased substantially after jacketing.

2.32. G. Navya and Pankaj Agarwal. (2016)

G. Navya and Pankaj Agarwal. [41] presented a detailed seismic evaluation and assessment of G + 6 reinforced concrete frame building designed by two design philosophies i.e., IS 456: 2000 and IS 1893 (Part 1): 2002 along with a ductile detailing according to IS 13920:1993. Steel bracing was used to retrofit a given structure to improve the elastic and post yield behaviour of the building for resisting the future seismic demand. The fragility analysis was also carried out to indicate the probability of damage under different states which reduces considerably after retrofitting of building. Analysis was carried out using SAP-2000 software and conclude that the fragility analysis indicated the probability of damage under collapse extensive state of damage reduces considerably after retrofitting of building.

2.33. Yue Li, Xiongfei Liu and Jiaqi Li. (2016)

Yue Li, Xiongfei Liu and Jiaqi Li. [42] presented an experimental investigation of retrofitted cracked concrete using FRP and Nanomodified Epoxy resin. Nanosilica powder was added to

modified the properties of epoxy binder. In this research, researcher was developed two types of modified epoxy resins such as crack glue and FRP glue to repaired cracks. After testing researcher was conclude that Nanosilica powder was improves the ductility, strength and workability of epoxy binders and FRP wrapping had very good ability to make bond with concrete.

2.34. Dubey R, Kumar P. (2016).

Dubey R, Kumar P. [43] reported experimental investigation on self-compacting concrete (SCC) mixes as a retrofitting material and studied its effectiveness and suitability as a jacket for cylindrical column by using Welded Wire Mesh (WWM). After the review of literature cited by various researcher including [16,31] understanded the effect of interface bond between old and new concrete and applied high bond layer with brush on surface for bonding. In this research, experimental programme consisted of 6 control specimens testing and 36 primary specimens for study. The test results from experimental investigation were revealed that the effectiveness of SCC as a retrofitting material. After study, researcher was concluding that axial loading capacity of reinforced concrete improves by confinement effect and use of WWM (Welded Wire Mesh) as a reinforcement increase the ultimate load carrying capacity of column specimen.

2.35. Minafò G, Di Trapani F and Amato G. (2016)

Minafò G, Di Trapani F and Amato G. [44] proposed a simplified analytical method to calculate the flexural strength and ductility of square RC jacketed sections subjected to axial load and bending moment based on moment curvature curve. In this research, researcher carried out a validation with experimental results available in literature [8,10,23,24] through numerical analysis. After modelling and studied obtained results researcher was concludes that stress - block approach was suitable to applied to RC jacketed section and also conclude that proposed methodology can be reliably used under the assumption of negligible bond degradation at old new concrete interface.

2.36. Eduardo Cavaco and Jose Camara. (2017)

Eduardo Cavaco and Jose Camara. [45] presented experimental research to study the behaviour of concrete-to-concrete interfaces subjected to a combination of shear and bending moment. Analysis and application of experimental work was based on shear friction theory to evaluate load transfer mechanism across different aged concrete subjected to a bending moment. In this research, Full scale model of I beam with 5 m length and 0.5 m height was casted, which was loaded at one section and supported at three points to simulate the lateral span of a continuous beam with 3 m length. After experimental research, results shows that the load transfer capacity of concrete-to-concrete interface was reduced due to the bending moment crack opening but it had no influence on the shear and bending strength of the beam.

2.37. Cheng Maili and Ma Jing. (2017)

Cheng Maili and Ma Jing. [46] presented and experimental research to study a shear behaviour of the interface of old- new reinforced concrete. In order to study shear behaviour, researcher was casted three kinds of reinforced concrete model with old-new concrete anchorage reinforcement were designed and constructed. Semi-cyclic loading was carried out and analyzed the failure mode, shear bearing capacity, interfacial shear slip and stress distribution of steel bars. After experimental research, results shows that the failure mode was split type shear failure and shear bearing capacity of concrete was mainly due to shear resistance of concrete and due to dowel pin shear. The maximum value of shear bearing capacity was about 1.186×10^4 kN/m^2, and which was increased by 28.5 %. Researcher was derived a formula to calculate shear capacity of old-new concrete interface which shows more correct results.

2.38. Masuzyo Chilwesa, Adriano Reggia, Fausto Minelli and Giovanni Plizzari. (2017)

Masuzyo Chilwesa, Adriano Reggia, Fausto Minelli and Giovanni Plizzari. [47] proposed a new experimental method to evaluate the shear bond strength of old- new concrete. In order to achieved the study objective, researcher was investigated three materials with different strength such as normal strength (20- 50 MPa), high strength concrete (51-120 MPa) and very high strength concrete (>120 MPa) to overlay on old concrete. Experimental results of proposed method shows that surface interface roughness, adhesion and cohesion of concrete materials plays an important role regarding bond strength.

2.39. Liu C, Ma H, Chen L, Li Z and Yang D. (2017)

Liu C, Ma H, Chen L, Li Z and Yang D. [48] proposed a new retrofitting method to strengthen frame column by asymmetric increased single lateral concrete section. The low cyclic reversed load experiment had been thrown to understand the seismic performance of one un-retrofit specimen and six retrofitted specimens. Experimental study was carried out to study different parameters such as failure mode, hysteresis loop, behaviour, bearing capacity, ductility, stiffness degradation and energy dissipation of retrofitted specimen. Researcher was concluding that ultimate strength of retrofitted section was increase about 40-155% by using proposed method and also increase deformation capacity of retrofit column about 10-20%.

2.40. Ma C-K, Apandi N, Sofrie C, Ng J, Lo W, Awang A and Omar W. (2017)

Ma C-K, Apandi N, Sofrie C, Ng J, Lo W, Awang A and Omar W. [49] presented a literature review on repair and rehabilitation of concrete structure using confinement and concludes that FRP confinement was the most popular and effective method of restorability and also made some recommendation for future scope of research.

2.41. Alhadid M and Youssef M. (2018)

Alhadid M and Youssef M. [50] reported a finite element analysis of continuous jacketed reinforced concrete beam to assessment of flexural strength. This research was aim to proposed a simplified method to study the influence of interfacial slip on the moment curvature and load deflection relationship of jacketed continuous reinforced beam. A parametric study was carried out including 5103 symmetric continuous beams subjected to uniformly distributed loads. Different parameters such as geometric properties, mechanical properties and surface treatment were investigated. The result of this research reveals that slip influence the stiffness of jacketed section and ductile failure mode of beam detected. A design procedure and stiffness monolithic factor were introduced to asses the flexural behaviour of the continuous RC beam.

2.42. Deng M, Zhang Y, Li Q. (2018)

Deng M, Zhang Y, Li Q. [51] developed an easy to apply strengthening method for reinforced concrete short column by using engineered cementitious composite. Engineered cementitious composite have a high-performance composite material with tensile strain hardening behaviour and multiple cracking mechanism in tension. Experimental investigation carried out by preparing seven identical RC short column and five of them were strengthened by using ECC jacket. lateral cyclic loading was applied over a specimen and studied failures mode, hysteresis response, deformation capacity, stiffness degradation and energy dissipation. The test results of experimental investigation shows that the ECC jacketed section was failed in ductile modes and exhibited significant improvement in plastic deformation ability and energy dissipation capacity of specimen compared with the original specimen. Shear strength and shear deformation of original specimen were improved effectively by ECC jacket.

2.43. Rodrigues H, Pradhan PM, Furtado A, Rocha P and Vila-Pouca N. (2018)

Rodrigues H, Pradhan PM, Furtado A, Rocha P and Vila-Pouca N. [52] reported a brief overview of the experimental investigation conducted by other researcher and also presented a numerical modelling of the behaviour of RC elements retrofitted with the RC jacketing. After experimental and numerical investigation two case study were carried out to evaluate the efficiency of RC jacketing to improve the original seismic performance of a soft-storey building and a university. The result of this research shows that RC jacketing increase a strength, stiffness and ductility of member.

2.44. Ou Y and Truong A. (2018)

Ou Y and Truong A. [53] proposed an innovative seismic retrofitting method to address the weak first storey issue of reinforced concrete houses in Taiwan. Large scale L and T column constructed and retrofitted from rectangular column with the proposed retrofitting method were tested by applying cyclic loading. Experimental test results shows that retrofitted column exhibited ductile, flexural dominated behaviour.

2.45. Raza S, Khan MK, Menegon SJ, Tsang HH and Wilson JL. (2019)

Raza S, Khan MK, Menegon SJ, Tsang HH and Wilson JL. [54] presented a review on strengthening and repair of RC column using jacketing method to provide a various strengthening and repair methods for RC columns proposed by different researchers in the last two decades. The scope of this review paper is limited to jacketing techniques for strengthening and/or repairing both normal- and high-strength RC columns. This review paper also identifies potential research gaps and outlines the future direction of research into the strengthening and repair of RC column.

2.46. Ali Naseri, Alireza Mirzagoltabar Roshan, Hossein Pahlavan and Gholamreza Ghodrati Amiri. (2020)

Ali Naseri, Alireza Mirzagoltabar Roshan, Hossein Pahlavan and Gholamreza Ghodrati Amiri. [59] studied a probabilistic seismic assessment of RC box-girder bridges retrofitted with FRP and steel jacketing seismic assessment of RC box-girder bridges retrofitted with FRP and steel jacketing analytically using openSEES. To study behaviour of RC box girder researcher compare a analytical results with actual results of retrofitted RC box-girder bridges using FRP and steel jacketing. Nine different models were studied by researcher to study different parameters of retrofitting. After constructing a model fragility analysis were carried out to study/accessed an actual behaviour of structure and presented comparison of twSo retrofitted measures.

2.47. Alireza Valikhani, Azadeh Jaberi Jahromi, Islam M. Mantawy and Atord Azizinamini. (2021).

Alireza Valikhani, Azadeh Jaberi Jahromi, Islam M. Mantawy and Atord Azizinamini. [59] proposed a design equation based on experimental and numerical research on the effect of mechanical connectors on interface shear strength between concrete substrates and Ultra High-Performance Concrete (UHPC). 39 specimens were casted and tested using modified push off test to evaluate the interface shear strength for combination of different surface treatments and different reinforcement ratio for mechanical connectors. The reinforcement ratio range taken as between 0 to 0.012. The experimental results were used to developed design equation to estimate interface shear strength following AASHTO-LRFD approach in terms of cohesion and adhesion combined with aggregate interlock and numerical model was used to calibrate interface model parameters with sufficient acceptance.

2.48. Sara Cattaneo, Giacoma Zorzato and Antonia Bonati. (2021)

Sara Cattaneo, Giacoma Zorzato and Antonia Bonati. [60] presented experimental and numerical research to investigate cyclic behaviour of concrete layers casted at different times. In this research common experimental test setup was carried out such as push of test two tests configuration that allow the application of reversed action which also analyzed numerically to select most reliable configuration to access the cyclic behaviour of concrete surface. After studying experimental and numerical results of tests researcher concludes that static assessment cannot be assumed in actual cases when cyclic actions are crucial and hence cyclic performance was need to consider for proper evaluation.

2.49. Yong Zhao, Renbo Zou, Tao Ding and Jianzhuang Xiao. (2021)

Yong Zhao, Renbo Zou, Tao Ding and Jianzhuang Xiao. [61] presented experimental study of the shear behaviour of concrete grout concrete joints. In this research, a monotonic and cyclic loading tests were carried out to examine the influence of the grouting thickness and the interfacial shear reinforcement ratio on the shear behaviour of this old new concrete joint. The shear behaviour was compared with that of the old new concrete interface. The experimental test results showed that the shear capacity of the concrete-grout-concrete joint was lower than that of the old new concrete interface and the shear transfer mechanism of the concrete-grout-concrete joint was proposed based on the extended friction shear model.

3. Implications from literature, codes and standards

The literature review conducted by author is aimed to identify the contribution given by researchers for the reinforced concrete jacketing beam column to strengthened/ retrofitted existing RCC structures in the last five decades. Literature review showed that some milestones were there to contribute a major significance such as Interface bond strength of old new concrete, Load transfer mechanism, Load carrying capacity, Strength, Stiffness and ductility of jacketed section, Assessment and evaluation methodology among others.

Among all the researchers following three major contributions in the field of retrofitting were found notable highlighting, (1) **Eduardo N. B. S. Julio *et al*** proposed a design expression for shear transfer, study interface bond strength of concrete-to-concrete and also study seismic evaluation of RC jacketing of column experimentally. (2) **A. P. Lampropoulos *et al*** extended the experimental study of Eduardo N. B. S. Julio *et al* and made a finite element-based model on ANSYS software to compare the analytical and experimental results. (3) Furthermore, **A. K. Sengupta *et al*** assessed and evaluate RC jacketed beam column sections experimentally and analytically and present a new scheme to enhance strength, stiffness and ductility of jacketed section. Although research of three milestone researchers are very useful to understand the experimental and analytical findings of RC jacketing of beam/column, but there are many researchers who have studied behavior of jacketed and original section (un-jacketed) using different materials, innovate new technique to strengthen damaged structures and likewise are presented below in Tabular form for easy reference,

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Table No-1: Comparison of Various Researcher

Sr. No	Author	Testing Parameter	Loading Scheme	Flexural/Shear Strength	Stiffness	Ductility	Load Carrying Capacity	Remark
1	Hellesland et al (1972)	Original and Jacketed Specimen	Lateral cyclic Loading	Decrease	Increase	Increase	Decrease	
2	Sugano S. et al (1981)	Original and Jacketed Specimen	Axial Load	Not Reported	Not Reported	Not Reported	Increase	Load carrying capacity increase using Jacketing
3	Rodriguez M et al (1991)	Arrangement in transverse reinforcement	Seismic Load	Increase	Increase	Increase	Increase	
4	Vistap M Karbhari et al (1997)	FRP Confinement	Constant Axial Load	Increase	Increase	Increase	Increase	
5	Tsonos A. G. (1999)	Original and Jacketed Specimen	Cyclic Loading/Constant Axial Load	Increase	Not Reported	Not Reported	Increase	
6	A. P. Lampropoulos et al (2003)	Finite Element Analysis of Interface between old New Concrete	Friction, Cohesion Study	Increase	Not Reported	Not Reported	Not Reported	
7	Abdullah et al (2003)	Wire mesh, Ferrocement Confinement Jacketing Used	Cyclic Loading/Constant Axial Load	Flexural strength Same	Same	Increase	Not Reported	
Sr. No	**Author**	**Testing Parameter**	**Loading Scheme**	**Flexural/Shear Strength**	**Stiffness**	**Ductility**	**Load Carrying Capacity**	**Remark**
8	Julio E N et al (2003)	Interface Preparation	Review on interface preparation	Not Reported	Not Reported	Not Reported	Not Reported	To increase Load carrying capacity of section Interface preparation treatment is important
9	Julio E N et al (2003)	Interface Preparation Treatment	Slant Shear test and Pull-out Test	Bond Strength Increase	Not Reported	Not Reported	Not Reported	
10	Ong K. c. et al (2004)	Original and Jacketed Specimen (Parametric Study)	Compare Experimental and Anlytical data of other researchers	Not Reported	Not Reported	Not Reported	Increase	

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11	Julio E N et al (2005)	Original and Jacketed Specimen	Monotonic Loading	Increase	Increase	Increase	Increase	
12	Julio E N et al (2006)	Original and Jacketed Specimen	Slant Shear Test and FEM analysis	Not Reported	Not Reported	Not Reported	Not Reported	Concrete to concrete bond strength influence a Compressive Strength
13	Tsonos A. G. (2008)	Existing and Jacketed Section (High Strength Fiber Jacket)	Cyclic Loading/Constant Axial Load	Increase	Not Reported	Increase	Increase	

Sr. No	**Author**	**Testing Parameter**	**Loading Scheme**	**Flexural/Shear Strength**	**Stiffness**	**Ductility**	**Load Carrying Capacity**	**Remark**
14	Chris K. G et al (2008)	Original and Jacketed Specimen (New type of RC Jacketing)	Constantly increasing Cyclic Loading	Increase	Increase	Increase	Increase	
15	Vandoros K. et al (2008)	Alternative Method of Jacketing Presented	Axial Load	Increase	Increase	Decrease due to No surface Preparation	Increase	
16	Julio E N et al (2008)	Original and Jacketed Specimen	Lateral cyclic Loading	Not Reported	Not Reported	Not Reported	Not Reported	BM/Shear >1 - Monotonic Behaviour BM/Shear <1 - Debondiong Jacketed without surface preaparation
17	Enuica C et al (2009)	Old New Concrete Bond Strength	Pull of Test	Not Reported	Not Reported	Not Reported	Not Reported	Increase bond Strength 15 %
18	Ariel D (2011)	Interface of Old New Concrete	Plasticity Theory (Analytical Study)	Not Reported	Not Reported	Not Reported	Not Reported	More Rational and Precise way of Evaluation of Cohesion Parameter Presented
19	PMD Santos et al (2011)	Interface Bond between Old and New Concrete	Slant Shear Test and Splitting Test	Not Reported	Not Reported	Not Reported	Not Reported	Bond Strength Increase with increasing difference of age between concrete layers

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Sr. No	Author	Testing Parameter	Loading Scheme	Flexural/Shear Strength	Stiffness	Ductility	Load Carrying Capacity	Remark
20	A. P. Lampropoulos et al (2011)	Original and Jacketed Specimen	FEM analysis	Not Reported	Not Reported	Not Reported	Not Reported	Reduced Compressive Strength due to biaxial stress
21	A. P. Lampropoulos et al (2011)	Original and Jacketed Specimen	FEM analysis (Increasing Axial Load)	Not Reported	Not Reported	Not Reported	Not Reported	Accurate Prediction of Behaviour of Jacketed Section can be calculated using modelling
22	A. P. Lampropoulos et al (2012)	Original and Jacketed Specimen	FEM analysis (Increasing Axial Load)	Same	Not Reported	Not Reported	Not Reported	Concrete Strength of jacket not significantly influence the monolithic coefficient
23	PMD Santos et al (2012)	Shear Friction of Concrete to Concrete Interface	Review Design Expression of Shear Friction Theory	Not Reported	Not Reported	Not Reported	Not Reported	Interface preparation influence a bond strength, Shrinkage and Stiffness study is important
24	Cho C et al (2012)	Original and HPFRC jacketed sections	Lateral cyclic Loading	Increase	Not Reported	Increase	Increase	
Sr. No	**Author**	**Testing Parameter**	**Loading Scheme**	**Flexural/Shear Strength**	**Stiffness**	**Ductility**	**Load Carrying Capacity**	**Remark**
25	A. P. Lampropoulos et al (2013)	Original and Jacketed Bridge Pier	FEM analysis (Cyclic Loading)	Decrease due to shrinkage	Decrease due to shrinkage	Not Reported	Not Reported	
26	G. Campione et al (2013)	Original and Jacketed RC Column	Axial Load (Analytical Test)	Flexural strength increase	Not Reported	Not Reported	Increase	
27	Marco Corradi et al (2014)	Case study of Historic Building Wall Panal in Italy using GFRP	Slant Shear	Shear Strength Increase	Not Reported	Not Reported	Not Reported	FEM Modelling can be helpful tool to study exact behaviour of Jacketing

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28	PMD Santos et al (2014)	Interface Shear Transfer of old new Concrete	Developed Laser Roughness Analyzer (NDT)	Not Reported	Not Reported	Not Reported	Not Reported	Study Load Transfer Mechanism, Stiffness and Shrinkage influences a strength
29	Chang S et al (2014)	Original and Jacketed Full Scale Model	Cyclic Loading	Increase	Increase	Increase	Not Reported	
30	Kaliyaperumal et al (2014)	Behavioral Study of RC Jacketed Specimen and InterfaceTreatment	Axial Load and bending Moment	Flexural strength increase	Not Reported	Not Reported	Increase	
31	Komathi M et al (2015)	Original and Jacketed Column (Strengthening for Shear)	Monotonic Single Point Lateral Loading	Shear Strength Increase	Not Reported	Not Reported	Not Reported	
Sr. No	**Author**	**Testing Parameter**	**Loading Scheme**	**Flexural/Shear Strength**	**Stiffness**	**Ductility**	**Load Carrying Capacity**	**Remark**
30	Kaliyaperumal et al (2014)	Behavioral Study of RC Jacketed Specimen and Interface Treatment	Axial Load and bending Moment	Flexural strength increase	Not Reported	Not Reported	Increase	
31	Komathi M et al (2015)	Original and Jacketed Column (Strengthening for Shear)	Monotonic Single Point Lateral Loading presence and absence of axial load	Shear Strength Increase	Not Reported	Not Reported	Not Reported	
32	G. Navya et al (2016)	Steel Jacketing	Fragility Analysis, Pushover Analysis	Increase	Increase	Increase	Not Reported	Fragility Analysis indicates the probability of Damaged under collapse
33	Yue Li et al (2016)	Retrofitted crack concrete using FRP and Nanomodified Epoxy Resin used	Pull of Test and Flexural Strength Test	Increase	Not Reported	Increase	Not Reported	

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34	Dubey R et al (2016)	Self-Compacted Concrete as a Jacketed Material and use Welded Wire Mesh	Monotonic Axial Load	Increase	Not Reported	Not Reported	Increase	LCC increased due to Confinement and WWM used
Sr. No	**Author**	**Testing Parameter**	**Loading Scheme**	**Flexural/Shear Strength**	**Stiffness**	**Ductility**	**Load Carrying Capacity**	**Remark**
35	Minafo G. et al (2016)	Original and Square RC Jacketed Section	Axial Load and bending Moment	Flexural strength increase	Not Reported	Increase	Not Reported	
36	Eduardo C et al (2017)	Interface Bond between Old and New Concrete	Loaded at one section and Supported at Three Point to Simulate Lateral Span	Flexural strength and Shear Strength Same	Not Reported	Not Reported	Not Reported	Load Transfer Capacity was reduced due to Bending Moment Crack
37	Cheng Mali et al (2017)	Shear Behaviour of Old New Concrete	Semi Cyclic Loading	Not Reported	Not Reported	Not Reported	Not Reported	Shear Bearing Capacity Increased by 28.5 %
38	Musuzyo Chilwasa (2017)	Proposed New Experiment Method to evaluate bond strength	Compressive Strength Test, Elastic Modulus and Tensile Strength Test	Increase	Not Reported	Not Reported	Increase	LCC Increased due to Roughness, Adhesion and Cohesion
39	Liu C et al (2017)	Proposed new retrofitting method (Original/Jacketed Section)	Low Cyclic Reverse Load	Increase	Increase	Increase	Slightly Increased	
40	Ma C. K. et al (2017)	Confinement	Present Review Results	Increase	Increase	Increase	Increase By FRP jacketing	
Sr. No	**Author**	**Testing Parameter**	**Loading Scheme**	**Flexural/Shear Strength**	**Stiffness**	**Ductility**	**Load Carrying Capacity**	**Remark**

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41	Alhadid M et al (2018)	Original and Jacketed Specimen (Interface Treatment)	FEM analysis	Influence by Slip	Influence by Slip	Not Reported	Not Reported	Design procedure introduced
42	Deng M et al (2018)	Original and Engineered Cementitious Concrete Jacketed Specimen	Lateral cyclic Loading	Same	Same	Increase	Not Reported	
43	Rodriguez M et al (2018)	Original and Jacketed Specimen	Present Review Results	Increase	Increase	Increase	Increase	
44	Ou Y et al (2018)	Innovative Seismic Retrofitting Method Proposed	Cyclic Loading	Influence due to interface	Not Reported	Not Reported	Increased by 120 %	
45	Raza S, Khan MK et al (2019)	Review on jacketing of section	-	-	Increase	Increase	Increase	-
46	Ali Naseri et al (2020)	Probabilistic evaluation of retrofitted bridge	Fragility analysis	Not reported	Not Reported	Not Reported	Not Reported	Fragility curves were developed to study actual behaviour of structure
47	Alireza Valikhni et al (2021)	Interface Strength Between Concrete and UHPC	Push of Test	Not Reported	Not Reported	Not Reported	Not Reported	Cohesion, Adhesion and Aggregate interlocking influence strength
48	Sara Cattaneo et al (2021)	Interface study of Concrete layer casted at different age	Pull of Test	Not Reported	Not Reported	Not Reported	Not Reported	Cyclic Loading Performance Gives Exact Results and behaviour of Jacketed Specimen
49	Yong Zhao et al (2021)	Concrete grout concrete	Monotonic and Cyclic Loading	Not Reported	Not Reported	Not Reported	Not Reported	
50								

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4. Summary and Conclusion

The present paper synthesizes and compares experimental test results and analytical model results to evaluate and assess feasibility of local retrofitting technique (Jacketing of Structural Members). It is found that among all the important parameters needful for retrofitting three key potential parameters must be addressed critically, while taking into account a feasibility of local retrofitting technique. They can be categorized as interface bond strength of old new concrete, load transfer mechanism and load carrying capacity of retrofitted section. Based on the review made above, the following inferences are drawn,

1. Most of the literature highlights the adoption of local + global strengthening methodology in which jacketing to beams / columns are proposed along with global retrofitting solution such as adding shear wall, steel bracing etc, whereas local retrofitting involves addition of high-grade concrete over the existing structural element column/ beam prominently.
2. From various research, it is observed that no one was focus on post retrofitted behaviour of structure. If it is possible to know the post retrofitted behaviour of every structure before going for retrofitting then it will be very easy to provide feasible technique over a structure for engineers/designers/consultants.
3. It is easy to study post retrofitted behaviour of globally retrofitting structures compared with a local retrofitted structure because local retrofitting techniques involved an addition of reinforced concrete layer over an existing section. Very few literatures are there which focus on composite strength of jacketed section. If it is possible to find out a composite strength of jacketed section then it will be very easy to decide actual behaviour of jacketed structure, which can be incorporated in modelling to study after retrofitted behaviour of structure.

The above findings highlight and are presented based on the authors observation made after review of literature contributed by various researcher from last five decades.

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