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A COMPARISON OF CLASSICAL MECHANICS MODELS AND FINITE ELEMENT SIMULATION OF ELASTICALLY TAILORED WING BOXES

Lawrence W. Rehfield, Richard D. Pickings, Stephen Chang and Michael Holl

University of California, Davis

SUMMARY

Structural tailoring concepts have been developed by Rehfield to create wings with elastically produced camber for the purpose of increasing lift during take-off conditions.

Simple models based upon enhancements to the thin-walled composite beam theory of Rehfield have been developed to investigate prospects for elastic tailoring of the chordwise deformation of wing structures. Previous correlation studies have shown that the thin-wall beam theory is very accurate for predicting bending and twisting deformation of thin-wall composite box beams, structural tubes, and rotor blades with both single and multiple cells. However, earlier work has not emphasized chordwise deformations.

Application of the modified theory to real-world problems must be executed with confidence and minimum risk. Consequently, it is imperative that the theory is of high enough fidelity to accurately predict not only the intentionally produced tailoring mechanisms, but also the actual overall behavior of wing box structures. Therefore, extensive correlation studies must be performed to establish that the theory is valid for predicting chordwise deformations.

Validation will be carried out in two steps: finite element correlation and experimental correlation. Extensive testing using scale models of wing box structures is planned. However, the purpose of present work is to provide a comparison of the theoretical results with a finite element model for the bending method of producing camber.

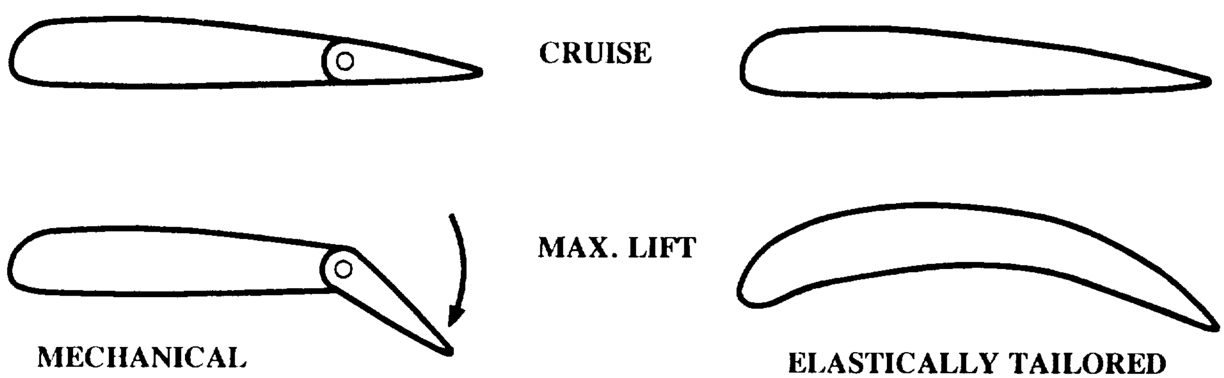
At present, finite element correlation studies have been completed for two cases: a bonded unstiffened structural box, and a bolted unstiffened structural box. Results from these studies show an error of less than one percent for the bonded case and less that six percent for the bolted case in predicting camber curvature for the structural box. Examination of the results shows that the theory is very accurate for the cases studied and therefore, will provide an excellent basis for conducting further tailoring studies.

ELASTIC TAILORING

THE USE OF

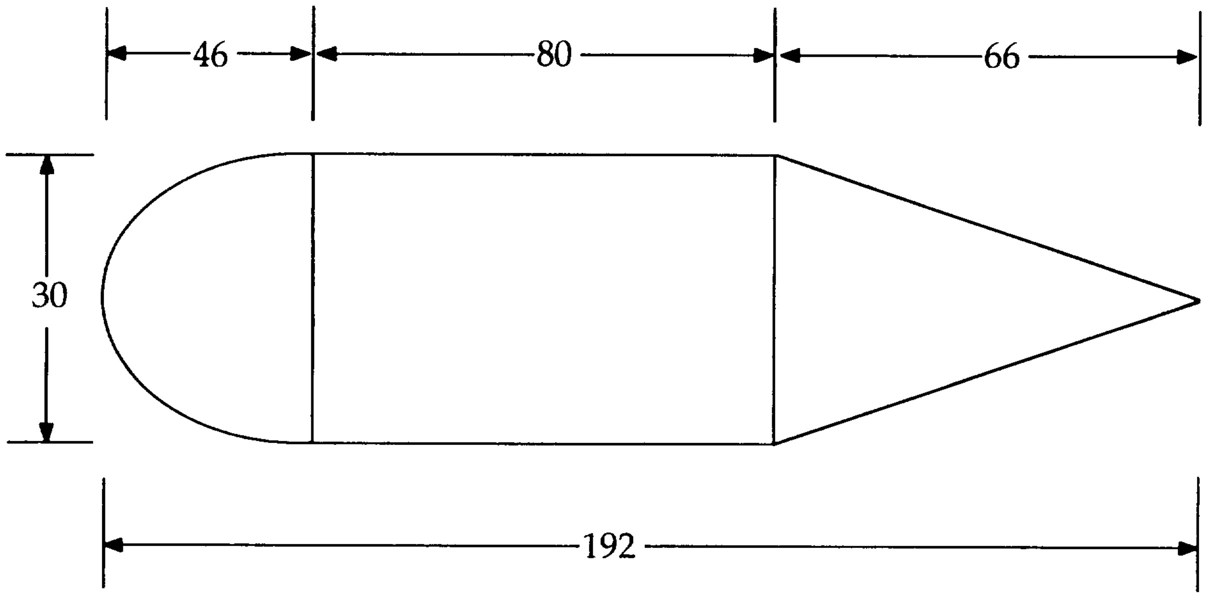
- STRUCTURAL CONCEPT
- FIBER ORIENTATION
- STACKING SEQUENCE
- BLEND OF MATERIALS

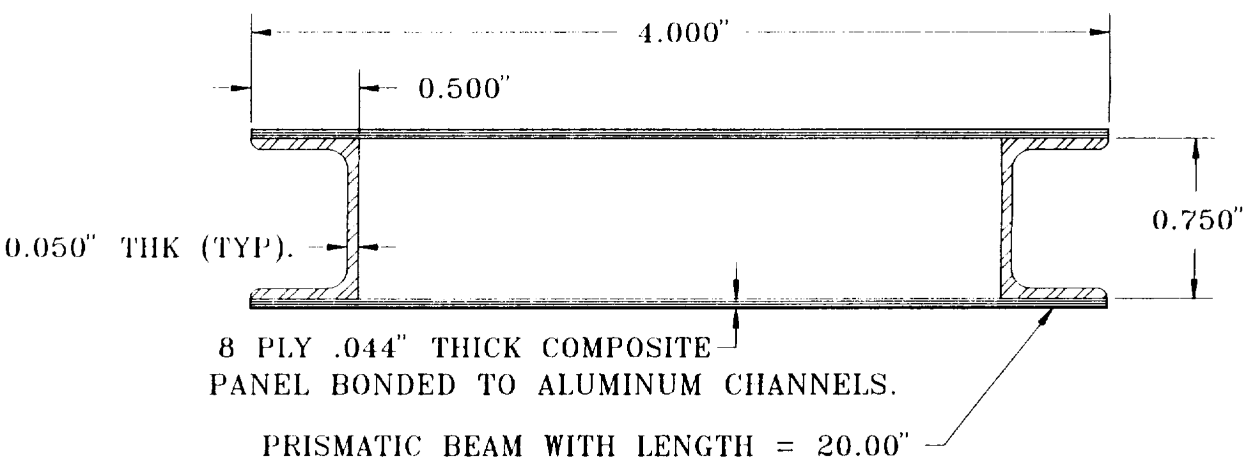
TO ACHIEVE SPECIFIC PERFORMANCE GOALS



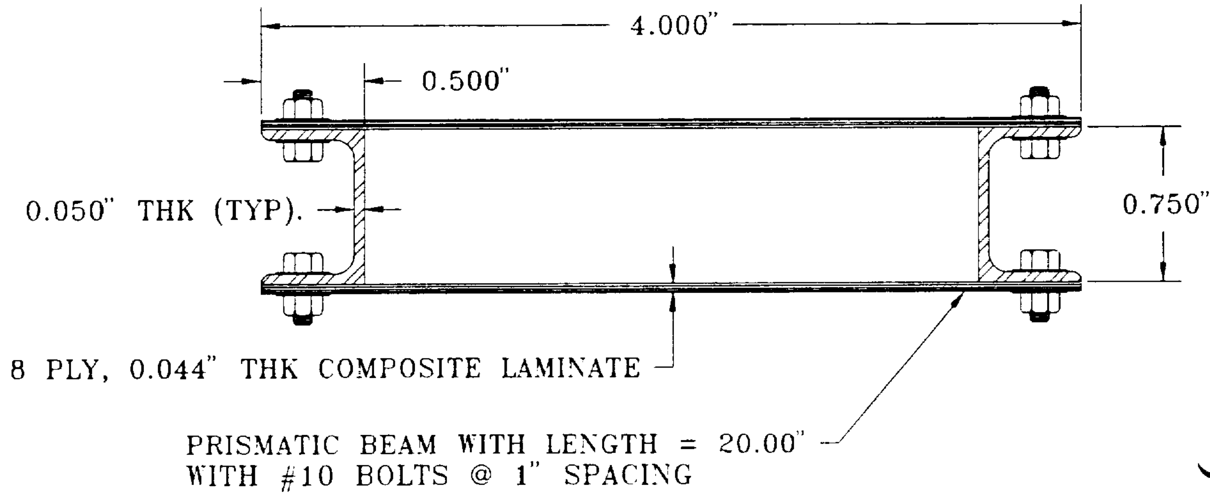
METHODS OF INCREASING AIRFOIL LIFT

C – 130 CENTER WING BOX MODEL





STRUCTURAL BOX CROSS SECTION



CROSS SECTION OF BOLTED STRUCTURAL BOX

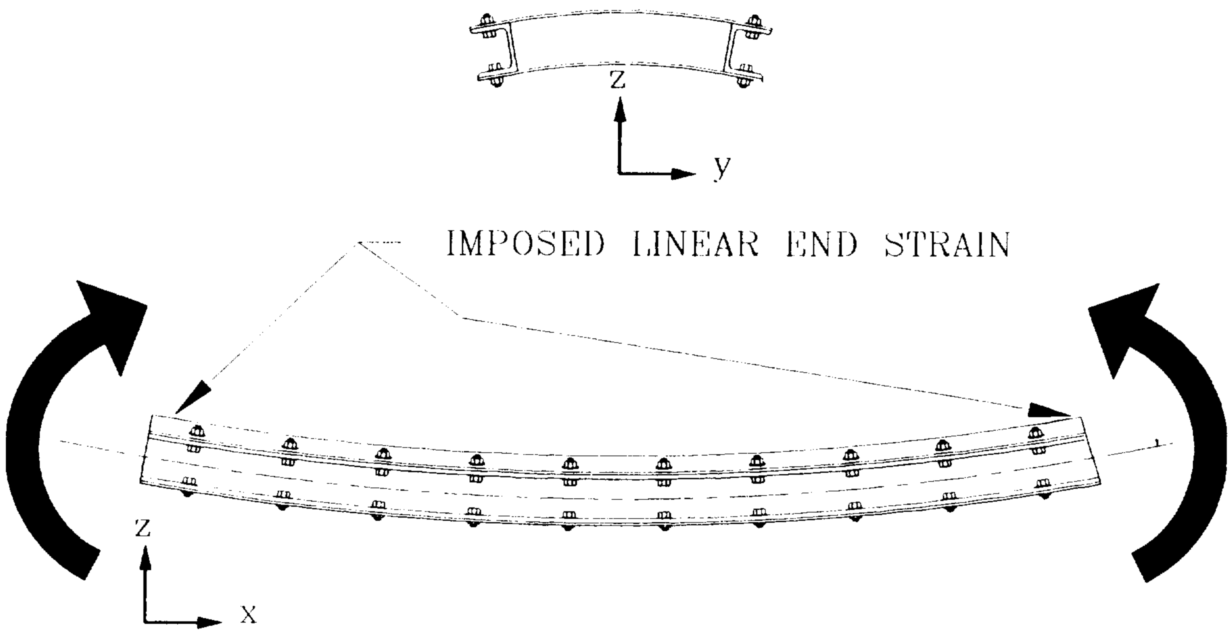
MATERIAL PROPERTIES

AS4/3501-6 GRAPHITE EPOXY

- E_{11} = 20.0 MSI
- E_{22} = 1.7 MSI
- G_{12} = 0.85 MSI
- ν_{12} = 0.3

ALUMINUM CHANNEL

- E = 10.0 MSI
- ν = 0.33

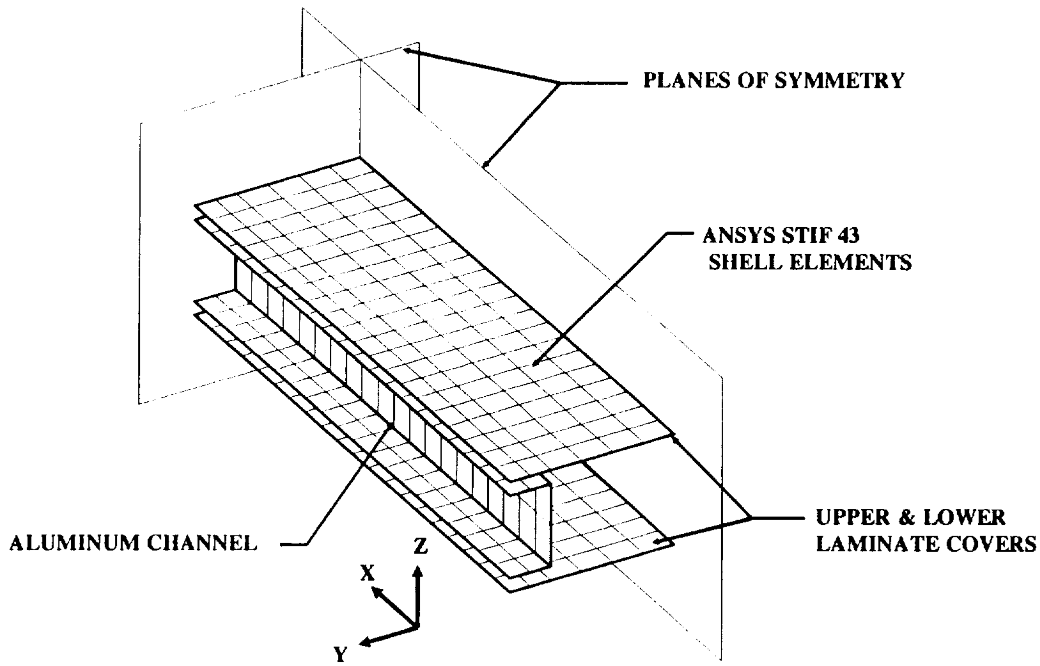


DEFORMED SHAPE OF STRUCTURAL BOX

ESTABLISHING A TECHNOLOGY BASE

GOAL: UTILIZATION OF TECHNOLOGY WITH CONFIDENCE AND LIMITED RISK

- PROOF OF CONCEPT
- DESIGN ANALYSIS METHODOLOGY
- FIDELITY OF MODELING
  - FINITE ELEMENT CORRELATION
  - EXPERIMENTAL CORRELATION
- CAUSE & EFFECT RELATIONSHIPS



FINITE ELEMENT MODEL

RESULTS OF CORRELATION STUDY

CHORDWISE CAMBER CURVATURE (IN $^{-1}$)

MODEL TYPE	BOLTED	BONDED
CLASSICAL	0.01040	0.00954
FINITE ELEMENT	0.00982	0.00947
PERCENT DIFFERENCE	-5.6	-0.7

CONCLUSIONS

- CORRELATION EXCELLENT
- CLASSICAL MODEL MAY BE USED FOR DESIGN