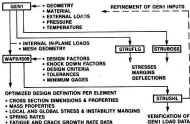


**COMPUTER AIDED
ENGINEERING SOFTWARE
SHELL STRUCTURES**

FEATURES

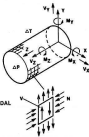
- FACILITATES OVERALL AND DETAIL SIZING OF STRUCTURES.
- PROVIDES A UNIFIED BASIS FOR COMPARATIVE EVALUATION OF ALTERNATIVE STRUCTURE TYPES.
- THERE IS VISIBILITY OVER ALL ASPECTS OF THE ANALYSIS PROCESS.
- ALL PROGRAMS ARE HIGHLY INTERACTIVE AND MENU DRIVEN.
- SOFTWARE TOOLS ARE PROVIDED FOR SYNTHESIS, TRADES, OPTIMIZATION AND POINT DESIGN.
- SOFTWARE WILL BE HOSTED ON MAIN FRAME OR MINI.
- COMPLETE USER DOCUMENTATION AVAILABLE.

ANALYSIS FLOW



GEN1

- GENERATES IN-PLANE COMPRESSIVE-TENSILE LOADS AND SHEAR LOADS ASSOCIATED WITH COMPRESSIVE-TENSILE LOADS. ELEMENTS IN WHICH LOADS ARE PRODUCED ARE USER SELECTABLE. TYPICAL SHELL HAS ONE END FIXED.
- APPLIED LOADS CAN BE:
 - MOMENTS M_X M_Y M_Z
 - SHEAR AND AXIAL LOADS V_X V_Y V_Z
 - DIFFERENTIAL PRESSURE ΔP
 - THERMAL GRADIENTS ΔT
- APPLIED LOADS CAN BE UNIFORM OR SINUSOIDAL
- USES UNIFORM SMEARED OUT STRUCTURAL PROPERTIES PER SECTION
- MULTIPLE LOAD CASES CAN BE INPUTTED, WORST COMPOSITE CASE COMPUTED



GEN1

- PRIMARY STRUCTURE CAN INCLUDE LONGITUDINAL STIFFENERS AT ANY CLOCK ANGLE.
- LOAD PEAKING DUE TO LOCAL LOADS CAN BE ADDED TO LOAD CASES.
- LOADS CAN BE COMPUTED AT SPECIFIC POINTS ON STRUCTURE.
- AVERAGE AND PEAK LOADS PER ELEMENT CAN BE COMPUTED.
- SPECIAL RESTRAINTS CAN BE ADDED TO SHELL TO AFFECT INTERNAL LOAD DISTRIBUTION.



GEN1

INPUTS — FROM DATA FILES & MENU

- GEOMETRY: RADI, LENGTHS
SMEARED SKIN THICKNESS
MEMBER CROSS SECTIONS
- LOADS: LOCAL GLOBAL
PRESSURE TEMPERATURE
- ELEMENT LOAD COMPUTATION CRITERIA:
AVERAGE PEAK
- SYMMETRY CONDITIONS: 1, 2 OR 4.



OUTPUTS

- FOR EACH INPUT LOAD CASE: IN-PLANE COMPRESSION/TENSION LOADS
SHEAR ASSOCIATED WITH COMPRESSION/
TENSION LOADS.
- DERIVATIVE WORST CASE DISTRIBUTED DESIGN LOADS
- SUMMARY OF INPUT DATA AND FACTORS
- IN ENGLISH AND SI UNITS

WAF9/IS09

- SIZES INTEGRAL WAFFLE AND ISOGRID STRUCTURES.
- DEVELOPS OPTIMUM STRUCTURAL PROPERTIES BASED ON LOCAL AND GLOBAL STRENGTH, STABILITY AND STIFFNESS SELECTED BY THE USER.
- MEMBER CROSS SECTIONS CAN BE BLADE, FLANGED BLADE, Z SHAPE OR ANY SPECIAL PURPOSE CROSS SECTION.
- INPUTS AND RESULTS ARE PER ELEMENTS DEFINED BY GEN1.



MEMBER CROSS SECTIONS

WAF9/IS09

ANALYSIS METHODOLOGY

- MINIMUM DIMENSIONS USED FOR LOCAL SKIN AND RIB STRESSES, BUCKLING AND FATIGUE.
- NOMINAL DIMENSIONS USED FOR GENERAL INSTABILITY ANALYSIS.
- IMPLEMENTED DESIGN METHODS AND EQUATIONS IN:

| | |
|---------------|-------|
| CR 912 | BRUH |
| SP 8887 | BOARK |
| CR 124075 | + |
| TN 2788 | + |
| AFDOL-TR-7532 | + |
| ETC. | + |
- MASS PROPERTIES BASED ON EXACT GEOMETRICAL ANALYSIS
- TEMPERATURE DEPENDENT MATERIAL PROPERTIES INCLUDED IN DATA BASE
- ~~RAMBERG-OSGON~~ ITERATIVE TECHNIQUES USED TO OPTIMIZE STRUCTURAL CONFIGURATION



Newton Raphson

WAF9/IS09

INPUTS

- LOADS FROM GEN1 OR FROM OTHER SOURCES, SUCH AS FINITE ELEMENT PROGRAM.
- GEOMETRY: LENGTHS, DIAMETERS
- MIN/MAX ALLOWABLE STRUCTURAL PARAMETERS:
 - SHELL THICKNESS
 - SKIN THICKNESS
 - GRID PATTERN SIZES
 - CROSS SECTION RIB AND FLANGE THICKNESS
- MANUFACTURING TOLERANCES ON:
 - CROSS SECTION
 - OVERALL SHELL MONOTONIC IRREGULARITIES
- MATERIAL TYPE AND TEMPERATURE
- DESIGN CRITERIA FOR EACH LOAD CASE
- DESIGN FACTORS: ULTIMATE, YIELD, KNOCK DOWN, FATIGUE, MINIMUM LOCAL SKIN RESONANT FREQUENCIES



INPUTS

- LOADS FEM
GEN1
- GEOMETRY
- TOLERANCES
- MATERIAL
- DESIGN
CRITERIA
FACTORS

WAF9/IS09

INPUTS

- LOADS FROM GEN1 OR FROM OTHER SOURCES, SUCH AS FINITE ELEMENT PROGRAM.
- GEOMETRY: LENGTHS, DIAMETERS
- MIN/MAX ALLOWABLE STRUCTURAL PARAMETERS:
 - SHELL THICKNESS
 - SKIN THICKNESS
 - GRID PATTERN SIZES
 - CROSS SECTION RIB AND FLANGE THICKNESS
- MANUFACTURING TOLERANCES ON:
 - CROSS SECTION
 - OVERALL SHELL MONOTONIC IRREGULARITIES
- MATERIAL TYPE AND TEMPERATURE
- DESIGN CRITERIA FOR EACH LOAD CASE
- DESIGN FACTORS: ULTIMATE, YIELD, KNOCK DOWN, FATIGUE, MINIMUM LOCAL SKIN RESONANT FREQUENCIES



INPUTS

- LOADS FEM
GEN1
- GEOMETRY
- TOLERANCES
- MATERIAL
- DESIGN
CRITERIA
FACTORS

WAF9/IS09

DATA FILE INPUTS FROM GEN1

- LOADS – GEOMETRY
- LOAD TYPE DESIGNATION

MENU SELECTABLE INPUTS

- MATERIAL, TEMPERATURE
- TYPES OF ANALYSIS
- FACTORS: ULTIMATE, YIELD, KNOCK DOWN, HCLIC, FATIGUE, ETC.
- TOLERANCES, MINIMUM GAGES, INITIAL CRACK SIZE.
- LIMITATIONS ON PART OF STRUCTURE TO BE ANALYZED – IF ANY
- RB CROSS SECTION TYPE.

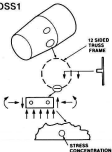
OUTPUTS

- SUMMARY AND/OR DETAILED OUTPUTS IN ENGLISH AND/OR SI UNITS
- BLOCKED DATA INCLUDES MARGINS FOR 5 TO 19 CONDITIONS
- DATA IS PER LOAD CASE, SECTION AND ELEMENT OF STRUCTURE AND TOTAL PRIMARY STRUCTURE
- OTHER DATA: STRESSES, DEFLECTIONS, SPRING RATES, PANEL RESONANCES, WEIGHTS, FATIGUE LIFE, – ETC. – PER ANALYTICAL ELEMENT OF SHELL.



STRUBOSS1

- USES A MINI VERSION OF STRUDL TO ANALYZE CUT OUTS AND BOSSES IN A SHELL STRUCTURE.
- BOSS LOCAL LOAD ENVIRONMENT COMPUTED WITH SPECIALIZED VERSION OF GEN1.
- BOSSES AUTOMATICALLY MODELLED AS 12 SIDED TRUSS FRAMES ON WHICH APPLIED LOADS ARE COMPUTED FROM LOCAL IN PLANE AXIAL AND SHEAR LOADS.
- LOADS AND STRESSES IN EACH TRUSS FRAME MEMBER ARE COMPUTED.
- STRESS CONCENTRATION FACTORS ARE COMPUTED FOR FLANGE BOLT HOLES.



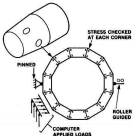
STRUBOSS1

INPUTS

- BOSS, ID, OD, CROSS SECTION
- BOSS LOCATIONS
- LOAD CASE
- TEMPERATURE
- DESIGN CRITERIA
 - YIELD
 - ULTIMATE
 - FATIGUE

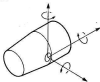
OUTPUTS

- CROSS SECTION PROPERTIES
- LOADS
- DEFLECTIONS
- STRESSES
- MARGINS



STRUBOSS2

- IN ADDITION TO LOADS USED IN STRUBOSS1 OUT OF PLANE LOCAL LOADS ARE USED.
- BUAARD, WICHMAN ANALYSES ARE FULLY IMPLEMENTED.
- BIAXIAL STRESSES AND STRESS MARGINS ARE COMPUTED FOR COMBINED IN-PLANE AND OUT-OF-PLANE LOADS.
- STRESSES ARE COMPUTED AT CIRCUMFERENTIAL AND LONGITUDINAL POSITIONS ON BOSS PERIFERY.



STRUBOSS2

INPUTS

- GEOMETRY
- MATERIAL
- DESIGN AND KNOCK DOWN FACTORS
- APPLIED SHELL LOADS
- LOCAL BOSS LOADS

OUTPUTS

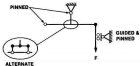
- STRESS CONCENTRATION FACTORS
- BIAxIAL STRESSES AND MARGINS AT 8 POINTS ON BOSS PERIPHERY.



STRESS COMPUTED AT 8 PLACES

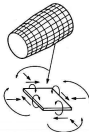
STRUFLNG

- COMPUTES BOLT AND FLANGE STRESSES DUE TO HEEL-TOW ACTIONS IN BOLTED FLANGE.
- USES FINITE ELEMENT MODEL WHICH CAN BE ADJUSTED FOR DIFFERENT BOLT-FLANGE CONNECTIVITIES.



STRUSHL

- AUTOMATICALLY CREATES A STRUHL MODEL SIMILAR TO THAT USED IN GEN1.
- USED TO VERIFY IN-PLANE LOAD DATA FROM GEN1 AND ELEMENT OUT OF PLANE MOMENTS AT TRANSITION BETWEEN CYLINDRICAL AND SHELL STRUCTURE.
- ELEMENT PROPERTIES FROM WAF9 AND IS33 ARE INPUT INTO STRUSHL.



OTHER SHELL STRUCTURES

- NON1
SKSTR1
MONOC1

} LIKE WAF9 AND IS88 FOR HONEYCOMB, SKIN
STRINGER AND MONOCOQUE STRUCTURES

- USE GEN1 INPUTS

- PROVIDE COMMON BASIS FOR EVALUATION OF
ALTERNATIVE STRUCTURAL TYPES

SUMMARY

- SIGNIFICANT COST AND TIME-TO-DESIGN SAVINGS CAN BE ACHIEVED WITH CAE SOFTWARE.
- FEATURES OF SOFTWARE
 - INTERACTIVE
 - VERSATILE
 - EASY TO USE
 - TO BE HOSTED ON BCS
- GROWTH POTENTIALS INCLUDE:
 - SPECIALIZATION FOR SPECIFIC STRUCTURAL CONFIGURATIONS
 - ADDITION OF NEW MATERIAL PROPERTIES DATA BASES
 - INCORPORATION OF USER PREFERRED ANALYSES
 - AUTOMATED DATA INTERCHANGE WITH OTHER CAE SOFTWARE
- PROCESSES FOR HOSTING SOFTWARE ON MAIN FRAMES OR MINIS ARE ESTABLISHED.