

Fig. 11 Tensile strength of stepped-lap joints and tapered flush joints



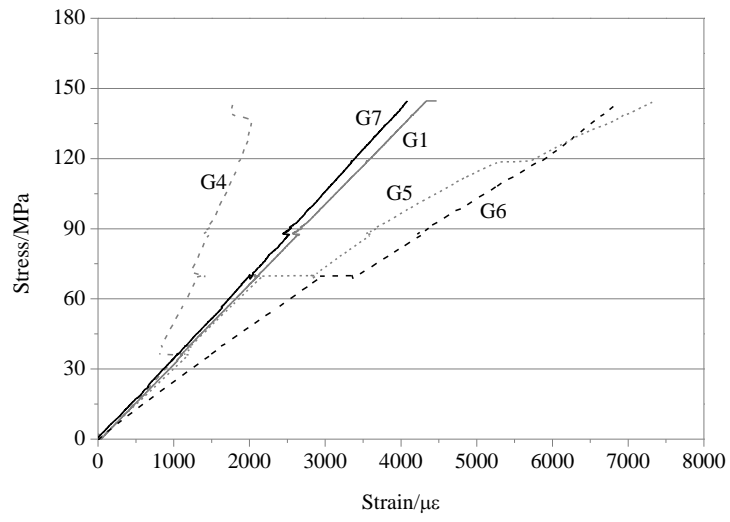
Fig. 12 Damage modes of tapered flush joints

3.4 Strain distributions

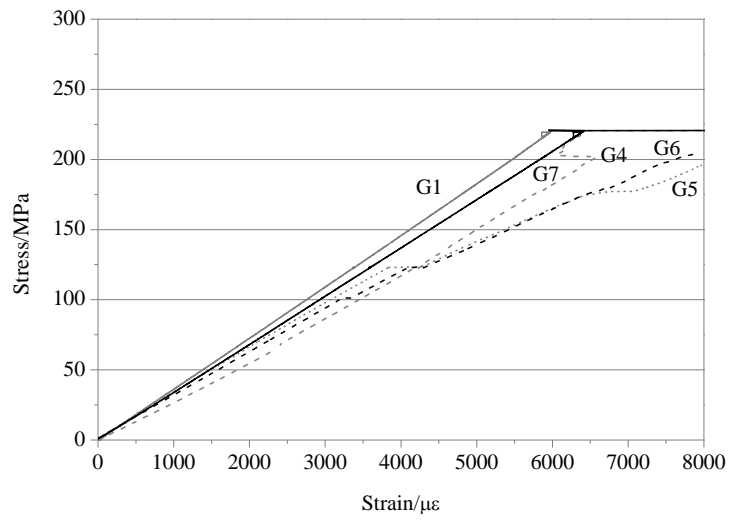
The stress-strain behavior observed for the stepped flush and tapered flush repair joints are shown in Fig. 13. The initial stress-strain response is linear, as expected, but there is significant variation between the strains recorded at different locations on the outer surface of the joint. For 2-step lap joint, the strain of G4 decreases at about 32MPa which means that the first failure occurs. It is due to the adhesive debond initiating at the edge of the repair region. Similarly phenomenon is found when the stress is 70MPa.

For 4-step lap joint without external plies, the strain G6 increases abruptly when the stress is about 100MPa, which means that the adhesive debonds at the inner side of the repair joint. For 4-step with 1 overply, the strain of G4 increase at about 125MPa. The two joints show the similar behaviors. However, as the external ply decreases the stress in the bondline, the failure initiation load is a little higher.

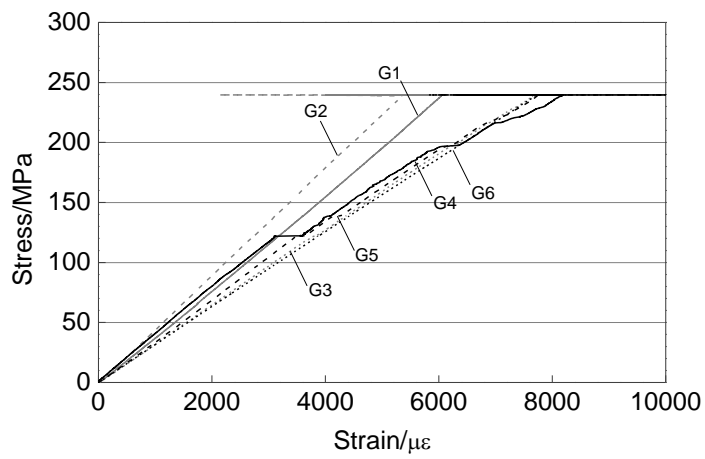
For tapered flush joints and 8-step lap joint, most of the strains keep linear until ultimate failure which means that almost no adhesive debond in the repair joint. The main failure modes are delamination and fiber breakage. This behavior can also be verified when investigate the damage mode after ultimate failure.



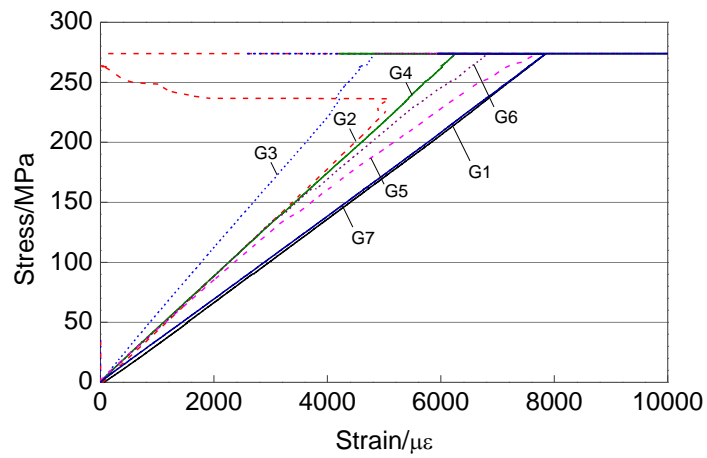
(a)



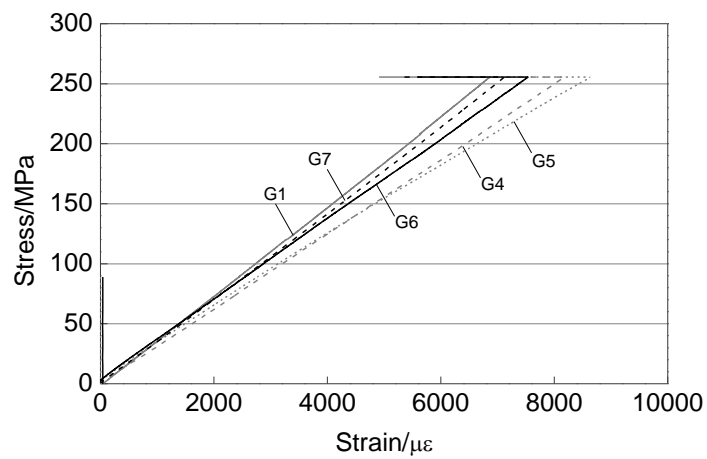
(b)



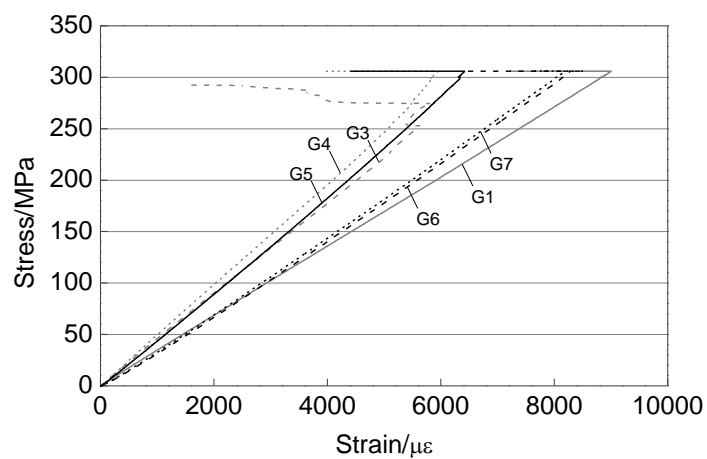
(c)



(d)



(e)



(f)

Fig. 13 Stress-strain curves for adhesively bonded joints: (a) 2-step lap joint, (b) 4-step lap joint, (c) 4-step lap joint with 1 external ply, (d) 4-step lap joint with 2 external plies, (e) 8-step lap joint, (f) scarf repair joint with 1 external ply

4. CONCLUSIONS

This study presents an investigation of the influence of joint parameters on the ultimate strength and failure mechanism of stepped-lap joint. For stepped-lap joints, the joint repair efficiency is obtained with focus on two joint design parameters: number of steps and external plies. Results show that the number of steps has a significant effect on the strength of the repaired joint. More steps yields higher ultimate strength. The introduction of external plies can also increase the joint ultimate strength. As the 8-step lap joint and tapered flush joint offer more uniform stress in the adhesive, almost no adhesive debond is found in the joints. The conclusions can be verified in the further study combined with finite element analysis.

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