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HS-4415: Optimization Study of a Landing Beam Using Excel

This tutorial demonstrates how to perform an optimization study in which the input variables are entered and the output responses are calculated in a Microsoft Excel spreadsheet. The Excel spreadsheet LandingBeamCalc_Public.xls file can be found in <hst.zip>/HS-4415/ and copied to your working directory. To watch a demonstration video of this tutorial, click here.

The objective is to find the cross-sectional dimensions of a tapering I- beam at its three sections that minimize the total cross-sectional area while meeting the margin of safety requirements for buckling, crippling, and combined bending and shear under ten loadcases.

The spreadsheet used here contains a page with the initial design and separate pages for crippling, buckling, and combined bending and shear calculations.

Step 1: Create a Matrix Input that HyperStudy Can Evaluate

- 1. In Excel, open the LandingBeamCalc_Public.xls spreadsheet.
- 2. Review the information, and locate the columns that contain the input variables and output responses.
 - **Note**: When creating a Spreadsheet model for HyperStudy on a Mac or Windows platform, variable labels should only contains English characters, or a combination of English characters and numbers.

Step 2: Perform the Study Setup

- 1. Start HyperStudy.
- 2. To start a new study, click **File** > **New** from the menu bar, or click \blacksquare on the toolbar.
- 3. In the **HyperStudy Add** dialog, enter a study name, select a location for the study, and click **OK**.
- 4. Go to the **Define models** step.
- 5. Add a Spreadsheet model by dragging-and-dropping the LandingBeamCalc_Public.xls file into the work area.

The **Solver input file** column displays hst_input.hstp, this is the name of the solver input file HyperStudy writes during any evaluation. The **Solver execution script** column now displays **SpreadSheet_HST**.

Explorer	irectory		3	Define Mo	odels	
Name	Size	Туре	_			
4 퉬 C:\HS-4415	laghat .		🔁 Add Model 🛛 Remove			
🖌 study_lock.xml	738 bytes	-	Active	Label	Varname	Model Type
🖻 퉲 _usr		Setting				
Study_1.xml		xml File	LandingBeamCalc_Public.xls			
🛃 LandingBeamCa	xls File					
						(+)

- 6. **Optional**. If a firewall prompt dialog appears, click *Allow*.
- 7. Click Import Variables. The LandingBeamCalc_Public.xls spreadsheet opens.
- 8. In the **Excel HyperStudy** dialog, click **Yes** to begin selecting input variables.

Excel - HyperStudy	23
Proceed to selecting Input(s)	?
Yes	No

9. In the spreadsheet, select the cells **AA_w1**, **AA_w2**, and **AA_w3** in **Section AA**, along with their corresponding values.

В	С	D	E	F	Excel - HyperStudy Input selector
Section AA					Select Design Variable(s).
width	initial		height	initial	
AA w1	6.000		AA h1	0.400	1
AA_w2	0.300		AA_h2	0.600	Hit Cancel when finished selecting items.
AA_w3	0.200		AA_h3	10.250	\$B\$16:\$C\$18
AA_w4	0.300		AA_h4	0.600	
AA_w5	6.000		AA_h5	0.400	OK Cancel
			AA_h_tot	12.250	O POR_IVIO_STIESS_LCO U.
AA area	7.21				7 AA MS stress LC7 0.0

- 10. In the Excel HyperStudy Input Selector dialog, click OK.
- 11. Select the following:
 - Section AA: AA_h1 and AA_h2
 - Section CC: CC_w1, CC_w2, CC_w3
 - Section CC: CC_h1, CC_h2
 - Section EE: EE_w1, EE_w2, EE_w3
 - Section EE: EE_h1, EE_h2



- 12. Click *Cancel* to stop selecting input variables from the spreadsheet.
- 13. In the **Excel HyperStudy** dialog, click **Yes** to begin selecting output responses.
- 14. In the spreadsheet, select the cell *AA_MS_BS* in **Section AA**, along with its corresponding value.

Н		J	K	Excel - HyperStudy Output selector		? 💌	
	M.S.		M.S.	-			
Loadcase	(stress)		(crippling)	Salact	Response(s).		
1	AA_MS_stress_LC1	7.18	AA_MS_crip_LC1	Jelect	Response(s).		
2	AA_MS_stress_LC2	0.99	AA_MS_crip_LC2	Hit Car	ncel when finished selecting	g items.	
3	AA_MS_stress_LC3	0.99	AA_MS_crip_LC3	\$I\$26:\$J\$26			
4	AA_MS_stress_LC4	7.81	AA_MS_crip_LC4				
5	AA_MS_stress_LC5	0.66	AA_MS_crip_LC5	OK Cancel			Cancel
6	AA_MS_stress_LC6	0.66	AA_MS_crip_LC6	0.24	AA_INIS_DUCK_ECO	1.15	
7	AA_MS_stress_LC7	0.69	AA_MS_crip_LC7	0.24	AA_MS_buck_LC7	1.79	
8	AA_MS_stress_LC8	1.13	AA_MS_crip_LC8	0.56	AA_MS_buck_LC8	7.71	
9	AA_MS_stress_LC9	0.66	AA_MS_crip_LC9	0.24	AA_MS_buck_LC9	1.90	
10	AA_MS_stress_LC10	3.40	AA_MS_crip_LC10	3.01	AA_MS_buck_LC10	1.79	
min	AA <u>MS</u> BS	0.66	AA_MS_C	0.24	AA_MS_B	1.79	

- 15. In the Excel HyperStudy Output Selector dialog, click OK.
- 16. Select the following:
 - Section AA: AA_MS_C
 - Section AA: AA_MS_B
 - Section CC: CC_MS_BS
 - Section CC: CC_MS_C
 - Section CC: CC_MS_B
 - Section EE: EE_MS_BS
 - Section EE: EE_MS_C
 - Section EE: EE_MS_B
 - Area ACE value from cell C10 (illustrated in the image below):

Α	В	С	D	E	F	G	Н		
	Green cells ar	e Responses		Excel - HyperStudy Output selector					
				Select Response(s).					
	Area ACE	61.37							
				Hit Cancel when finished selecting items.					
				\$B\$10:\$C\$10					
	Section AA				_				
	width	initial				ОК	Cancel		
	AA_w1	6.000		···-	0.400		<u> </u>		



- 17. Click **Cancel** to stop selecting output responses from the spreadsheet. Fifteen input variables and ten output responses are imported from the LandingBeamCalc_Public.xls spreadsheet.
- 18. Go to the **Define Input Variables** step.
- 19. Review the input variable's lower and upper bound ranges.
- 20. Go to the **Specifications** step.

Step 3: Perform the Nominal Run

- 1. In the work area, set the **Mode** to **Nominal Run**.
- 2. Click Apply.
- 3. Go to the **Evaluate** step.
- 4. Click **Evaluate Tasks**. An approach/nom_1/ directory is created inside the study directory. The approaches/nom_1/run_00001/m_1 sub-directory contains the sse output.csv file, which is the results file of the nominal run.
- 5. Go to the **Define Output Responses** step.

Step 4: Add an Optimization Approach and a Run Optimization

- 1. In the **Explorer**, right-click and select **Add** from the context menu.
- 2. In the Add HyperStudy dialog, select Optimization and click OK.
- 3. Go to the **Select Input Variables** step.
- 4. Review the input variable's lower and upper bound ranges.
- 5. Go to the Select Output Responses step.
- 6. Click Add Objective.
- 7. In the **Add HyperStudy** dialog, add one objective.
- 8. Define the objective.
 - a. Set **Type** to *Minimize*.
 - b. Set Apply On to Area ACE (r_10).

	Active	Label	Varname	Туре	Apply On	Evaluate From
1	v	Objective 1	obj_1	Minimize 👻	Area ACE (r_10) 💌	SOLVER -

- 9. Click the *Constraint* tab.
- 10. Click Add Constraint.
- 11. In the **Add HyperStudy** dialog, add nine constraints.
- 12. Define **Constraint 1** through **Constraint 9** by selecting the options indicated in the image below from the **Apply On**, **Bound Type**, and **Bound Value** columns.



	Active	Label	Varname	Туре	Apply On	Bound Type	Bound Value
1	v	Constraint 1	c_1	Deterministic 👻	AA_MS_BS(r_1) 💌	>= •	0.0000000
2	1	Constraint 2	c_2	Deterministic 👻	AA_MS_C (r_2) 🔹	>= •	0.2000000
3	1	Constraint 3	c_3	Deterministic 👻	AA_MS_B (r_3) ▼	>= •	0.2000000
4	1	Constraint 4	c_4	Deterministic 👻	CC_MS_BS (r_4) ▼	>= •	0.0000000
5	1	Constraint 5	c_5	Deterministic 👻	CC_MS_C (r_5) 🔹	>= •	0.2000000
6	√	Constraint 6	c_6	Deterministic 👻	CC_MS_B (r_6) ▼	>= •	0.2000000
7	√	Constraint 7	c_7	Deterministic 👻	EE_MS_BS (r_7) ▼	>= •	0.0000000
8	√	Constraint 8	c_8	Deterministic 👻	EE_MS_C (r_8) ▼	>= •	0.2000000
9	√	Constraint 9	c_9	Deterministic 👻	EE_MS_B (r_9) ▼	>= •	0.2000000

- 13. Click Apply.
- 14. Go to the **Specifications** step.
- 15. In the work area, set the Mode to Sequential Quadratic Programming (SQP).Note: Only the methods that are valid for the problem formulation are enabled.
- 16. Click Apply.
- 17. Go to the **Evaluate** step.
- 18. Click *Evaluate Tasks* to launch the optimization.

Step 5: View the Iteration History of the Optimization

- 1. Click the *Iteration Plot* tab to monitor the evolution of the objective function and constraints vs. the iterations.
- 2. Using the **Channel** selector, select **Constraint 1** through **Constraint 9**. The Optimization iteration history of the constraints is plotted.



