博士論文要旨

CR ステアリング補強層を用いた CFRP ボルト接合継手の高強度化

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本研究では CFRP ボルト接合継手に対し, 繊維ステアリング技術による新たな補強層 Circular（C 層），Radial（R 層）を提案した．C 層はボルト継手における最大主応力分布をもとに，ボルト孔に沿って円弧状に繊維を配向した補強層である．R 層はボルト継手における最小主応力分布をもとに，ボルト孔から放射状に繊維を配向した補強層である．まず，ダブルラップジョイント方式による面圧強度試験により，CFRP ボルト接合継手に対する C および R 層の補強効果を検討した．C 層はせん断破壊を抑制し，最大破壊点における面圧強度を向上させることが明らかになった．R 層は初期臨界点および最大破壊点における面圧強度を向上させることが明らかになった．また，C，R 層について，有限要素法による数値解析を用いて，破壊発生の初期段階における補強メカニズムを明らかにすることを試みた．*e*/*d* が十分大きい場合（破壊モードは面圧破壊モード），R 層は 45°層の $\theta \fallingdotseq 45°$および-45°層の $\theta \fallingdotseq -45°$の繊維方向の圧縮応力 σ_{Lc} を低減するため，面圧破壊モードの臨界値を上昇させることが明らかになった．*e*/*d* が小さい場合（破壊モードはせん断破壊モード），C 層は 0°層の$-90° < \theta < -45°$，$45° < \theta < 90°$の面内せん断応力 τ_{LT} を低減するため，せん断破壊モードを抑制し，面圧破壊モードに遷移させることが明らかになった．一方，R 層は 45°層の $\theta \fallingdotseq 45°$および-45°層の $\theta \fallingdotseq -45°$の繊維方向の圧縮応力 σ_{Lc} を低減するため，C 層と組み合わせることで，面圧破壊モードの臨界値を上昇させることが明らかになった．

Abstract of Doctoral Thesis

Strengthening of CFRP bolted joints using C and R steered reinforcing layers

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A novel reinforcement method for carbon fiber reinforced plastic (CFRP) bolted joints is proposed considering the cylindrical stress fields around bolt holes. The C and R layers are circularly and radially steered reinforcement layers in the directions of the maximum tensile and maximum compressive stresses, respectively. First, the effects of the C and R layers on the bearing strength of CFRP bolted joints were investigated by conducting double lap shear tests. The experimental results showed that the C layer was effective at preventing the shear-out failure and increasing the bearing strength of joints during the ultimate stage of failure. By contrast, the R layer was effective at increasing the bearing strength of joints during the initial and ultimate stages of failure. Second, the reinforcement mechanisms of C and R layers were investigated based on finite element results. In the case of the specimens having large edge distance (e/d=3), the longitudinal compressive stress, σ_{Lc}, at $\theta \cong 45°$ on the 45° layer and at $\theta \cong -45°$ on the -45° layer was reduced by the R layer, resulting in the improvement of the initial failure strength of bearing mode. On the other hand, in the case of the specimen having small edge distance (e/d=1), the in-plane shear stress, τ_{LT}, in the ranges $-90° \leqq \theta \leqq -45°$ and $45° \leqq \theta \leqq 90°$ on the 0° layer was reduced by the C layer, resulting in the transition of the failure mode from shear-out to the bearing mode. Additionally, the longitudinal compressive stress, σ_{Lc}, at $\theta \cong 45°$ on the 45° layer and at $\theta \cong -45°$ on the -45° layer was reduced by the R layer, resulting in the improvement of the initial failure strength when the C and R layers were combined.