DEVELOPMENT AND IMPROVEMENT OF CFRP ADHESIVE JOINTS USING VACUUM-ASSISTED RESIN TRANSFER MOLDING (VARTM)

マハモド, ラマダン, モハメド, アブスリア

https://doi.org/10.15017/1866330

出版情報：九州大学, 2017, 博士（学術）, 課程博士

氏　名　：（マハモド　ラマダン　モハメド　アブスリア）

Name　Mahmoud Ramadan Mohamed Abusrea

論文名　：DEVELOPMENT AND IMPROVEMENT OF CFRP ADHESIVE JOINTS USING VACUUM-ASSISTED RESIN TRANSFER MOLDING (VARTM)

Title（真空樹脂含浸法（VARTM）によるCFRP接合継手の開発と改良に関する研究）

区　分：甲 (Kou)

Category

論文内容の要旨

Thesis Summary

The use of carbon fiber reinforced plastic CFRP composites in engineering structures brings many advantages because of their high performance and mechanical properties, such as high strength-to-weight and stiffness-to-weight ratios. For this reason, they have been used for heavy duty structures in aviation, space, automotive, shipbuilding, and wind turbine applications. These applications generally involve large scale manufacturing, so the parts are produced from smaller components and are joined together. So, the mechanical performance of these structures is highly dependent on the joining efficiency. Typically, wind-lens turbine structures are fabricated in segments, and then bonded to form the final structure. The main objective of this work is to develop CFRP adhesive joints with high mechanical performance for the wind-lens and other similar structures. This is to be done by either improving the current joints and/or developing new adhesive joints. First, the emphasis is given to develop new joints. Then subsequent improvements on these joints are to be done. All CFRP joints and fabrics is made using vacuum assisted resin transfer molding VARTM manufacturing process. The thesis's chapters are organized as follows:

Chapter 1 introduces a background and general introduction on wind-lens structures, CFRP composites, VARTM, and CFRP adhesive joints

Chapter 2 introduces five new adhesive joints, divided into two types: the first type is constructed between dry carbon and CFRP fabrics, and the second is constructed with two dry carbon fibers. These CFRP joints are made in our laboratory using VARTM manufacturing technique. Specimens are prepared for tensile testing to measure joint performance. The tensile test results show low strength when one half of the joint is CFRP fabrics, which was the case for the first two developed joints, staircase join-1 and staircase joint-2. On the other hand, second joint type such as laminated joint and multiple-covers joint, showed higher tensile strength. Fracture analysis showed the same fracture pattern, crack initiation at the joint ends followed by crack propagation until fracture.

Chapter 3 describes the effect of using the stitching technique on the tensile strength of both CFRP adhesive joint types. Tensile test results revealed improved strength when stitching was applied to the multiple-covers and staircase joints. The improvement achieved for multi-overlapped joint higher than that for the staircase joint. For the staircase joint, the strength improvement caused by the extra carbon fiber pieces which were put at the joint ends not by applying the stitching technique.

Chapter 4 introduces the improvements that made for the first joint type. For this joint type, three adhesive joints were introduced: the first is the original stepped joint and the other two are improved

stepped joints. Specimens were prepared for tensile testing to measure joint performance. The results showed an enhanced tensile load for the modified staircase joints. The percentage increase depended on the number of carbon fiber layers. For example, the total percentage increase in the tensile load recorded was 39% for the five-carbon-fiber- layer CFRP, with a further 14% increase for the seven carbon fiber layers. The final joining efficiencies reached 51% and 59% for five- and seven-carbon-fiber-layer CFRP fabrics.

Chapter 5 introduces the improvements that made for the second joint type. Further improvements were made by overlapping the two halves or adding extra carbon fiber pieces. Four laminated joints were investigated: the original laminated joint (OLJ), two overlapped joints, O20 and O40, with overlap lengths of 20 mm and 40 mm, respectively, and a multiple-covers joint (MLJ). Specimens were prepared for tensile tests to evaluate joint performance. The overlapped joint O40 achieved the highest ultimate failure load, of 22.3 kN, with a 56% increase over the OLJ. The load-displacement curve showed a linear relationship in the first two stages for the OLJ and a non-linear relationship in the third stage. However, the entire load-displacement curve showed a linear relationship for the other joints. The joining efficiency ranged from 44.5% to 69.5% for all joints. The highest ultimate stress, of 1,250 MPa, was recorded for the O40 overlapped joint. Fracture analysis showed a delamination failure mode for the OLJ and O20 joints, while a mixture of delamination and fiber breakage failure modes was observed for the O40 and MLJ joints.

Chapter 6 continues the improvements that made for the second joint type. For this joint type, some improvements are provided to enhance performance in terms of bending strength. These improvements included stitching of the two halves together by carbon fiber bundles and inserting extra carbon fiber covers in the joint connection. We studied three adhesive joints: a conventional laminated joint and two improved laminated joints. All joints and CFRP fabrics were made in our laboratory using VARTM techniques. Specimens were prepared for bending tests to evaluate the joint performance. Two acoustic emission (AE) sensors were placed on a specimen to monitor fracture progresses during the test. The results, for the six-layer laminates, showed a considerable improvement in bending strength for the modified laminated joints. The percentage increases in the bending strength were 27% and 112% for stitched and multiple-cover laminated joints, respectively.