Structural Testing and Research (StaR)

INTRADEPARTMENTAL

Test Engineering Department 17 October 2002

To: Michael Jenkins
Director, Test Engineering

From: Joe Tech
Junior Test Engineer

Re: Strains, Deflections and Beams in Bending [Memo report is two page maximum of written text combined with an unlimited length appendix that contains the supporting details]

Summary: [The summary provides a one paragraph synopsis of what was done, why it done, what resulted and what was the outcome] *The following memo report contains details on a recent exercise we conducted to evaluate the validity of certain experimental methods (strain gages and deflectometers) in evaluating the strains and deflections of simple beams in bending. Experimental results were comparable within about 5% to predictions from analytical results. We recommend extending the experimental techniques to other types of laboratory investigations.*

Introduction: [The introduction is a very brief background and rationale for the exercise.] *Experimental mechanics is that branch of engineering mechanics involving the measurement of strains, displacements, stresses and forces acting on or within models, components and/or structures. One of the most useful and widespread measurement devices used in experimental mechanics is the resistance strain gage.*

Often, experimental method are verified using analytical models……

Procedure: [The procedure is a very brief description of the test setup and step by step operation] *A C-channel beam (shown in the appendix) subjected to simply supported three-point flexure was configured with three uniaxial strain gages and two rosette strain gages (delta and rectangular). A deflectometer was positioned to record beam deflection at the longitudinal location of the rectangular rosette. A proving ring type force transducer was used to determine a reaction force produced by a turnbuckle loading device at the beam's longitudinal midpoint. Two forces were applied to the beam with the strains and deflections recorded at each force. Experimental results were then analyzed using various strain transformation relations and compared to analytical relations for beams in bending.*

Results: [In the results section, present both reduced test results and anlystical results for comparions and relevant equations for reducing the data] *The experimental and analytical results are compared in Table 1. Experimental strains and deflections are reported directly. Analytical predictions for normal stress, $|\sigma|$, were determined from the beam bending relation,* $\sigma = \frac{My}{I}$ *where M is the bending moment at the point of interest as determined from the applied experimental force, y is the distance from the neutral axis of the point of interest, and I is the moment of inertia calculated for the C-channel cross section. Generalized Hookes Law (e.g.,* $\varepsilon_x = \frac{1}{E}\left[\sigma_x - \nu\left(\sigma_y + \sigma_z\right)\right]$*) was then used to calculate the normal strains at each point of interest from the nonuniform, uniaxial stress state. Deflection at the point of the interest was calculated from the relation derived from the elastic curve analysis for a beam in three-point bending such* *that* $\Box = \frac{PL_a X}{6EIL}\left(L^2 \Box L_a^2 \Box X^2\right)$ *where P is the applied force, L is the total supported length of the beam,* L_a *is the length between the support and the applied force that includes the point of interest, and x is the distance from a support to the point of interest. ………*

Table 1 Comparsion of Experimental and Analytical Results

Applied Force = XXX N				Applied Force = XXX N			
Parameter	**Experimental**	**Analytical**	**% Diff**	**Parameter**	**Experimental**	**Analytical**	**% Diff**
Max Principal Strain at Rect Rosette	μm/m	μm/m		Max Principal Strain at Rect Rosette	μm/m	μm/m	
Angle of Max Principal Strain	°	°		Angle of Max Principal Strain	°	°	
Max Principal Strain at Delta Rosette	μm/m	μm/m		Max Principal Strain at Delta Rosette	μm/m	μm/m	
Angle of Max Principal Strain	°	°		Angle of Max Principal Strain	°	°	
Strain Gage 7	μm/m	μm/m		Strain Gage 7	μm/m	μm/m	
Strain Gage 8	μm/m	μm/m		Strain Gage 8	μm/m	μm/m	
Strain Gage 9	μm/m	μm/m		Strain Gage 9			
Deflection at Rect Rosette	**mm**	**mm**		Deflection at Rect Rosette	mm	mm	

Discussion: [In the discussion section, provide insight into the exercise, explaining any errors/differences greater than 10%, any anomalies, etc.] *Generally the experimental and analytical results differ by about 5%. The greater difference was for the principal angle relative to the longitudinal axis. The expected angle is 90, however, angles of 88° and 96,° One possible explanation of these difference is the applied angle of the strain gages. It is generally accepted that technicians can apply strain gages to within ±2° of the required angle. Other sources of error include misread strain gages, drift in the signal, eccentric loading of the beam…………*

Recommendation: [In the discussion section, provide a wrapup of the lab exercise] *Overall, the lab exercise demonstrated that strain gages can provide good agreement with analytical methods. In addition, the use of the deflectometer provided confirmation of beam deflection relation and the concept of the elastic curve. One observation was that strain gages are very sensitive to untended loading including temperature changes and eccentric loads………..*