黏著劑對被貼覆基板應力影響之分析 = The stress analysis of the adhesive's influences on bonded substrate

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摘 要

本文以材料力學為基礎將黏著件之基板簡化為樑，利用一維 樑模型，先推導膠層剪應力與剝離應力之控制方程式及其解，利 用系統力平衡進一步推導基板之應變方程式，並將膠層應力、基 板應變之解析解，與二維有限元素分析法數值解做驗證。黏著件 受力分析包含由軸向力、彎矩、軸向力與彎矩等三種不同負載條 件，探討膠層應力、基板應變之分佈。參數分析方面，探討膠層 之材料與厚度，基板之材料與厚度，以及黏著長度等參數，對膠 層應力、基板應變分佈之影響。最後以拉伸實驗，對黏著件施予 軸向力負載時，上下基板之應變值並與解析解做驗證。

關鍵詞 : 黏著件，樑理論，膠層剪應力，膠層剝離應力，基板應變，參數分析

目錄

參考文獻

[1] S.P. Timoshenko and J.M. Lessells,“ Applied Elasticity, ” D. Van Nostrand Company, 1925.

[2] A.J. Kinloch,“ Adhesion and Adhesives, ” Chapman and Hill,1987.

[3] M. Goland and E. Reissner,“ The Stress in Cemented Joints, ”ASME J. Applied Mechanics, Vol.11, pp.A17-A22, 1944.

[4] L.J. Hart-Smith,“ Adhesive-Bonded Single-Lap Joints, ” NASA CR-112236, 1973.

[5] F. Delale, F. Erdogan, and M.N. Aydinoglu,“ Stresses in Adhesively Bonded Joints: A Closed-Form Solution, ” Journal of Composite Materials, Vol.15, pp.249-271, 1981.

[6] Du Chen, and Shun Cheng,“ An Analysis of Adhesive-Bonded Single-Lap Joints ”, Journal of Applied Mechanics, Vol.50, pp.109-115, 1983.

[7] M.Y. Tsai and J. Morton,“ An Evaluation of Analytical and Numerical Solutions to the Single-Lap Joint, ” International Journal of Solids and Structure, Vol.31, pp.183-194, 1994.

[8] M.Y. Tsai and J. Morton,“ An Experimental Investigation of Nonlinear Deformations in Single-Lap Joints, ” Mechanics of Materials, Vol.20, pp.183-194, 1995.

[9] M.Y. Tsai, D.W. Oplinger, and J. Morton,“ Improved Theoretical Solutions for Adhesive Lap Joints, ” International Journal of Solids and Structures, Vol.35, No.12, pp.1163-1185, 1998.

[10] Gang Li and Pearl Lee-Sullivan,“ Finite Element and Experimental Studies on Single-Lap Balanced Joints in Tension, ” International Journal of Adhesion and Adhesives, Vol.21, pp.211-220, 2001.

[11] J.P.M. Goncalves, M.F.S.F. de Moura, and P.M.S.T. de Castro,“ A Three-Dimensional Finite Element Model for Stress Analysis of Adhesive

Joints, ” International Journal of Adhesion and Adhesives, Vol.22, pp.357-365, 2002.
[12] G.P. Zou, K. Shahin, and F. Taheri, “ An Analytical Solution for the Analysis of Symmetric Composite Adhesively Bonded Joints, ” Composite Structures, Vol.65, pp.499-510, 2004.
[13] Quantian Luo and Liyong Tong, “ Analytical Solutions for Adhesive Composite Joints Considering Large Deflection and Transverse Shear Deformation in Adherend, ” International Journal of Solids and Structures, Vol.45, pp.5914-5935, 2008.
[14] K.S. Alfredsson and J.L. Hogberg, “ A Closed-Form Solution to Statically Indeterminate Adhesive Joint Problems—Exemplified on ELS-Specimens, ” International Journal of Adhesion and Adhesives, Vol.28, pp.350-361, 2008.
[15] F.M. Lucas da Silva, J.C. Paulo das Neves, R.D. Adams, and J.K. Spelt, “ Analytical Models of Adhesively Bonded Joints—Part I: Literature Survey, ” International Journal of Adhesion and Adhesives, Vol.29, pp.319-330, 2009.
[16] F.M. Lucas da Silva, J.C. Paulo das Neves, R.D. Adams, A. Wang, and J.K. Spelt, “ Analytical Models of Adhesively Bonded Joints —Part II: Comparative Study, ” International Journal of Adhesion and Adhesives, Vol.29, pp.331-341, 2009.
[17] V. Alphonsus Pocius, “ Adhesion and Adhesives Technology: An Introduction, ” Hanser Gardner, 2000.
[18] G.R. Wooley and D.R. Carver, “ Stress Concentration Factors for Bonded Lap Joints, ” Journal of Aircraft, Vol.8, pp.817-820, 1971.
[19] J.N. Reddy and S. Roy, “ Non-Linear Analysis of Adhesively Bonded Joints, ” International Journal of Non-Linear Mechanics, Vol.23, pp.97-112, 1988.
[20] R.B. Pipes and N.J. Pagano, “ Interlaminar Stresses in Composite Laminates under Uniform Axial Extension, ” Journal of Composite Material, 4, 538-548, 1970.
[21] N.J. Pagano, and R.B. Pipes, “ Some Observations on the Interfaminar strength of Composite Materials, ” Int. Journal of Mech. Sci. Pergamon Press, 15, 679-688, 1973.
[22] R.Y. Kim and S.R. Soni, “ Experimental and Analytical Studies on the Onset of Delamination in Laminated Composite, ” Journal of Composite Materials, 18-January, 1984.
[23] John Tomblin, Waruna Seneviratne, Paulo Escobar, and Yap Yoon Khian, “ Shear Stress-Strain Data for Structural Adhesives, ” Office of Aviation Research Washington, D.C. 20591, 2002.
[24] Quantian Luo and Liyong Tong, “ Exact Static Solutions to Piezoelectric Smart Beams Including Peel Stresses — I :Theoretical Formulation, ” International Journal of Solids and Structures, Vol.39, pp.4677-4695, 2002.
[25] Quantian Luo and Liyong Tong, “ Exact Static Solutions to Piezoelectric Smart Beams Including Peel Stresses — II :Numerical Results, Comparison and Discussion, ” International Journal of Solids and Structures, Vol.39, pp.4697-4722, 2002.
[26] W.T. Chen and C.W. Nelson, “ Thermal Stress in Bonded Joints, ” IBM Journal of Research and Development, Vol.23, No.2, 1979.