An Attempt to Develop High Strength Industrial Belt Using Carbon Fiber – A Technical Review

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Abstract— Carbon fibers are globally more accepted today because it fulfils many requirements of Today's world in the field of manufacturing. Growth rate and investments in the field of CFRP products are rapid from last decades .carbon fiber in the form of CFRP is used in civil engineering for the purpose of seismic retrofitting .Now carbon fiber in the form of high strength woven belts is used in the civil engineering for seismic retrofitting repair and maintenance of walls, beams, and column. The important properties which are tested for the woven carbon belts are tensile strength, seam strength which is important when it is used.

Key words: Carbon Fiber, Seismic Retrofitting, CFRP, Reinforced Concrete, Carbon Belt

I. Introduction

Today the world is facing many fundamental challenges like change in the economic environment, climatic change, energy/raw material availability. The solution may be energy efficiency, alternative energy and light weight, the carbon fibers contribute to these all because .it is lighter than steel and aluminum so it is better than others for manufacturing of body parts of wind energy rotor blade and automotive, aircraft body parts which makes it fuel efficient and in case of rotor blades the length can be increase with high strength .day by day we are now able to harvest more energy by using low weight long rotor wind blade. Carbon fibers are used for light weight car. In civil engineering today, only 20 to 30% of the strength of carbon-fiber-reinforced polymer (CFRP) strips is used when they are applied as externally bonded strips for flexural and shear strengthening or in confinement of reinforced concrete (RC) structural elements . These all applications are in the form of CFRP but now carbon fibers in the woven form are also used in many industrial applications. Carbon belts are used in the construction and maintenance of already constructed building. These narrow width belts of 100% carbon fibers are woven on Jacob Muller narrow width China made needle loom having very high tensile strength up to 100 KN.

A. *Market Demand of Carbon Fibers:*

In a survey it is seen that the demand of the carbon fibers in different field is increasing rapidly to look after these data the investments in the carbon fields is increasing rapidly day by day and it is believe that from 2010 to 2020 the graph of investment will be rise sharply. The major application is industrial.

II. Literature survey

H. Katsumata, K. Kimura, and Y. Kobatake, (1) this paper present New retrofitting techniques using carbon fibers are presented. For existing reinforced concrete columns, a CFRP winding technique is employed, in which carbon fiber strands or sheets are wound onto the surface of columns, impregnating and curing epoxy resin. The additional CFRP hoops are constructed to make the columns more ductile. However, debonding of CFRP from a concrete surface limits applications of these CFRP techniques for other retrofit works. From experimental and analytical research, debonding strength and effective bond length are found.

Retrofit techniques using CFRP are widely spread in Japan as one of seismic strengthening measures for building columns and beams, chimneys, and bridge columns. These techniques have a problem of debonding of CFRP from concrete. The debonding usually has no influence on the behavior of retrofitted building columns but limits improvement by CFRP glued in the longitudinal direction. The debonding behavior and strength was discussed by loading tests and analyses. Future research is still required to obtain more detail knowledge on the debonding, for example, influence of concrete strength, evaluation of bond strength from a fracture mechanics approach, and so on.

Mesay A. Endeshaw, Mohamed ElGawady, Ronald L. Sack and David I. McLean (2) This study investigated retrofitting measures for improving the seismic performance of rectangular columns in existing bridges. Experimental tests were conducted on 0.4-scale column specimens which incorporated details that were selected to represent deficiencies present in older bridges in Washington State. Two unretrofitted specimens were tested to examine the performance of the as-built columns incorporating lap splices at the base of the columns and deficient transverse reinforcement. Five columns were retrofitted with carbon fiber reinforced polymer (CFRP) composite wrapping and one specimen was retrofitted with a steel jacket. The specimens were subjected to increasing levels of cycled lateral displacements under constant axial load. Specimen performance was evaluated based on failure mode, displacement ductility capacity and hysteretic behavior. Failure in the as-built specimens was caused by either spalling followed by longitudinal reinforcement buckling and eventual low cycle fatigue fracture or lap splice failure. Reasonable energy dissipation and ductility were achieved in the as-built specimens. While results from this study and from past research indicate satisfactory column performance for displacement ductility levels of 4 or more, these results should be applied carefully due to possible scaling effects, and it is anticipated that full-scale columns may perform worse than the scaled specimens. Hence, it is conservatively recommended that all columns be retrofitted to ensure a ductile performance for displacement ductility demands of 2 or more. For retrofitting of rectangular columns, it is recommended that oval-shaped jackets be used whenever possible. Column specimens with oval-shaped jackets of steel and CFRP composite material performed similarly, both producing ductile column performance. Failure in these specimens was due to flexural hinging in the gap region between the footing and retrofit jacket, leading to eventual low-cycle fatigue fracture of the longitudinal reinforcement. Details and procedures for the design of oval-shaped steel jackets are provided in FHWA Seismic Retrofitting Manual for Highway Bridges (2006). Design guidelines for oval-shaped CFRP jackets are given in ACTT-95/08 (Seibel et al., 1995). Oval-shaped jackets designed according to these recommendations can be expected to prevent slippage of lapped bars within the retrofitted region. Columns retrofitted with rectangular-shaped CFRP jackets all demonstrated ductile column performance. Failure in these specimens was due to flexural hinging in the gap region followed by low-cycle fatigue fracture of the reinforcement. The CFRP jacket designed based on ACTT-95/08 recommendations for rectangular-shaped retrofits resulted in satisfactory performance, but bulging of the CFRP jacket was observed towards the end of testing. Increased thickness of CFRP jackets resulted in reduced bulging of the CFRP jacket and, in the case of the specimen retrofitted with a CFRP jacket designed based on 150% of the ACTT-95/08 recommendations, improved performance. Design guidelines for rectangular-shaped retrofitting using CFRP composite materials are proposed for application to columns with cross-section aspect ratios of 2 or less. While no slippage of the lap splice was observed, it is conservatively recommended that rectangular-shaped CFRP wrapping be used only for the situation where controlled debonding of the lap splice is acceptable.

The experimental results of this study indicate that rectangular columns present in bridges in Washington State built in the 1950s and 1960s may perform better than has been reported for older bridge columns elsewhere in the U.S. Failure in the specimens representing the as-built conditions was caused by spalling due to flexural loading, leading to buckling and eventual low cycle fatigue fracture of the reinforcement along with lap splice failure. Reasonable energy dissipation and ductility were achieved in the as-built specimens, reaching a displacement ductility level of 6. The superior performance obtained for the as-built specimens are due to specific parameters present in the columns of this study, namely a relatively long lap splice (35 times the spliced bar diameter), relatively low axial load (7% of the column axial capacity), and a low reinforcement content (1.2%). Although the investigated parameters are representative of columns in Washington State's interstate bridge inventory, caution is necessary in widely applying these conclusions to the performance of all existing rectangular bridge columns.

The column specimen retrofitted with an oval-shaped steel jacket demonstrated a ductile performance, reaching a displacement ductility level of 7. Failure in this specimen was due to flexural hinging in the gap region between the footing and retrofit jacket, leading to eventual low-cycle fatigue fracture of the longitudinal reinforcement. The column specimen retrofitted with an oval-shaped carbon fiber reinforced polymer (CFRP) jacket performed essentially the same as the steel-jacketed specimen, also achieving displacement ductility of 7 and with the same failure mode. Columns retrofitted with rectangular-shaped CFRP jackets all demonstrated ductile performance, achieving displacement ductility of 7 or higher. Failure in these specimens was due to flexural hinging in the gap region followed by low-cycle fatigue fracture of the longitudinal reinforcement. No slippage of the lapped bars occurred during testing. The CFRP jacket designed based on ACTT-95/08 recommendations for rectangular-shaped retrofits resulted in performance similar to that for the specimens with oval-shaped jackets. Bulging of the CFRP jacket was observed towards the end of testing. Increased thickness of CFRP jackets resulted in reduced bulging of the CFRP jacket and, in the case of the specimen retrofitted with a CFRP jacket designed based on 150% of the ACTT-95-08 recommendations, improved performance, achieving a displacement ductility of 9. The retrofit measures of this study resulted in only modest improvements over the performance of the as-built specimens. This is due to the relatively good performance of as-built specimens that limited the available potential for improvement. Moreover, it should be noted that all retrofitted specimens achieved or exceeded a displacement ductility capacity of 7, which may be an acceptable performance level for all but the most severe seismic loading.

Harmed LAYSSI & Denis MITCHELL,(3) this paper present The reversed cyclic loading responses of full-scale shear wall specimens were investigated. The walls were designed and detailed to simulate non-ductile reinforced concrete construction of the 1960's, having lap splices of the longitudinal reinforcement in the potential plastic hinge region, and having inadequate confinement of the boundary regions. The walls were tested under reversed cyclic loading with loading applied near the tip of the walls. The response of the original walls was associated with the brittle failure of the lap splice. The effectiveness of a retrofit technique and a repair technique were investigated. The retrofit involved the use of carbon fibre-reinforced polymer (CFRP) wrap for improving the lap splice behaviour and the shear strength of the walls. The repair of the previously tested specimens using a steel fibre-reinforced self consolidating concrete (SFRSCC) jacket, and CFRP wrap was investigated. The retrofit and repair techniques improved the displacement ductility, and prevented premature failure of the lap splices.

The reversed cyclic responses of existing deficient shear walls were studied. The as-built walls had inadequate lap splices in the flexural reinforcement at the base of the wall and inadequately anchored transverse reinforcement offering no confinement at the ends of the walls. These walls experienced sudden failure of the lap splice prior to general yielding. The retrofit method consisted of applying CFRP wrap that was designed as a minimal intervention technique, aimed to prevent the premature failure of the lap splice and provide some yielding. The retrofitted walls were able to develop their nominal flexural capacities, and achieved a ductility of 2.0.The repair technique consisted of a SFRSCC jacket over the lap splice region, which increased the nominal flexural capacity of the wall at its base. The walls developed significant yielding in the flexural bars and achieved higher displacement ductilities and flexural moment capacities.

Patrick Bischof 1,*, René Suter 1, Eleni Chatzi 2 and Pierino Lestuzzi 3 (4) This work reports the outcomes of an extensive experimental campaign on the retrofitting of masonry walls by means of carbon fiber reinforced polymer

(CFRP) sheets, carried out at University of Applied Sciences (UAS) Fribourg. In the first stage, static-cyclic shear tests were conducted on the masonry walls, followed by a second stage of tensile tests on alternative configurations of mechanical anchorage so as to assess the effects on the structural response and to identify the associated limits. In the static-cyclic shear tests, it was found that the resistance of masonry walls retrofitted with CFRP sheets was improved by up to 70%, and the deformability was improved by up to 10% in comparison to the un-retrofitted specimens. The experimental tests conducted on alternate configurations of mechanical anchorages indicate that the tested materials and configurations rely heavily on details. The sensitivity of CFRP sheets to edges, non-uniformities on any adhered and bonding defects can cause premature CFRP failure and, hence, pose problems for the efficient design of a retrofitting scheme. As indicated by the results of this investigation, effective anchorage can be achieved when eccentric loading of the Mechanical anchorage is avoided and a smooth bonding surface is guaranteed.

This paper reports the outcomes of an experimental campaign aiming to quantify the seismic capacity of URM walls, the benefit of CFRP retrofitting, and the influence of anchorage in the performance of the retrofitting solution. The results of these tests are valuable in engineering practice as they discuss in detail the effectiveness of a frequently used solution, which nonetheless is very infrequently tested. The outcome of this experimental series serves in establishing some guidelines in the proper setup and anchoring of the CFRP sheets The results of the experimental series MR-B show that the tested masonry walls can be retrofitted with CFRP sheets in order to increase the horizontal load capacity by 10%–70% and the deformation capacity by 2%–10%, depending on the configuration of CFRP sheets. Vertically applied sheets increase the bending strength and assist in resisting rocking effects whereas diagonally applied sheets strongly enhance the shear capacity. By applying CFRP sheets or carbon meshes as reinforcement to masonry walls, a new inner state of stress is generated. The reinforcement acts as a tension strut, whereas the masonry acts as a compression strut. The analysis of this tension and compression strut creates the possibility to design according to the truss analogy or according to stress fields. The static tensile tests conducted on the mechanical anchorage of CFRP sheets show that the effectiveness of the tested materials and configurations largely relies upon details. The sensitivity of the CFRP sheet to edges, non-uniformities on any adherend, inconsistencies of bond stress (e.g., abrupt change from steel to polystyrene), and bonding defects can cause premature CFRP failure and, hence, pose problems for the design of a retrofit. Especially for the configuration tested in Series AT-C, these problems cannot be satisfactorily controlled. Nevertheless, the results in Series AT-H and Series AT-F show that effective anchorage can be achieved when eccentric loading of the mechanical anchorage is avoided and a smooth bonding surface is guaranteed. From Series AT-H, it can be concluded that the bonded length of 40 mm is sufficiently long for both CFRP sheets used. This conclusion was confirmed by numerical simulations and analytic considerations. However, the bonding behavior of bonded CFRP sheet-to-metal joints was not studied in detail and further research is required. In Series AT-F, anchorage was reliably achieved. It was established that the mortar between concrete and masonry influences the specimens' stiffness up to its failure. Bonded joints between the CFRP sheets and the metallic mechanical anchorage as well as between the CFRP sheets and concrete interact until the concrete fails. Consequentially, the tensile strength of CFRP sheets is better exploited by metallic mechanical anchorage than by anchorage on concrete or masonry only.

N. H. Hamid, N. D. Hadi, K. D. Ghani (5) this papper presents the retrofitting of beam-column joint using CFRP (Carbon Fiber Reinforced Polymer) and steel plate. This specimen was tested until failure up to 1.0% drift. This joint suffered severe damages and diagonal cracks at upper crack at upper column before retrofitted. CFRP were wrapped at corbel, bottom and top of the column. Steel plates with bonding were attached to the two beams and the jointing system. This retrofitted specimen is tested again under lateral cyclic loading up 1.75% drift. Visual observations show that the cracks started at joint when 0.5% drift applied at top of column. Damage of retrofitted beam-column joint occurred inside the CFRP and it cannot be seen from outside. Analysis of elastic stiffness, lateral strength, ductility, hysteresis loops and equivalent viscous damping shows that these values are higher than before retrofitting. Therefore, it is recommended to use this type of retrofitting method for beam-column joint with corbel which suffers severe damage after the earthquake.

The overall performance of the retrofitted beam-column joint had increased when compared to the control specimen. This indicates that the retrofitting method was able to strengthen the beam-column joint with corbel under lateral cyclic loading. The control specimen experienced diagonal shear failure at the top column that contributed to the soft-storey mechanism phenomenon when tested under lateral cyclic loading at 1% drift. However, the retrofitted specimen experienced cracking at interfaces and rupture of CFRP sheet and bended reinforcement when retested under lateral cyclic loading at 1.75% drift. By retrofitting the exterior beam-column joint with CFRP, the lateral strength is increased by 5% for the beam-column joint. The stiffness of beam-column joint also increases after retrofitting. At yield point, the stiffness increased by nearly 46% for the first cycle and 29% for the second cycle in the positive direction. The ductility of the retrofitted beam-column joint has increased to almost twice the value of the control specimen after retrofitting as compared to before retrofitting in the first cycle while the equivalent viscous
Damping for the retrofitted specimen is higher than the control specimen.

YASMEEN TALEB OBAIDAT (6) this papper presents this thesis details experimental work and finite element simulations of reinforced concrete beams retrofitted with carbon fiber reinforced polymer (CFRP). The objectives of this study were to investigate the behaviour of retrofitted beams experimentally, develop a finite element model describing the beams, verifying the finite element model against the experimental results and finally investigating the influence of different parameters on the behaviour of the retrofitted beams. The experimental tests were performed to investigate the behaviour of beams designed in such a way that either flexural or shear failure will be expected. The beams were loaded in four-point bending until cracks developed. The beams were then unloaded and retrofitted with CFRP. Finally the beams were loaded until failure. The ABAQUS program was used to develop finite element models for simulation of the behaviour of beams. The concrete was modelled using a plastic damage model and two models, a perfect bond model and a cohesive model, were evaluated for the concrete-CFRP interface. From the analyses the load deflection relationships until failure, failure modes and crack patterns were obtained and compared to the experimental results. The FEM results agreed well with the experiments when using the cohesive model regarding failure mode and load capacity while the perfect bond model was not able to represent the debonding failure mode. The results showed that when the length of CFRP increases the load capacity of the beam increases both for shear and flexural retrofitting. FEM results also showed that the width and stiffness of CFRP affect the failure mode of retrofitted beams. The maximum load increases with increased width. Increased CFRP stiffness increases the maximum load only up to a certain value of the stiffness, and thereafter it decreases the maximum load.

The paper investigated the flexural and shear behaviour of reinforced beams retrofitted with CFRP after preloading. The following conclusions are drawn from this experimental study:

- The stiffness of the CFRP-retrofitted beams is increased compared to that of the control beams.
- Employing externally bonded CFRP plates resulted in an increase in maximum load. The increase in maximum load of the retrofitted specimens reached values of about 23 % for retrofitting in shear and between 7% and 33 % for retrofitting in flexure. Moreover, retrofitting shifts the mode of failure to be brittle.
- The crack width for the retrofitted beams is decreased compared to the control beams.
- Experimental results showed that increasing the CFRP plate length in flexural retrofitting can make the CFRP more effective for concrete repair and strengthening. This means that insufficient strengthening lengths do not produce the intended strengthening effect.
- The results showed that the main failure mode was plate debonding which reduces the efficiency of retrofitting. Based on this conclusion deeper studies should be performed to investigate the behavior of the interface layer between the CFRP and concrete. Also numerical work should be done to predict the behaviour of retrofitted beams and to evaluate the influence of different parameters son the overall behavior of the beams.

D.Dan, T. Nagy-Gyorgy, V .stoian, A.Fabian & I. Demeter (7) Friction between soil and foundation materials is of major significance to make a good estimation of frictional resistance between soil and substructures. Soil-substructure interaction problems including retaining walls, deep foundations, soil samplers, soil and geo-membrane interface strength, and the stability of mechanically stabilized structures. Fibre Reinforced Polymer (FRP) is a synthetic material and can be effectively used for strengthening of soils and substructures retrofitting. This paper describes the results of an experimental study of interface friction between Carbon Fibre Reinforced Polymer (CFRP) wrapped concrete specimens and gravel soils. The experimental results showed that there is a significant decrease in the angle of interface friction with CFRP wrapping.

The friction between soil and construction materials is a major problem in soil-structure interaction study. Direct shear tests were conducted to investigate the interface angle of friction between well and poorly graded gravel and CFRP wrapped concrete specimens. Examining the data obtained from direct shear test, it could be seen that, in general, there was a decrease in the angle of interface friction with CFRP wrapping. Angle of interface friction between well graded gravel and CFRP wrapped concrete specimens were higher than the angle of interface friction between poorly graded gravel and CFRP wrapped concrete specimens. Higher angle of interface friction between gravel and 90^0 CFRP wrapped (Fibers are perpendicular to shear) concrete specimens than 0^0, 45^0 and bi-directionally CFRP wrapped concrete specimens. Further research might be required to have better understanding of shear strength parameters between soil and construction materials which could be proposed and used as a reference for design engineers to solve various geotechnical problems.

III. CONCLUSION

Today The Retrofit techniques using CFRP are widely used in all over the world as one of seismic strengthening measures for building columns and beams. These practices have a problem of debonding of CFRP from concrete and at some place it cannot be used in the form of CFRP the solution is carbon fibers in the form of woven high strength belt. The high strength

Narrow width woven belts of 100 % carbon fiber having very high tensile (up to 100 KN) is made on narrow width loom and can be used as retrofitting in place of CFRP products as 100% carbon woven belts are having very longer life and can be used in the water for retrofitting of the beams of bridges.

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