CLAS-NOTE-93-003

TEST OF 4'X8' SANDWICH PANEL . PREPRODUCTION SAMPLE OF FRONT PLATE FOR A SHOWER COUNTER.

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1 Introduction

This report describes deflection and strength tests that were performed on a 4'x8' composite structure . This composite sandwich is a test panel for the front face of the forward calorimeter of the CLAS detector.

2 Description of the test samples and test setup

The composite structure consisted of a 3" thick structural foam sandwiched between .075" thick stainless steel (type 304) skins. One stainless skin was cut apart and welded to simulate the weld seams on the final product.
The skins were bonded to the foam using Hysol EA939 epoxy. The structural foam, type FR-3700 (density 15lb/cuft), was manufactured by General Plastic MFG Co.
The stainless skin was thoroughly cleaned with trichlorethane just prior to bonding.
We employed the following test setup.
The sandwich was simply supported at the ends of two I-beams . The load was applied uniformly over the entire surface. Deflection of the central region was measured with a height transducer attached to an I-beam spanning the composite structure.
The panel was uniformly loaded to 10,400 lbs. This load introduced a stress in the center of the panel 1.5 times higher than maximum expected in the

final product.
The panel was subsequently loaded to a total of 27,000 lbs. This load introduced a stress 4 times the maximum stress in service .

3 Theoretical deflection based on the existing formula

The *Hexcell Corp.* does provide analytical formulae to evaluate composite beams loaded according to the same schematic as the tested beam. All of these formulae are based on two following terms:
a) deflection due to pure bending:

$y1 = \frac{2KBPL^3\lambda}{Eth^2b}$

b) deflection due to pure shear

$y2 = \frac{KSPL}{hGb}$

where:

$P - total\ load$
$L = 96" - distance\ between\ supports$
$t = 0.075" - skin\ thickness$
$h = 3.075" - distance\ betweenthecentersoftheskins$
$E = 30 \times 10^6 psi - elastic\ modulus\ of\ skin$
$G = 6200psi - foam\ shear\ modulus$
$b = 48" - width\ of\ sample$
$\lambda = 1 - \mu^2$
$\mu = 0.3 -\ Poisson's\ ratio\ of\ facing\ material$
$KB = 0.01302 - bending\ deflection\ constant$ - see attached
$KS = 0.125 - shear\ deflection\ constant$

Introducing all constants into the equation for deflection due to the pure bending and shear, the final expression for the total deflection has the following form:

$y = .0000342P$

This expression is plotted on fig.1.

4 Test results

Figure 1 gives comparison between the test results and analytical calculation for the 3.15" composite structure . The results clearly shows a very good agreement between the test and theory. The small discrepancy may be due to a variation of elastic modulus of the foam in "strong" and "weak" direction.

5 Creep of the panel under 1.5 of operating load.

An attempt was made to measure the long term creep while the panel was under 1.5 times the normal service load.
Small changes in deflection were observed, but the readings were erratic (Varying by thousand of inch).
We conclude that no significant creep occured during 240 hours of loading.

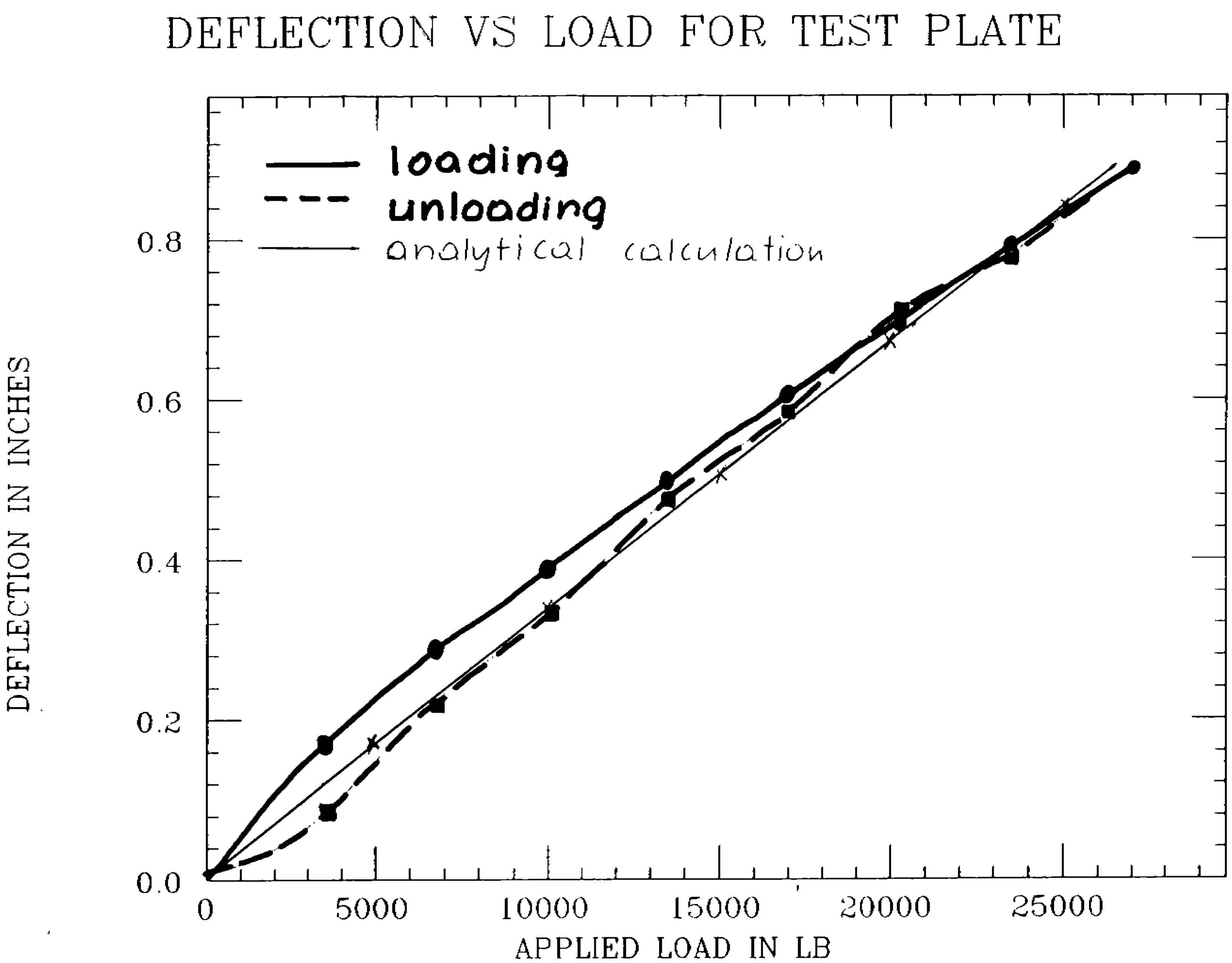
DEFLECTION VS LOAD FOR TEST PLATE
loading
unloading
analytical calculation
DEFLECTION IN INCHES
0.0
0.2
0.4
0.6
0.8
0
5000
10000
15000
20000
25000
APPLIED LOAD IN LB

Fig 1

SANDWICH DESIGN (continued)

ANALYSIS OF FLAT RECTANGULAR SANDWICH BEAMS

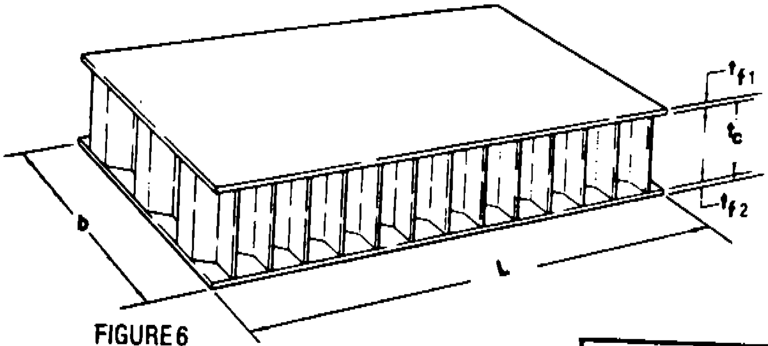

FIGURE 6

$$h = \frac{t_{f1}}{2} + \frac{t_{f2}}{2} + t_c$$

FIGURE 7
BEAM CHART

BEAM TYPE	MAXIMUM SHEAR FORCE V	MAXIMUM BENDING MOMENT M	BENDING DEFLECTION CONSTANT K_b	SHEAR DEFLECTION CONSTANT K_s
SIMPLE SUPPORT, UNIFORM LOAD, $P = ql$	0.5P	0.125PL	0.01302	0.125
BOTH ENDS FIXED, UNIFORM LOAD, $P = ql$	0.5P	.08333PL	.002604	0.125
SIMPLE SUPPORT, CENTER LOAD, P	0.5P	0.25PL	0.02083	0.25
BOTH ENDS FIXED, CENTER LOAD, P	0.5P	0.125PL	.00521	0.25
CANTILEVER, UNIFORM LOAD, $P = ql$	P	0.5PL	0.125	0.5
CANTILEVER, END LOAD, P	P	PL	0.3333	1
CANTILEVER, TRIANGULAR LOAD, q, $P = \frac{1}{2}ql$	P	0.3333PL	0.06666	0.3333
ONE END SIMPLY SUPPORTED, ONE END FIXED, UNIFORM LOAD, q, $P = ql$	0.625P	0.125PL	0.005405	.07042

*If deflections are critical actual deflections should be verified by tests

BENDING STRESS IN FACINGS

$$\sigma_{fi} = \frac{M}{t_{fi} h b} \quad i = 1 \text{ or } 2$$

where M is determined by Figure 7

CORE SHEAR STRESS

$$\tau_c = \frac{V}{hb}$$

V is from Figure 7

DEFLECTION

K_b and K_s from Figure 7

$$\Delta = \frac{2 K_b P L^3 \lambda}{E_f t_f h^2 b} + \frac{K_s P L}{h G_c b} \quad \text{(for same skin materials)}$$

or

$$\Delta = \frac{K_b P L^3}{D} + \frac{K_s P L}{h G_c b} \quad \text{(see D below)}$$

(For most long beams, the second term is relatively small, but should be checked if deflection is critical.)

FACE DIMPLING

$$\sigma_{CR} = \frac{2 E_f}{\lambda} \left[\frac{t_f}{S}\right]^2$$

FACE WRINKLING

$$\sigma_{CR} = 0.82 E_f \left[\frac{E_c t_f}{E_f t_c}\right]^{1/2}$$

$$D = \frac{E_1 t_1 E_2 t_2 h^2 b}{E_1 t_1 \lambda_2 + E_2 t_2 \lambda_1} \quad \text{or} \quad \frac{E t_1 t_2 h^2 b}{(t_1 + t_2)\lambda} \quad \text{or} \quad \frac{E t h^2 b}{2\lambda}$$

LIST OF TERMS

- P = Total Load
- L = Span
- σ_f = Facing Stress
- t_f = Skin Thickness
- h = Centroid Distance
- τ_c = Core Shear Stress
- Δ = Deflection
- E_f = Facing Modulus
- G_c = Core Shear Modulus
- b = Width
- σ_{CR} = Critical Facing Stress
- D = Panel Stiffness
- $\lambda = 1 - \mu^2$
- μ = Facing Poisson's Ratio
- S = Cell Size
- E_c = Core Compression Modulus
- t_c = Core Thickness
- I = Moment of Inertia