



Design Space Navigator for Beam-Stiffened Ship Structures



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NSRP Ship Design & Material Technologies Panel Project “Design Manual for Fabricated Shapes”

Awarded February, 2011

Project Team:

Applied Thermal Sciences, Inc.

Marinette Marine

HII - Ingalls

Concurrent Technologies Corp.

Scheduled Completion: 1/31/2012

Outline

- **Programmatic Overview**
- **Historical Perspective**
- **Technical Approach**
 - **“Substitutional Design”**
 - **Replacement of existing T-beams in existing design**
 - **“Optimal Design”**
 - **“Clean sheet of paper” - no prior design**
- **Design Tool Development Overview**
 - **“Design Space Navigator”**
 - **Beta Trials**
- **Future Work**

Historical Perspective

- Legacy Stiffeners
 - I/T's, W/T's, Angles, Bulb Flats, Flats
- First NSRP-Funded Analysis
 - N7-91-4 Tee-Beam Manufacturing Analysis (I/T's)
- Extended Analysis
 - DDG-51 Shapes – included W/T's as well as I/T'S
- Implementation on CVN-78
 - Shift to HSLA-65; Saves >480 Tons; Saves Assembly Costs
- ATS Completes Sandwich Panel Design Tool
 - Fast Iteration of Potential Designs
 - Less Than One Minute 30 Combinations of 16 design attributes
- Implementation on DDG-1000
 - Shift to HSLA-80
- Inquiry Regarding LCS
 - Issues with Mill Schedules, Interested in Potential

Programmatic Update

- Project Team: ATS – NGSB-GC – Marinette Marine - CTC
- Contracts / Subcontracts in Place: February 2011
- Conference Call with Marinette Marine 2/22/11 & 5/19/11
- “Optimal” Approach;
- “Look and Feel” of “Manual of Combined Properties...”
- “Alpha” Design Tool Development Completed April 2011
 - Inputs / Outputs / Constraints / User Interface
- Beta-Level Review Started 6/13/2011
- Developing User’s Manual
- Determination of Next Steps
- Project Status - Nearly 80% Complete
- Funding Status – Nearly 40% Remaining
- Completion well before 1/31/2012

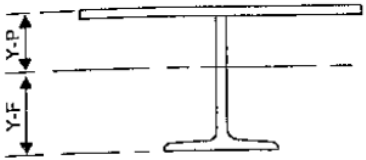
Referential Guidelines

MANUAL OF PROPERTIES OF COMBINED BEAM AND PLATE

PART I **TEES AND ANGLES**

Coordinated by the Society of Naval Architects and Marine Engineers for the Maritime Administration, U. S. Department of Commerce, and the Bureau of Ships, Department of the Navy

Referential Guidelines



STEEL

**PROPERTIES OF
COMBINED BEAM AND PLATE
I-T AND T**

60t

5.1# PLATE WEIGHT

NOMINAL SIZE IN. x IN. x LBS./FT.	WEIGHT PER FOOT LBS.	SECTION MODULUS		I IN. ⁴	r IN.	YF IN.	YP IN.	BEAM DIMENSIONS				
		LESSER IN. ³	GREATER IN. ³					AREA IN. ²	DEPTH IN.	FLANGE		SHEAR AREA IN. ²
										WIDTH IN.	THICK IN.	
18 x 11 3/4 x 105 I-T	71.22	70.6	161.4	905.8	6.43	5.6	12.8	20.95	18.32	11.79	0.911	10.14
96 I-T	65.10	65.2	148.0	827.6	6.42	5.6	12.7	19.15	18.16	11.75	0.831	9.29
18 x 8 3/4 x 85 I-T	60.34	66.1	128.7	805.3	6.56	6.3	12.2	17.75	18.32	8.84	0.911	9.63
77 I-T	54.46	60.4	117.4	728.9	6.56	6.2	12.1	16.02	18.16	8.79	0.831	8.62
70 I-T	49.48	55.6	106.9	663.0	6.54	6.2	11.9	14.55	18.00	8.75	0.751	7.88
64 T-T	45.19	51.7	98.3	609.4	6.54	6.2	11.8	13.29	17.86	8.71	0.686	7.20

Tool Development Overview

- Design and develop:
 - BEAM-stiffened plate optimization tool
 - MS Excel / Visual Basic
 - Run as a macro within MS Excel
- User Manual:
 - Guide for the using the tool
 - Section on fundamental theory

Input Parameters

- Load Case
 - Simply supported with uniform pressure distribution
- Span or Frame Spacing
 - Input parameters (Substitutional)
 - Output values (Optimal design)
- Safety Factor
- Deflection Criteria

The screenshot shows a software window titled "Load Input" with the following elements:

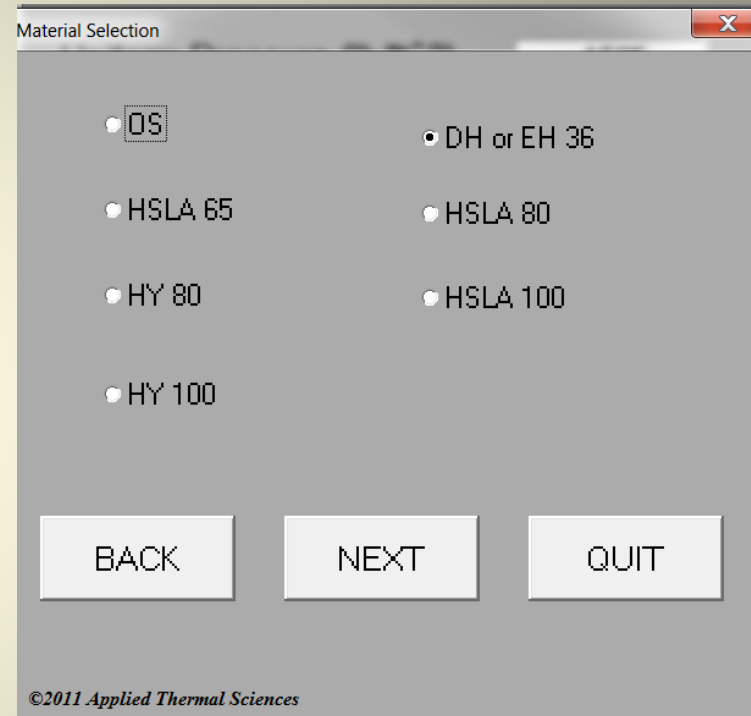
- Uniform Pressure (lb/ft²)**: Input field with value 1585.
- Span (ft)**: Input field with value 8.0.
- Global Deflection Criteria**: Input field with value 500 and a dropdown arrow.
- Local Deflection Criteria**: Input field with value 2.0.
- Minimum Plating Thickness Criteria**: A section with three tabs: "Case 1", "Case 2", and "Case 3".
 - Case 1**:
 - Plating Location**: Shell below a line 2 ft below the full load waterline and Tank boundaries, Floodable Voids and Bulkheads separating adjacent compensated fuel tanks.
 - Loading Scenario**: Wave Impact, Hydrostatic Head Compensated fuel tank pressures, Tank pressure to top of overflow, Hydrostatic pressure to tank top or to overflow.
 - Case 2**: Selected with a radio button.
 - Case 3**: Selected with a radio button.

At the bottom of the window are two buttons: "NEXT" and "QUIT". The footer text reads "©2011 Applied Thermal Sciences".

Input Parameters (continued)

Material Selection Dialog box:

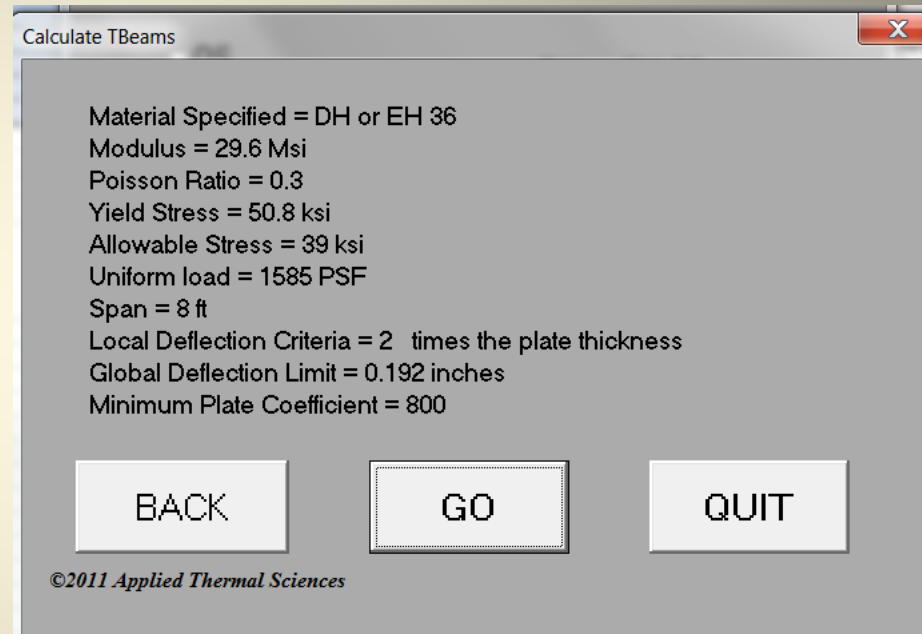
- All steel alloys currently in NVR:
 - OS
 - DH 36 /EH 36
 - HSLA 65
 - HSLA 80
 - HSLA 100
 - HY80
 - HY100
- Program selects & computes:
 - Standard thicknesses
 - 1/8" - 3/4" in 1/16" increments
 - Easily converted to metric units
 - Can be converted to gauge units



Input Parameters (continued)

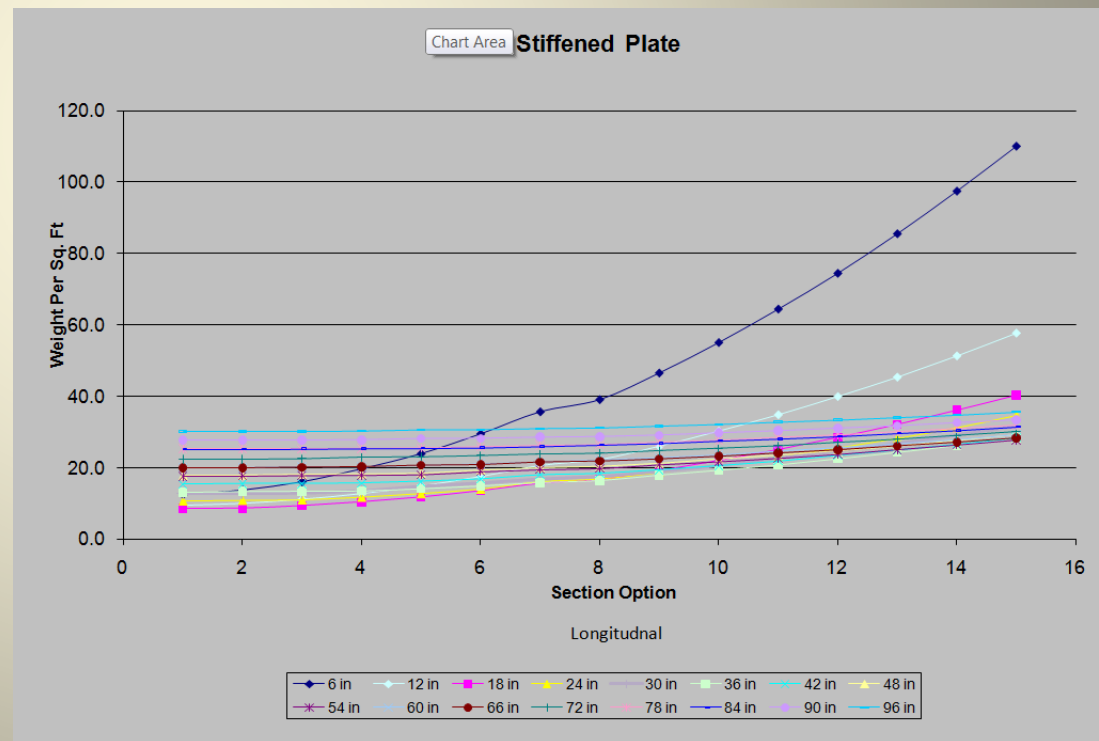
Final Dialog box:

- Summarizes input values
- Options as shown



Output Parameters

- Table of output parameters
 - T-Beam
 - Elastic properties: I_{xx} , I_{yy} , S_x , S_y , r_x , and r_y
 - Area
 - Web details
 - Flange details
 - Stiffener Spacing



Summary: Input & Output Parameters

Input Parameters				
Load	Span	Dfl Crit -Global	Dfl Crit-Local	Min Pltg Crit
Mat'l (Catlg)	Mat'l Usr-Def	Modulus	Poisson's Ratio	Yield Stress
Density	Safety Factor	Min Pltg "C" Fctr		

Output Values				
"Option"	Weight/Sq Ft	Ctr Defl Ratio	Local Defl UF	Local Strs UF
Web Shr Strs UF	Norml Strs UF	Lmtg Elmnt P? F?	Pl Thk Min	Lsr Sect Mod
Grtr Sect Mod	Effective I	R Gyr – Eff Sect	YF –ctrd to Flg	YP-Ctrd to Pl
Area – Full Sect	Sect Depth	Flg Width	Flg Thickness	Shear Area
Sect Wgt/ft	Web Thickns	I –Major Axis	Sect Md Mjr A	R Gyr Major
I Minor Axis	S Minor Axis	R Gyr - Minor	K- dst flg -ctrd	Lgtdl Spc Opt
Eff. Breadth				

Future Work

- Complete Beta Testing
 - Secure comments from shipyard
 - Update and complete
 - Finish “User Manual”
- Depending on Resources
 - “Publish” - Release to NSRP Community
 - Hold a Workshop for Potential Users
- Potential future project
 - Evaluate “In-Plane” Loading Scenarios
 - Evaluate other materials (e.g., Aluminum)

Questions?



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