EFFECT OF SPEW GEOMETRY ON STRESS OF ADHESIVE JOINT FOR WIND TURBINE BLADE

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Abstract

This study focuses on adhesive joint of wind turbine blade. The stress of adhesive layer between web and shell has been analyzed according to the different types of spew fillet geometry by finite element analysis. Peel and shear stress of adhesive layer have been compared. The presence of spew fillet and its length influence on stress reduction at the edge of the adhesive layer.

1 Introduction

Composite wind turbine blade consists of shell and shear web structure. The two components are connected by adhesive joint. In large scale blade, adhesive part is not ignorable because crack initiation of bond can lead grate damage to the whole large wind turbine system. Adhesive joint reliability is more important recently.

Spew is created along edge of adhesive joint. In many studies spew contribute on stress distribution [1][2]. In this study, various spew fillets of adhesive layer in web-shell system have been evaluated. Stress distribution near fillet edge of adhesive layer has been analyzed by finite element method.

2 Finite element modeling

The structural analysis of joint models has been performed using a commercial FEM code, ABAQUS. Three-dimensional joint model is shown Figure 1. Three different spew shapes are shown schematically in Figure 2. Fillet lengths are 0mm, 5mm and 10mm. Adhesive thickness is t=3mm except fillet zone. The maximum thickness of adhesive layer is 7mm. Dimension of fillet radius is same at all models.

Glass fiber laminates have been used for composite shell and web. Adhesive is epoxy based [4]. Material properties applied in analysis are listed in Table 1.

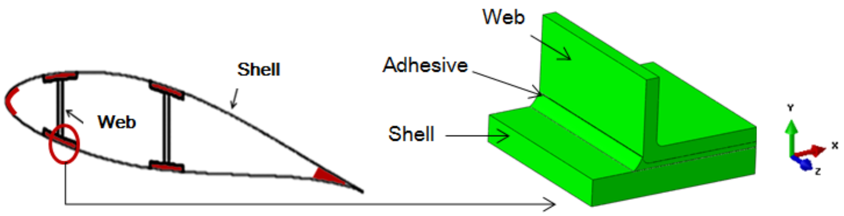

Figure 1. Blade cross section and adhesive joint model

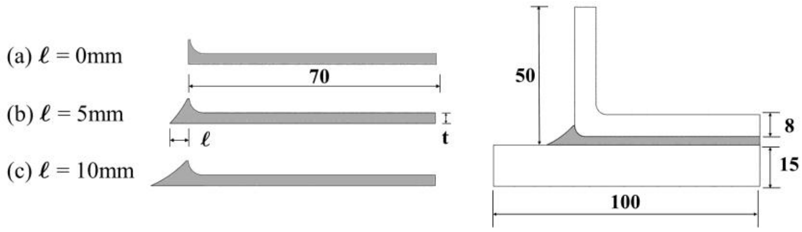

Figure 2. Configuration of Spew fillets and joint model

Properties	Glass/epoxy	Adhesive
E_1 (GPa)	40	2.8
E_2 (GPa)	11	-
E_3 (GPa)	11	-
G_{12} (GPa)	3.4	-
G_{13} (GPa)	3.4	-
G_{23} (GPa)	1.7	-
ν_{12}	0.26	0.35
ν_{13}	0.26	-
ν_{23}	0.5	-

Table 1. Material properties

Solid element C3D8R is used for web and shell. For adhesive, C3D8R and C3D6 element are used together with mesh size 0.5mm. Far end of finite model is constrained 6 degree of freedom. Joint model was subjected to Flatwise load of wind turbine blade. 20MPa of negative y direction was applied on the other end of shell. Web and shell are tied completely by adhesive layer. Geometrically nonlinear analysis was carried out.

3 Results and discussions

In the following, peel stress S22, shear stress S12 and S23 have been compared with each models through the adhesive layer thickness along two paths. Figure 3. shows the paths near the curved zone of web.

Figure 4. shows that lower interface of adhesive layer at the edge is stress concentrated zone in the joint without fillet. Figure 5, 6 and 7 show the distributions of peel and shear stresses through the paths.

Stress difference of joint without fillet is significant along path 1. Stresses are reduced along path 2 and distributions are even in joints with fillet. The stress in the spew-end region of adhesive layer decreases as spew fillet length increases as shown in Figure 8.

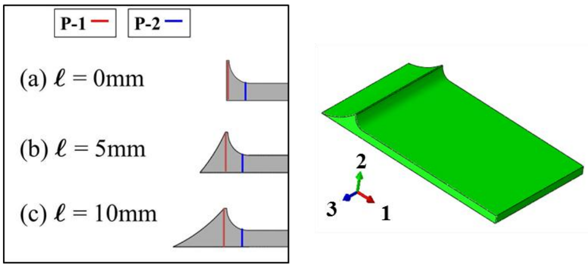

Figure 3. Paths for measuring stress

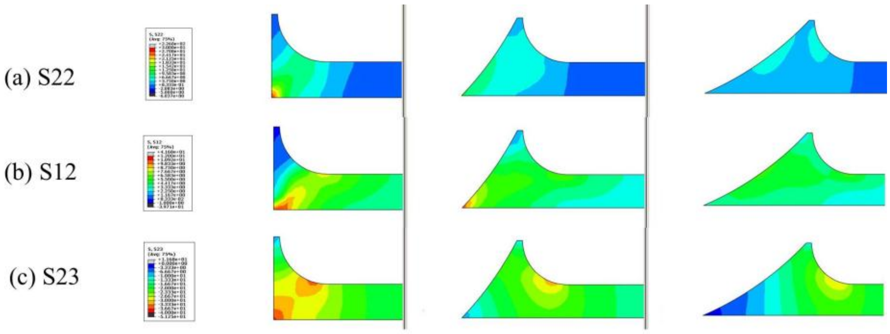

Figure 4. Stress distribution of spew fillet

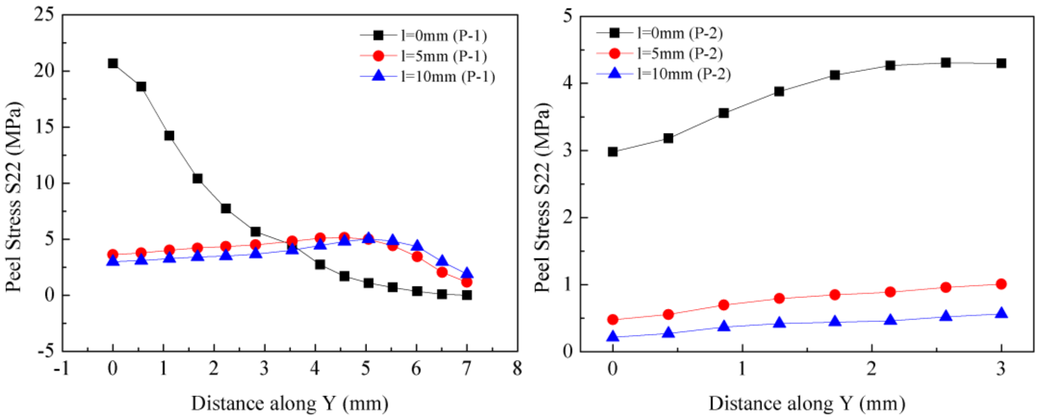

Figure 5. Peel stress S22 along paths

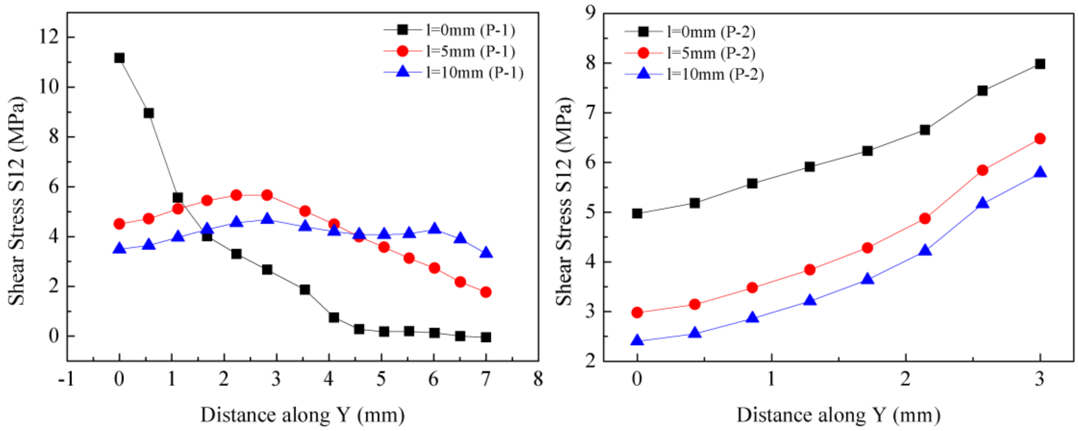

Figure 6. Shear stress S12 along paths

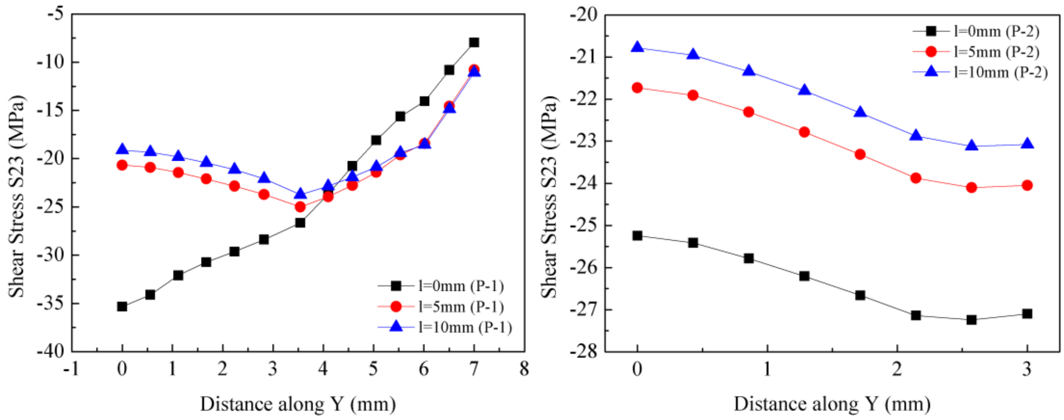

Figure 7. Shear stress S23 along paths

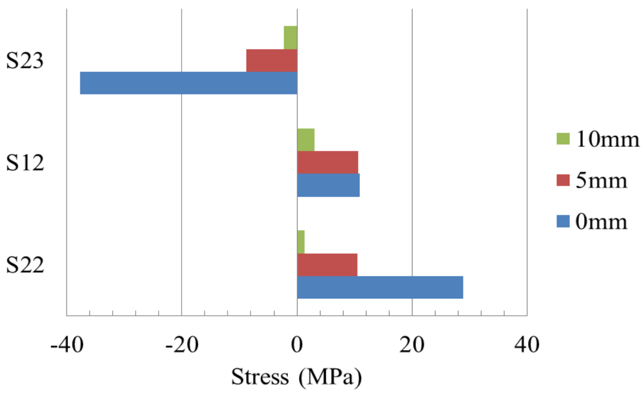

Figure 8. Stress at the edge of adhesive layer

4 Conclusions

The structural analysis adhesive joint of rotor blades was conducted by means of finite element analysis. The results show that spew geometry influence on stress distribution of the adhesive joint. The presence of fillet and increase of spew length influence on reduction stress concentration at the edge of adhesive layer.

Acknowledgement

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