S2890: Inner Bottom Transformation

NSRP All Panel Meeting 2025

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Advanced Technology International

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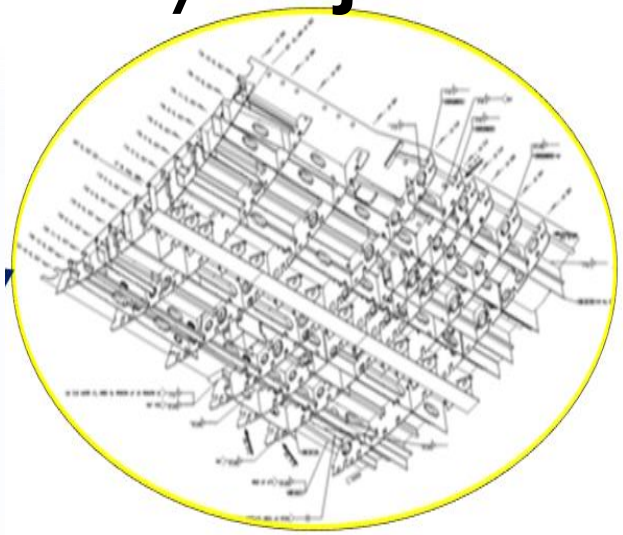
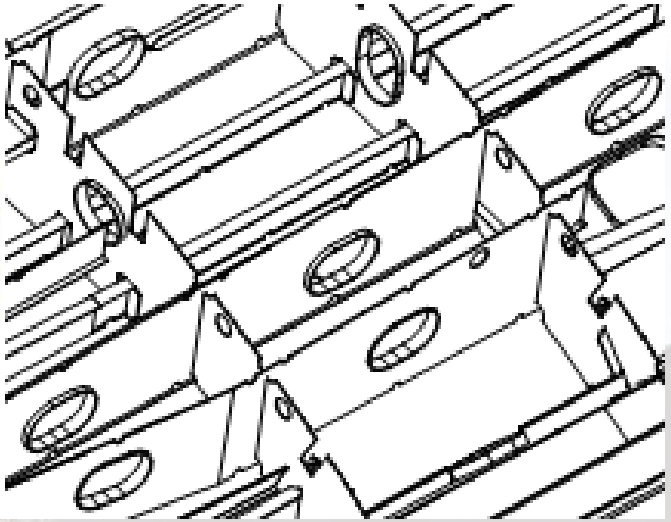
Agenda

1. Platform/Issue Description & Project Objectives
2. Project Team
3. Project Schedule
4. Technical Goals
5. Technical Approach
6. Transition/Implementation Plan
7. Next Steps
8. Q & A

Project Overview/Objectives

- Platform(s):
  - DDG
  - LHA
  - LPD





Left -Complexity of Inner Bottom Construction

- Issue Description:
  - **Hundreds of structural support assemblies are used throughout a typical Navy ship.**
  - **Ship's hull inner bottom assemblies are large and complex structures:**
    - Construction is expensive and consumes a long build cycle time
    - Limited use of mechanized welding machines
    - Poor ergonomics and working conditions for the shipbuilders (cramped spaces, dark, poor ventilation, difficult to access)

Arleigh Burke-class destroyer

https://en.wikipedia.org/wiki/USS_Arleigh_Burke#/media/File:USS_Arleigh_Burke_(DDG_51)_steams_through_the_Mediterranean_Sea.jpg

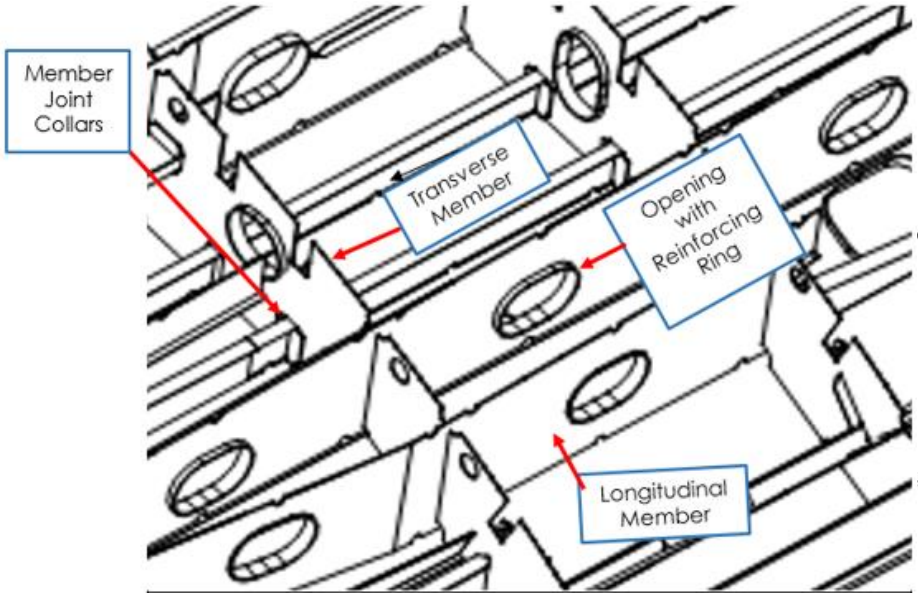
America-class Amphibious Assault Ship

https://en.wikipedia.org/wiki/America-class_amphibious_assault_ship#/media/File:USS_America_(LHA-6)_F-35B_loaded.jpg

Project Overview/Objectives

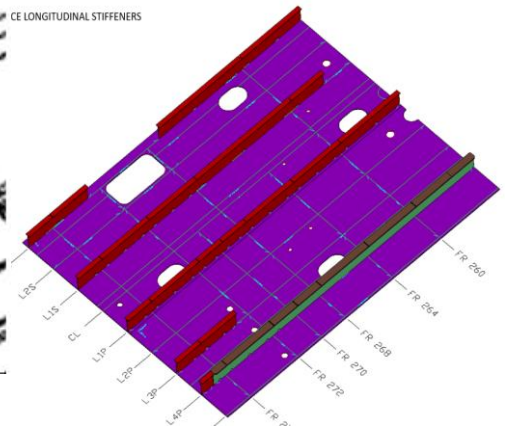
- **Project Objectives**
  - **Two major construction processes are being evaluated for improvement.**
    - Reduction of reinforcing rings around openings inside the inner bottom structure
    - Defining a slotted construction process for the grid framework of the assemblies

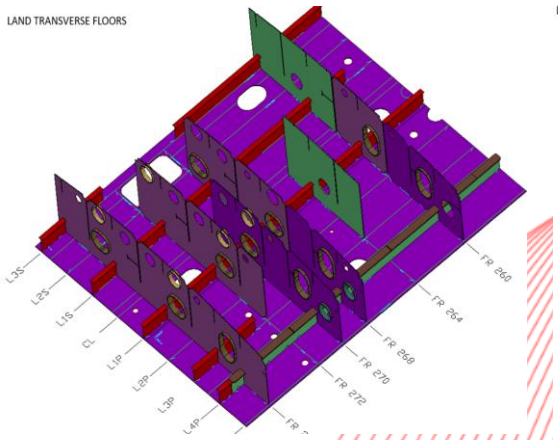
Inner Bottom Access Openings and Service Penetration

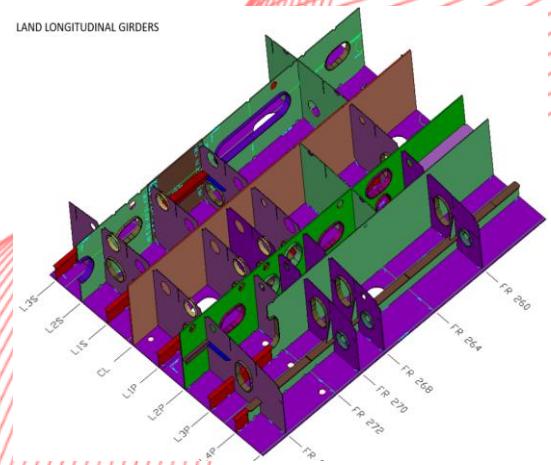


Slotted Construction Concept

Place Longitudinal Stiffeners → Land Transverse Floors → Land Longitudinal Girders







Project Overview/Objectives

Specific Technical Goals

- Unreinforced Openings
  - Study and tests to reduce the reinforcing collars around openings in Inner Bottom structural supports (beyond 36 inched in web depth).
    - A structured box girder test comparing reinforced and unreinforced openings
    - Data to update and further develop FEA
    - Data to modify the appropriate Navy Shipbuilding specifications and Design data Sheets

- Slotted Construction
  - Study and tests using slotted construction for longitudinal and transverse Inner Bottom members
    - Fatigue testing and comparison to previous fatigue testing for non–slotted construction.
    - Data to update and further develop FEA
    - Structural Element Testing
    - UNDEX and Shock testing for qualification post project
    - Data to support modifying the appropriate Navy Shipbuilding specifications and Design data Sheets

Project Organizational Structure

Project Schedule

	Task	Description
	Phase I – Baseline Requirements/Test Plans and Market Survey	
✓	1	**Phase I Program Management** *D#1: Kick-off Meeting Minutes (03 January 2022)* *D#2: Technology Transition Plan (03 March 2022)*
✓	2	**Unreinforced Openings Test Plan Development** *D#3: Inner Bottom Reinforced Openings Baseline Manufacturing Process Report (03 February 2022)* *D#4: Inner Bottom Unreinforced Openings Test Plan Report (01 March 2022)*
✓	3	**Slotted Construction Test Plan Development** *D#5: Inner Bottom Member Joining Baseline Manufacturing Process Report (03 February 2022)* *D#7: Inner Bottom Slotted Construction Test Plan Report (16 September 2022)*
✓	4	**Test Vendors Down Selection** *D#7: Function Specification and Procedure Qualification Requirements Report (26 April 2022)*
✓	5	**Phase I Report and Go/No-Go Gate Review** *D#9: Inner Bottom Manufacturing Phase I Go / No-Go Report (03 November 2022)*
✓	7	**Reinforcing Ring Testing (moved from Phase II to Phase I)** *D#13: Inner Bottom Unreinforced Openings Test Report (06 October 2022*

✓ - Complete | → - In Progress | ▭ - Transition Event | ▭ - Require ONR Contract Action

Project Schedule

	Task	Description
	Phase II – Perform Testing and Fabricate Test Samples	
✓	6	**Phase II Program Management** *Various Deliverables: Successive Quarterly Reports (Various Due Dates thru PoP)*
→	8	**Slotted Construction Testing** *D#17: Slotted Construction Test Report (ECD - 26 June 2025)* *D#17A: Structural Element Test Report (27 September 2024)* *D#17B: Fatigue Testing Report (ECD – 25 April 2025)*
→	9	**Analyze Results** *D#5: Inner Bottom Manufacturing Parameters Report (ECD – 28 April 2025)*
	10	**Final Reporting** *D#20: Final Business Case (ECD – 20 April 2026)* *D#21: Implementation Plan (ECD – 20 April 2026)* *D#23: Inner Bottom Transformation Final Review Presentation (ECD – 20 April 2026)* *D#24: Inner Bottom Transformation Final Report (ECD – 20 April 2026)* *D#25: Test Article(s) and Accessories (ECD - 21 April 2026)*

✓ - Complete | → - In Progress | ■ - Transition Event | ■ - Require ONR Contract Action

Phase I Technical Update/Discussion

Reinforcing Ring Testing

- ✓ Successful testing was completed at the University of Texas
- ✓ Three unreinforced and three reinforced test articles were fabricated then tested under three separate load applications for a direct comparison between reinforced and unreinforced specimens

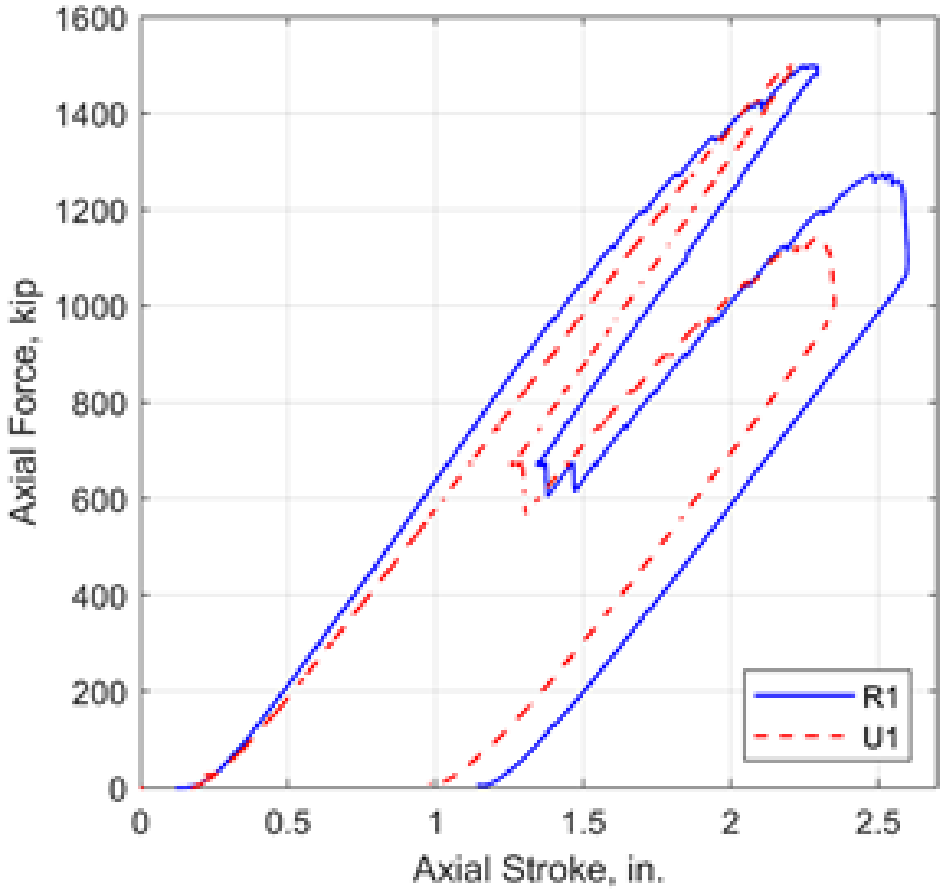
(**left/right**) Reinforced Opening Specimen #1 Installed in the Test Fixture and Tested

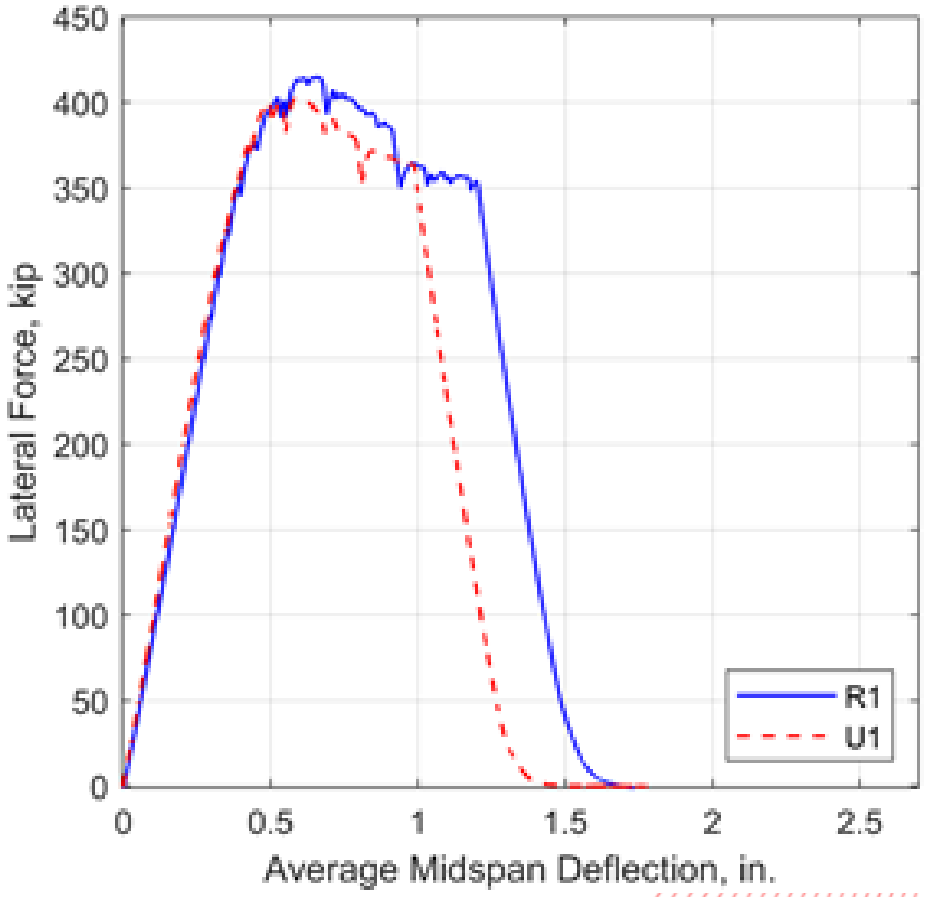
Phase I Technical Update/Discussion

Reinforcing Ring Testing

✓ **Testing Results**

- These charts measure force vs. displacement while destructively testing the first reinforced and unreinforced test specimens.
- The unreinforced test specimen performed very similarly to the reinforced specimen





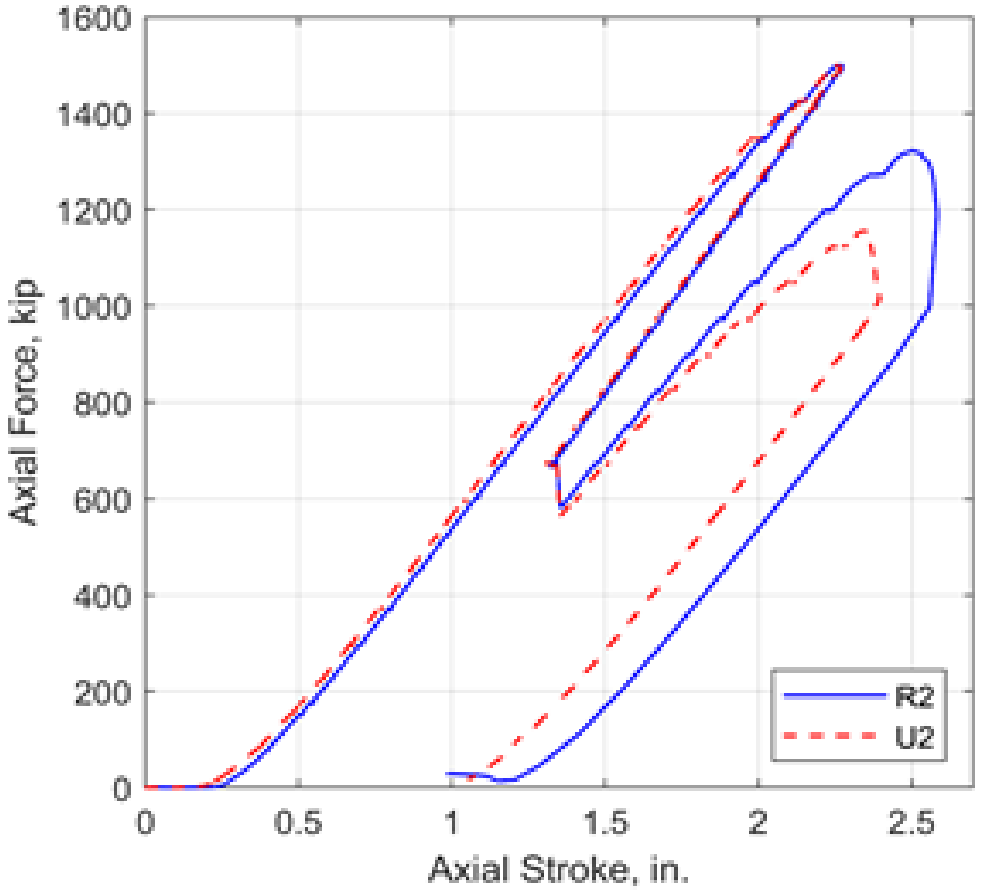
Combined Displacement-Force Plot R1 and U1

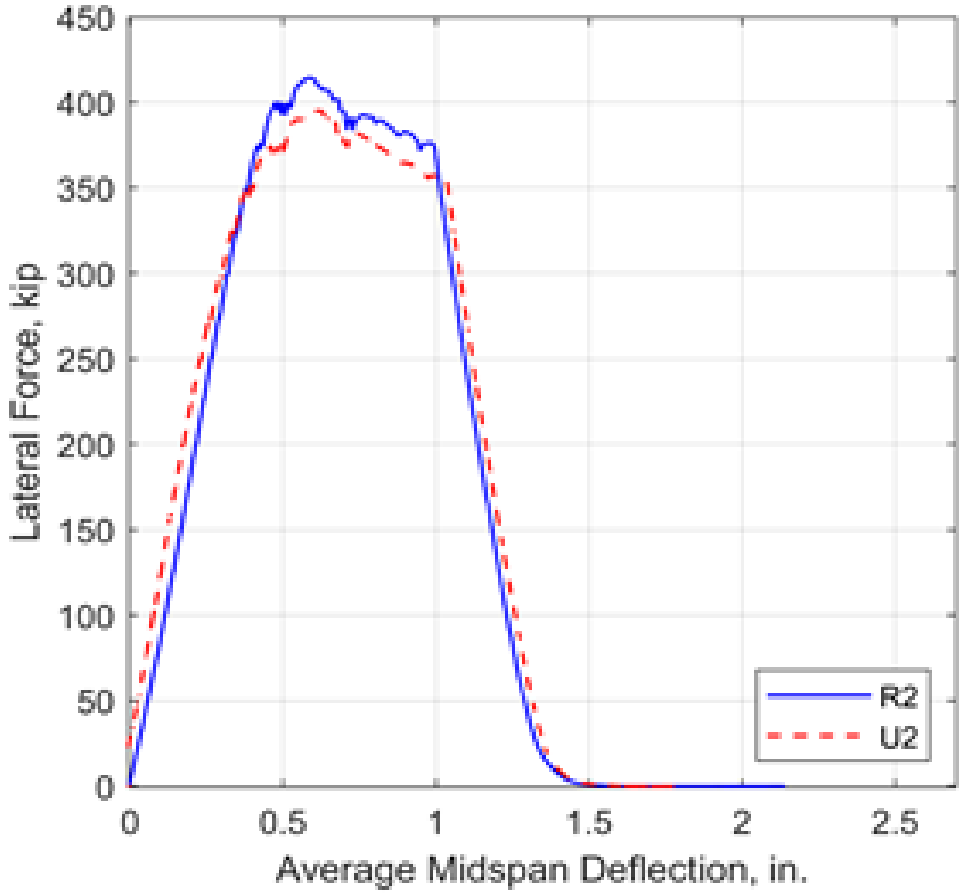
Phase I Technical Update/Discussion

Reinforcing Ring Testing

✓ **Testing Results**

- These charts measure force vs. displacement during the course of destructively testing the second reinforced and unreinforced test specimens.
- The unreinforced test specimen performed very similarly to the reinforced specimen





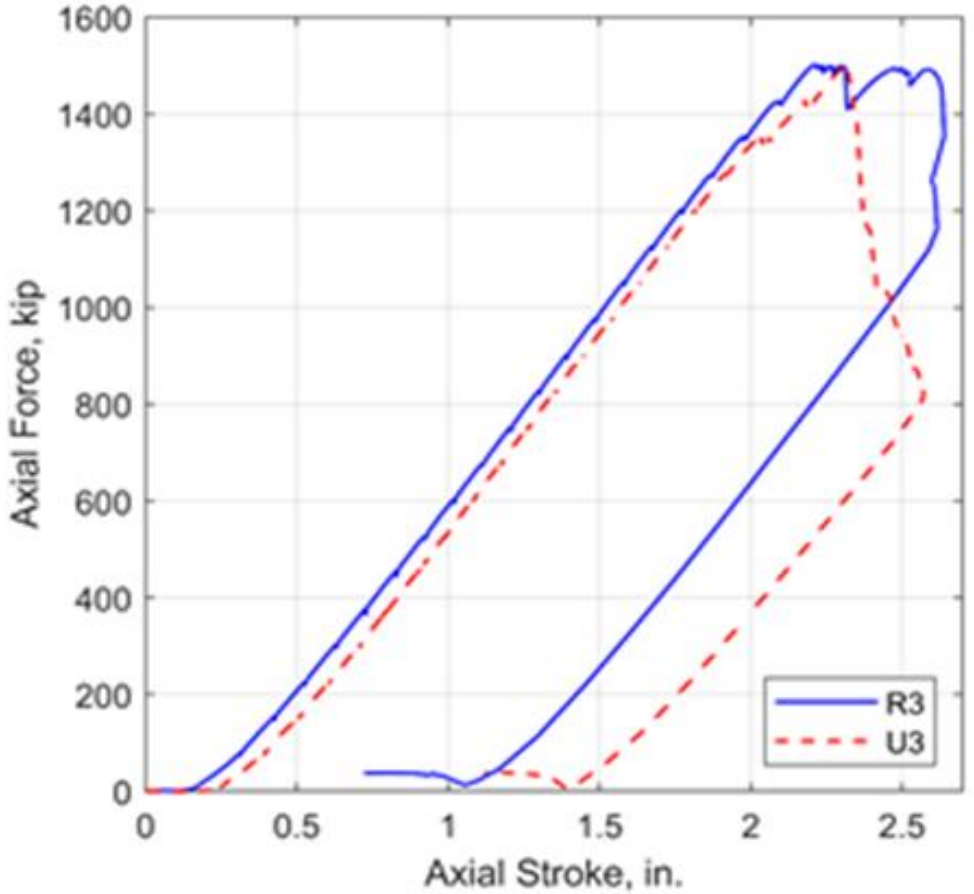
Combined Displacement-Force Plot R2 and U2

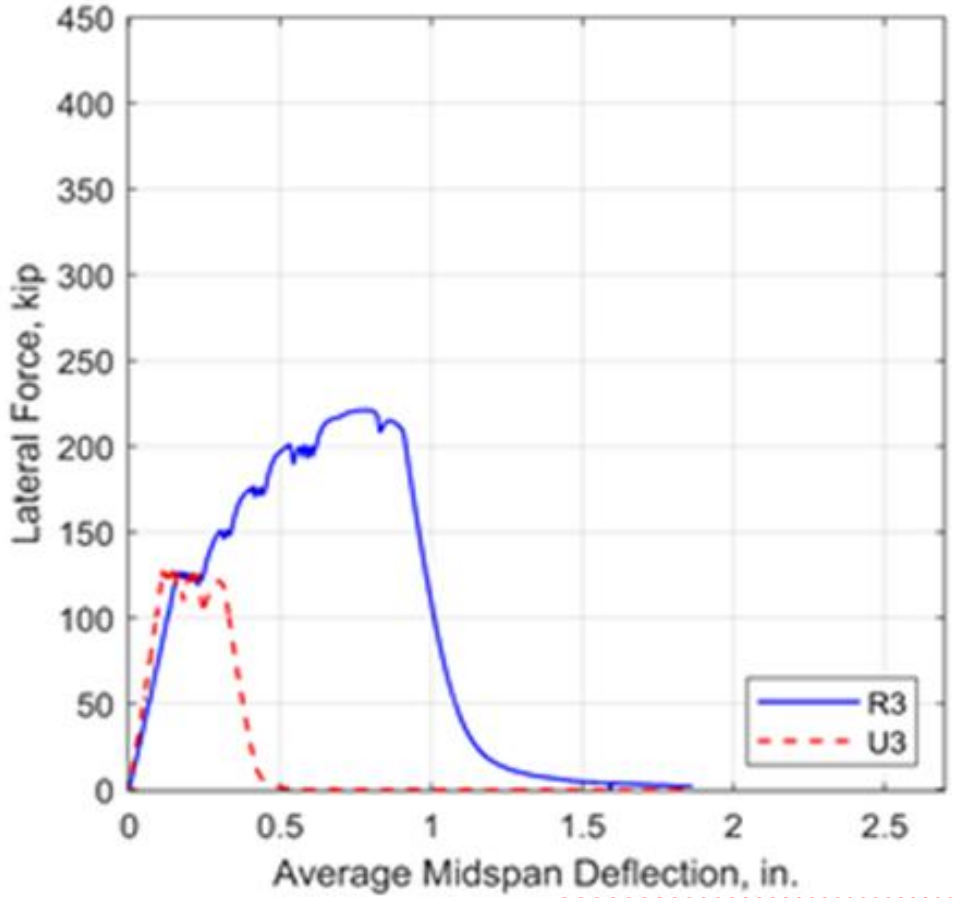
Phase I Technical Update/Discussion

Reinforcing Ring Testing

✓ **Testing Results**

- These charts measure force vs. displacement while destructively testing the third reinforced and unreinforced test specimens.
- The unreinforced test specimen failed at a lateral load application of approx. 100 kips below the reinforced test specimen failure load
- This behavior was predicted by the load simulation model and the character was validated via testing

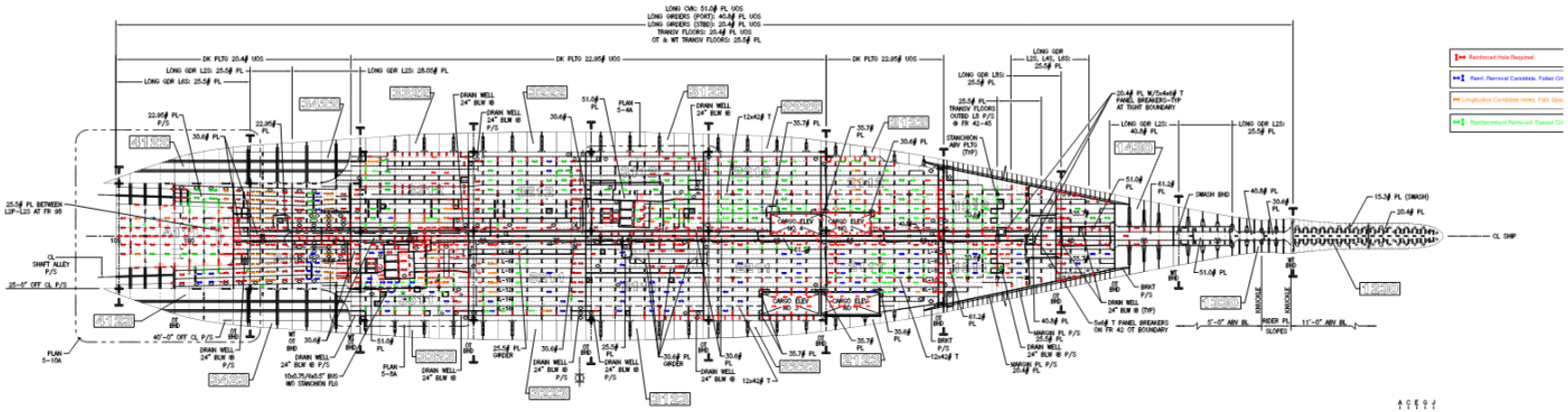




Combined Displacement-Force Plot R3 and U3

Phase I Technical Update/Discussion

- **Accomplishments**
  - **LHA unreinforced analysis COMPLETE** - Approximately 77% of the candidate openings reinforcing rings have been removed from LHA (333 removed).
  - **LPD unreinforced analysis COMPLETE**– Approximately 20% of candidate openings reinforcing rings have been removed from LPD (221 removed) .
  - **DDG unreinforced analysis *IN PROGRESS***



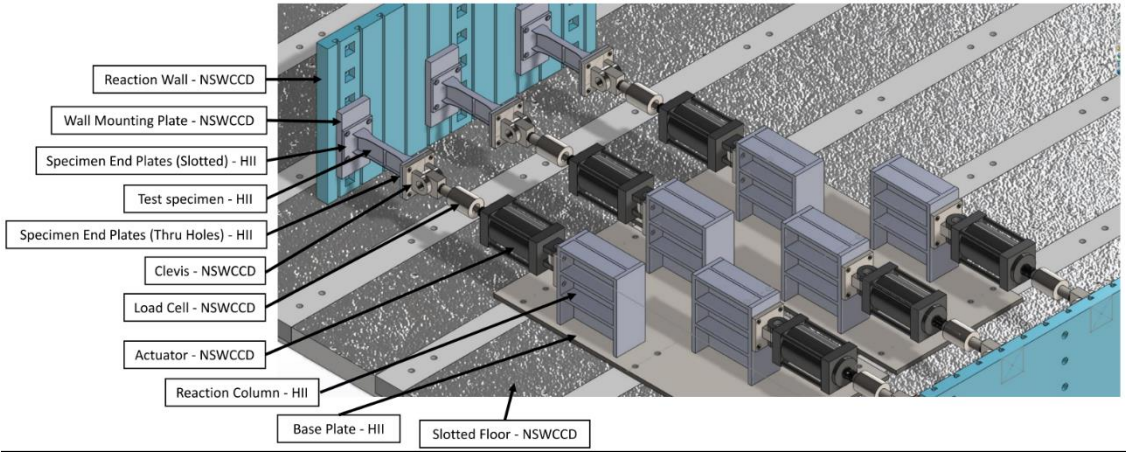
(**above**) Construction drawing marked up to identify candidate areas

	Total Openings	Candidate Openings	Total Removed	
1430	40	6	4	
1511	83	19	13	
1512	71	30	30	
2111	120	42	27	
2112	162	51	47	
2211	84	25	12	
2212	112	55	55	
3111	71	15	0	
3112	111	25	25	
3211	61	20	14	
3212	68	24	22	
3311	193	41	21	
3312	101	23	22	
3411	164	15	4	
4111	194	43	37	
	1635	434	333	**76.73%**

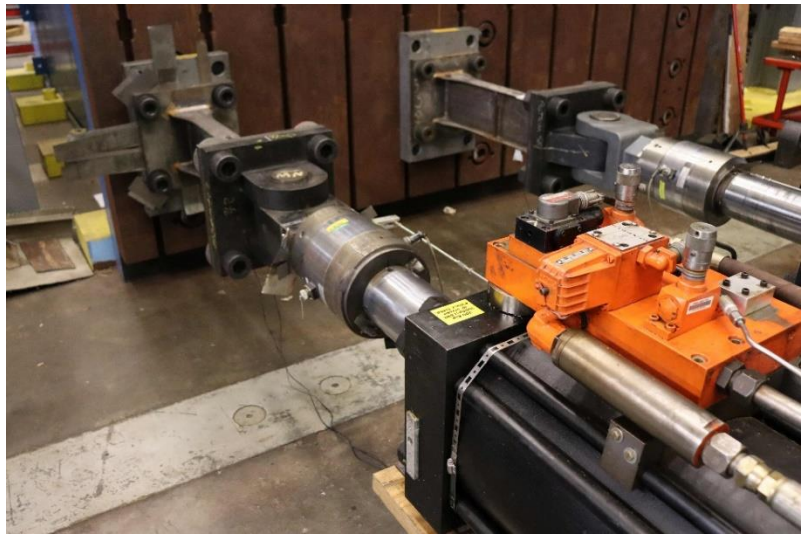
(**above**) Tabulated results of analysis showing 77% of candidate LHA openings to be removed

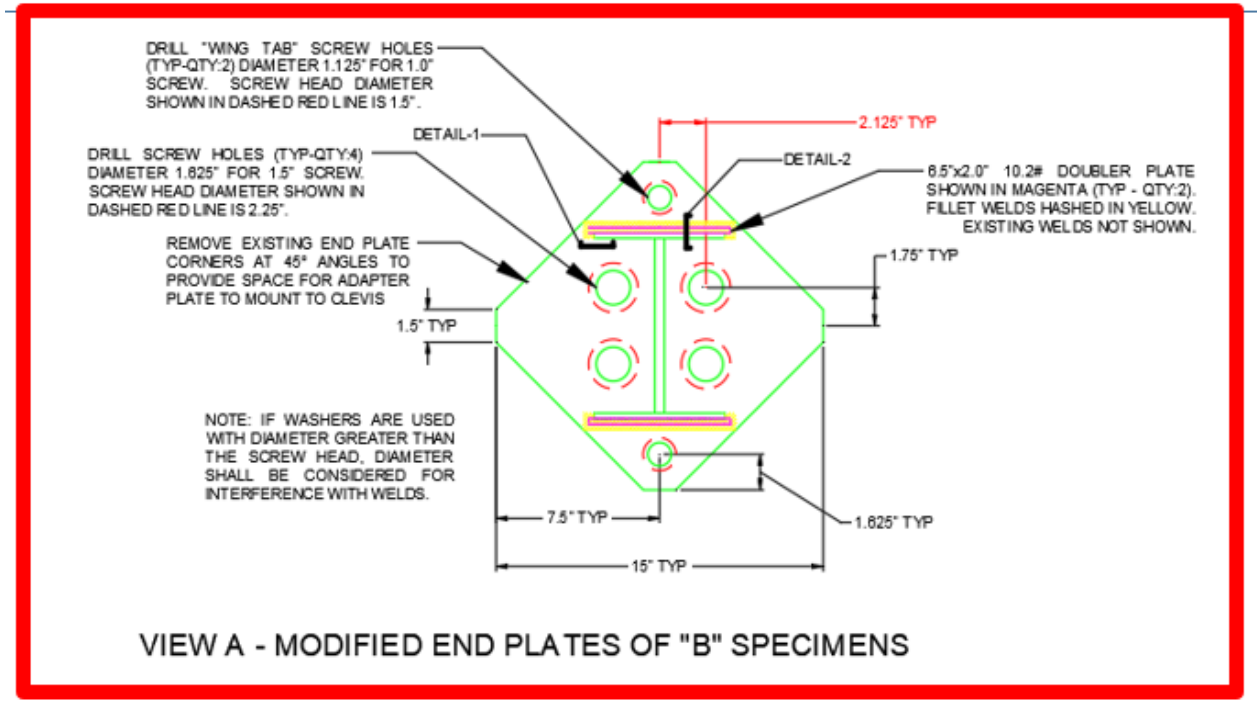
Phase I Technical Update/Discussion

Fatigue Test Fixture Design- Complete; Testing in Progress



(above) Initial design of the fatigue test fixture. During tuning at NSWCCD, excessive deflection of the fixture occurred at high loads.
(below) Fabricated test fixture at NSWCCD

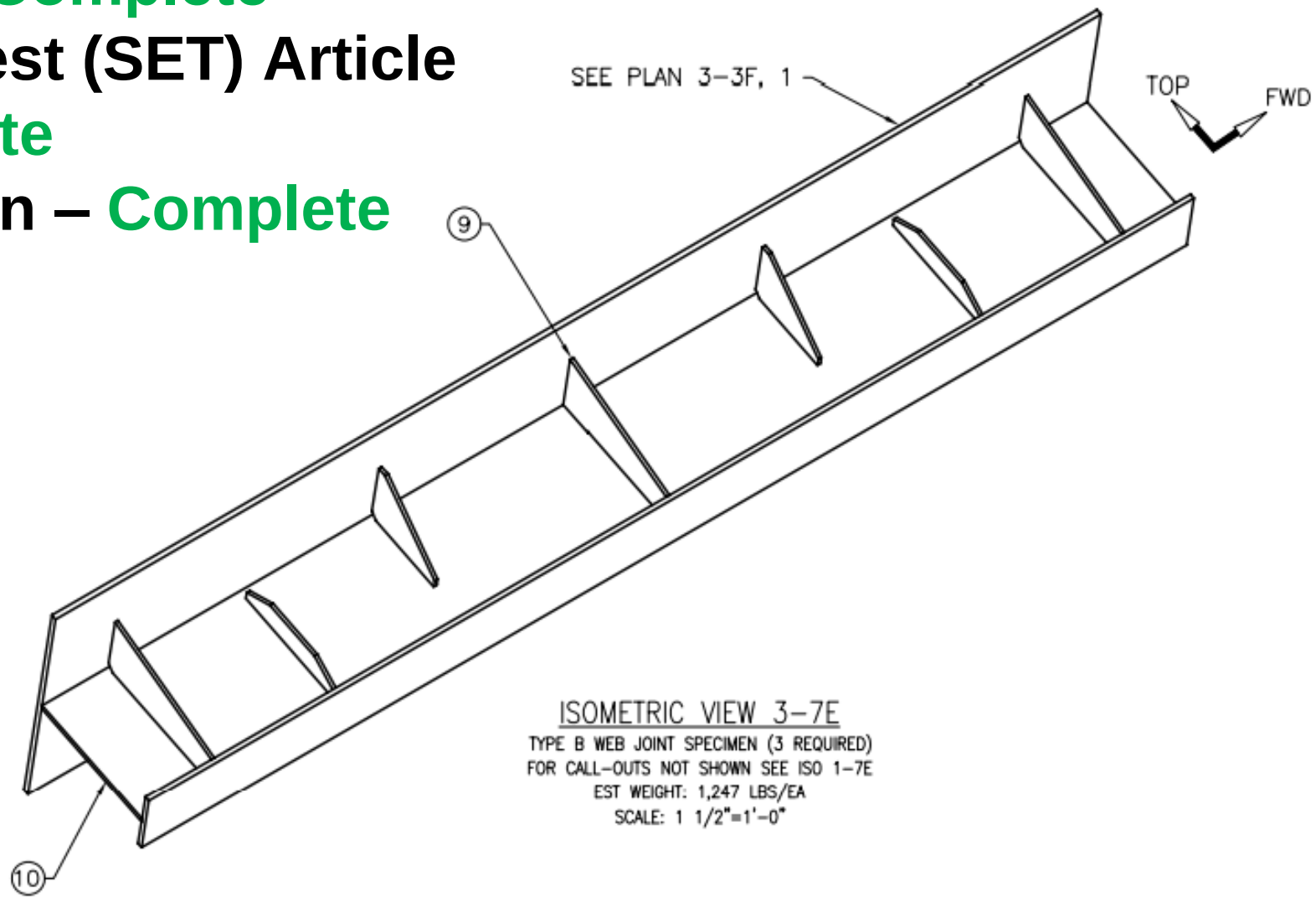




(above) Reformatted hole format with tighter bolt pattern inside of flanges distributing loading closer to the axis of the assembly.

Phase II Technical Update/Discussion

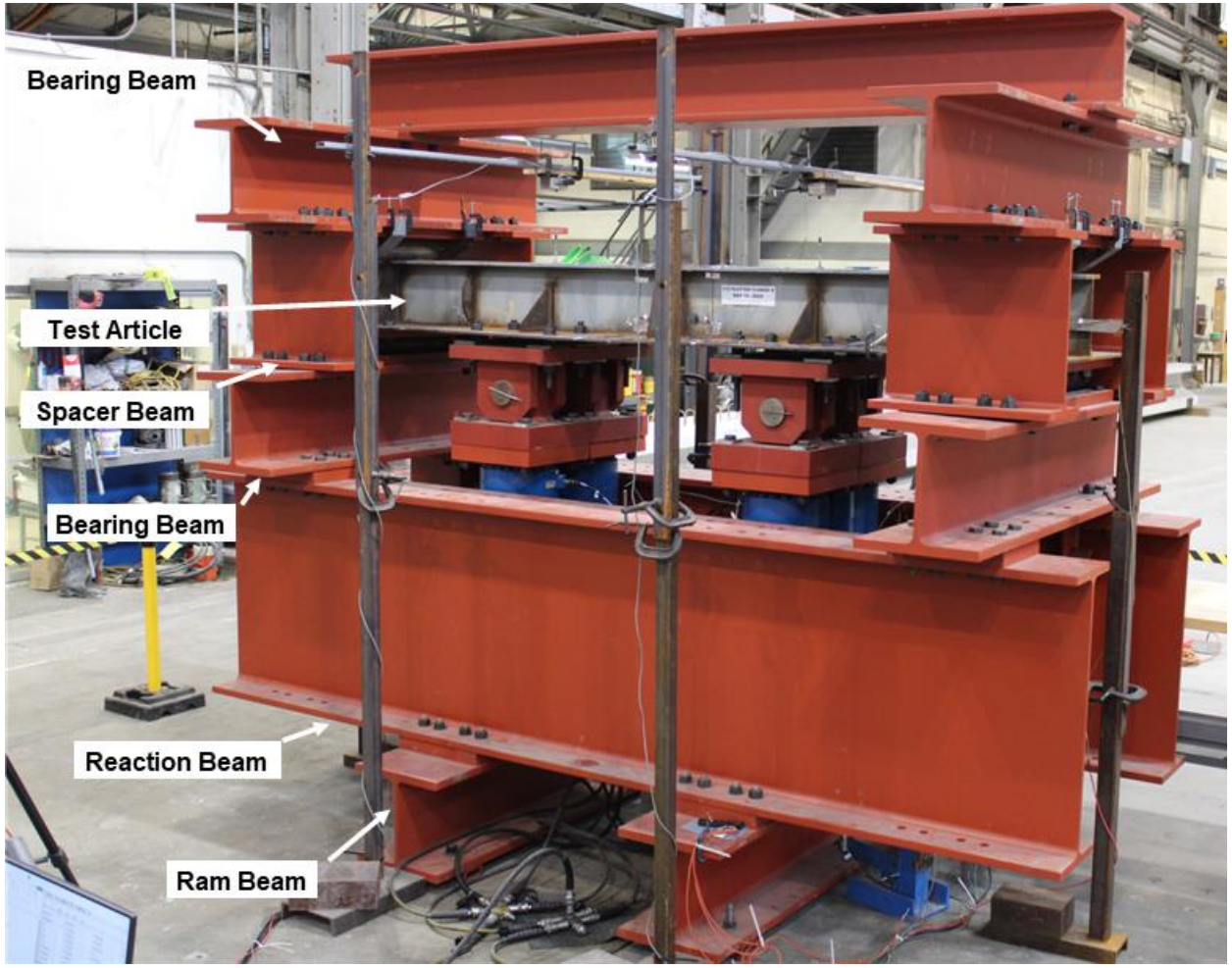
- **Test Article Design - Complete**
- **Structural Element Test (SET) Article Fabrication – Complete**
- **Test Stand Fabrication – Complete**
- **Testing – Complete**



SET Specimens – 10.5’ x 2.5’ x 1.5’

Phase II Technical Update/Discussion

- **Conduct Testing**
  - **Test Schedule – February 13, 2024 – May 22, 2024 - COMPLETE**



(**above)** Physical representation of the SET test stand at U of Texas

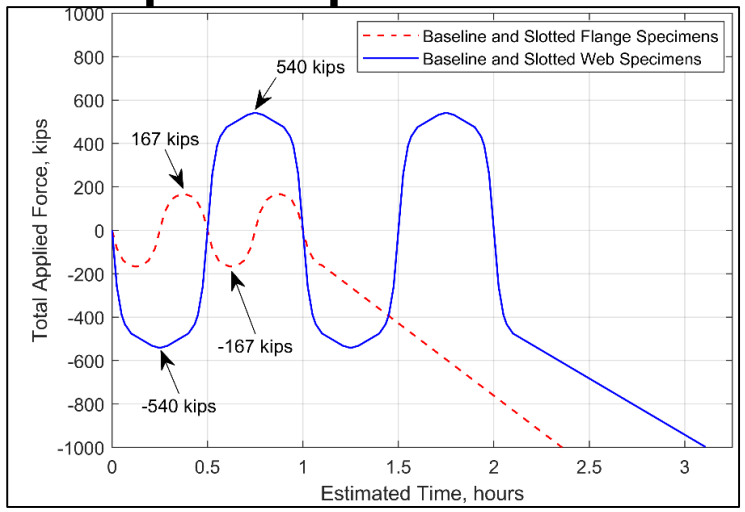
(**below**) Structural Element Test Matrix

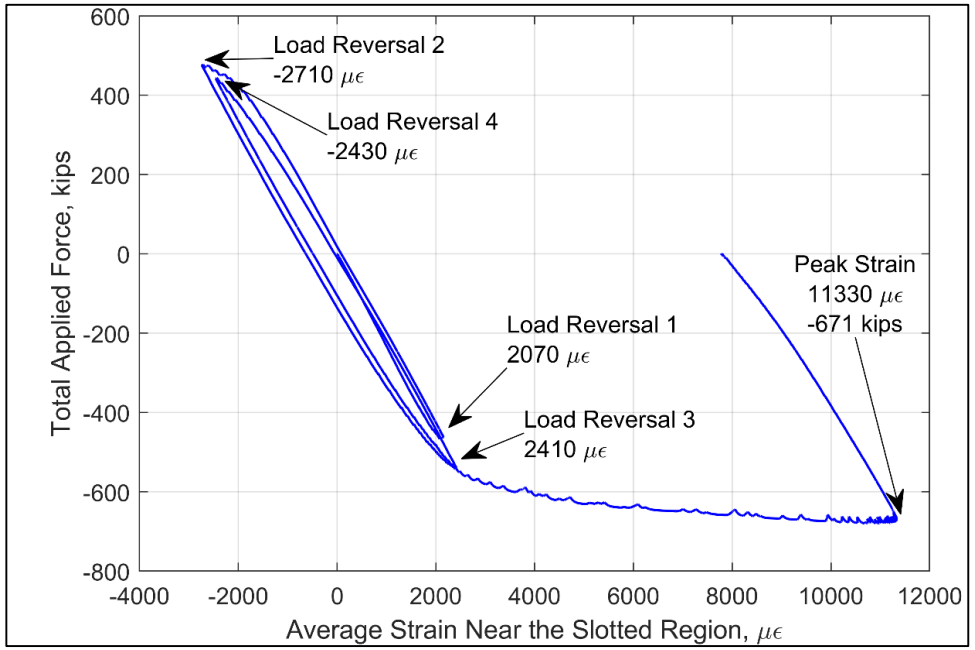
Specimen Number: Overall specimen number Specimen Type	Specimen Number
Baseline Web	1
Baseline Web	2
Slotted Web A	3
Slotted Web A	4
Slotted Web B	5
Slotted Web B	6
Baseline Flange	7
Baseline Flange	8
Slotted Flange A	9
Slotted Flange A	10
Slotted Flange B	11
Slotted Flange B	12

Phase II Technical Update/Discussion

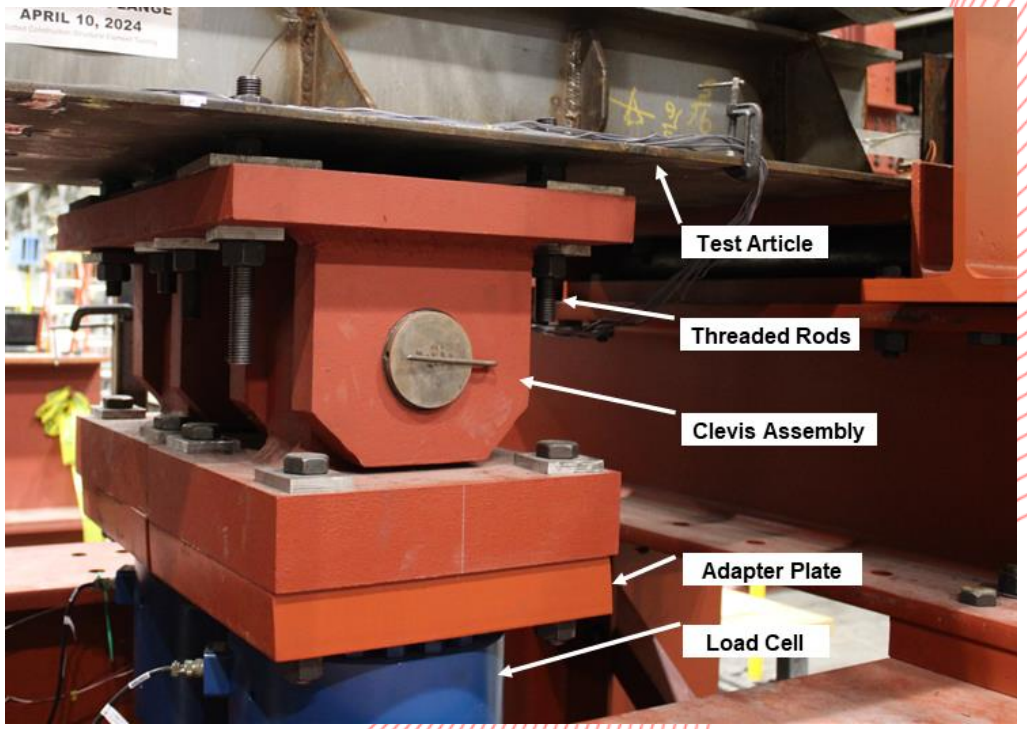
- **Loading Protocol & Sample Output**

(**right**) Loading protocol for all test samples



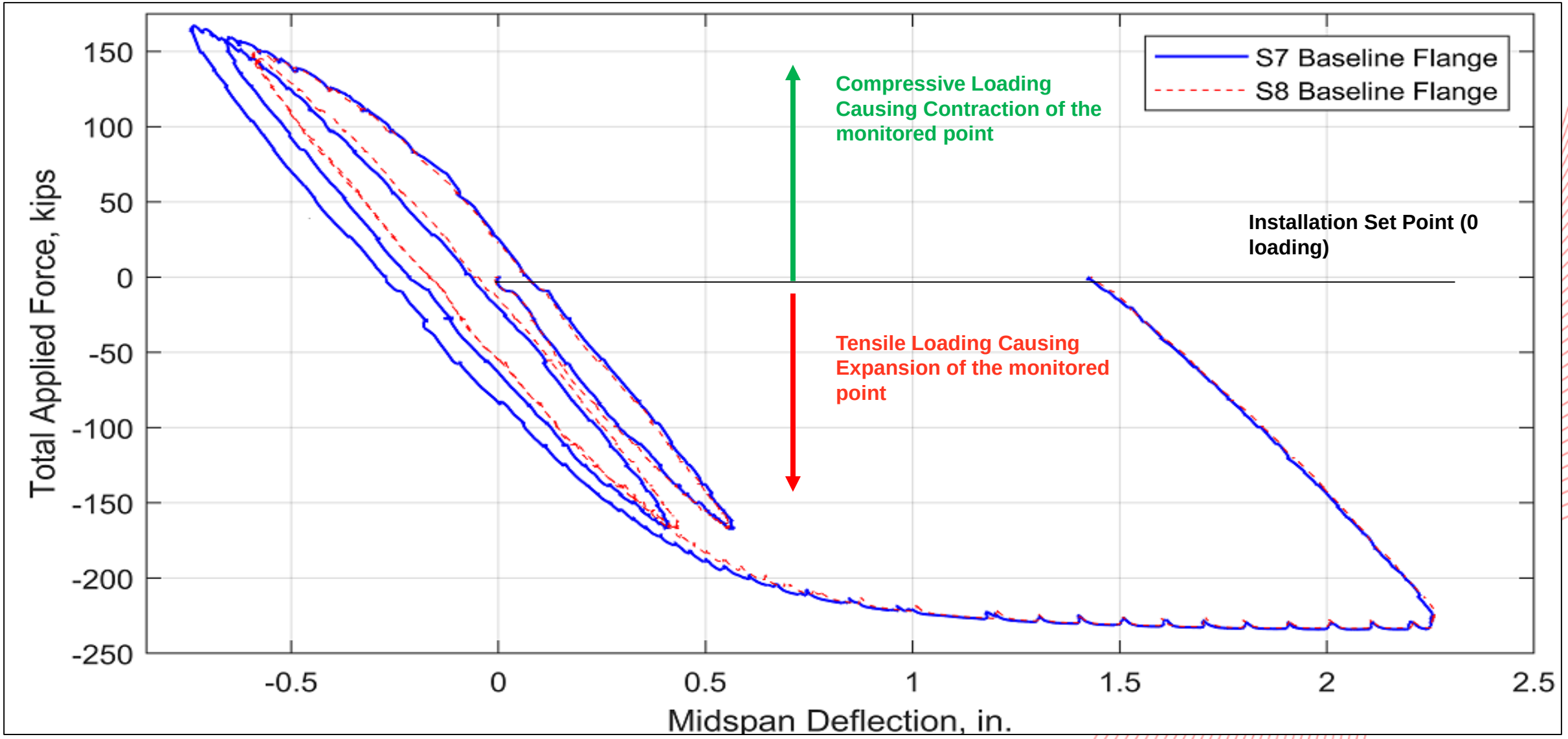


(**left**) Sample output from SET Sample 1 strain output



(**above**) Physical representation of the SET test stand at U of Texas

Phase II Technical Update/Discussion

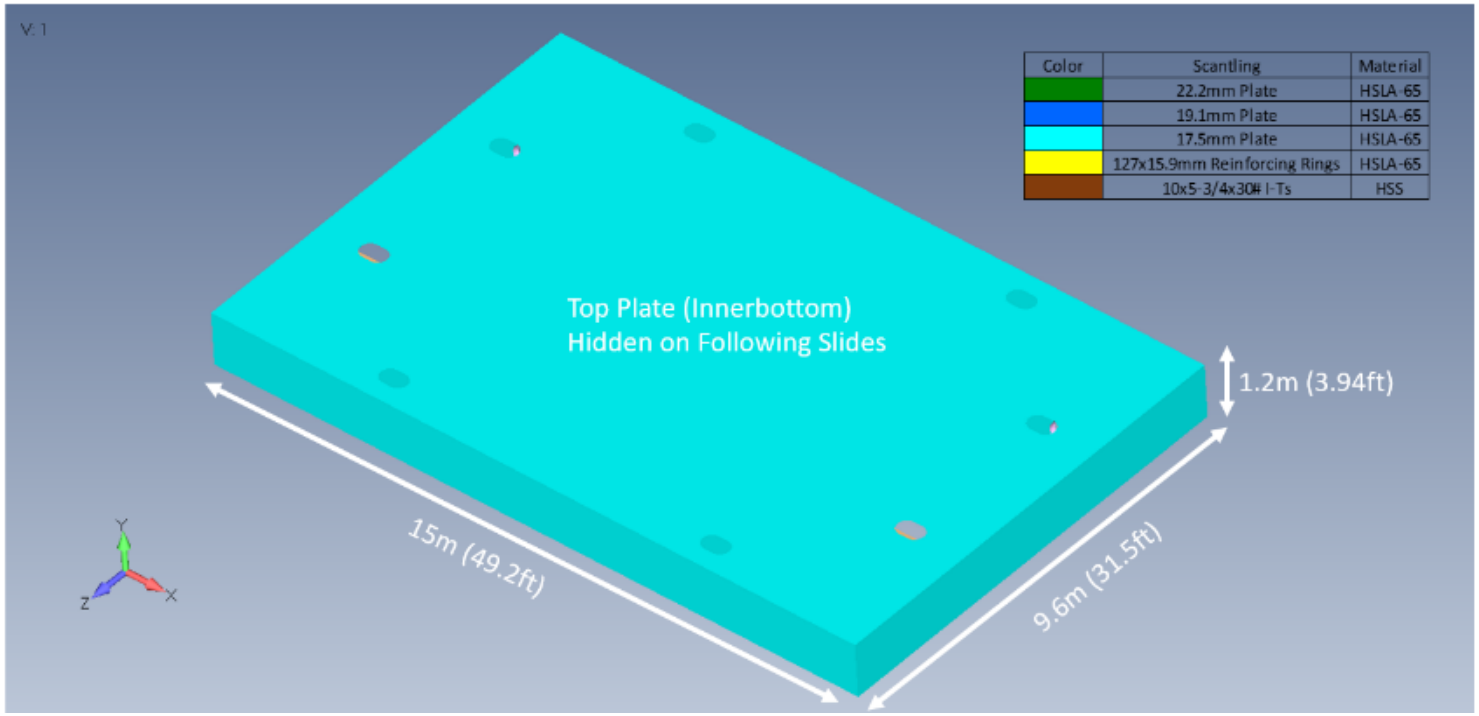


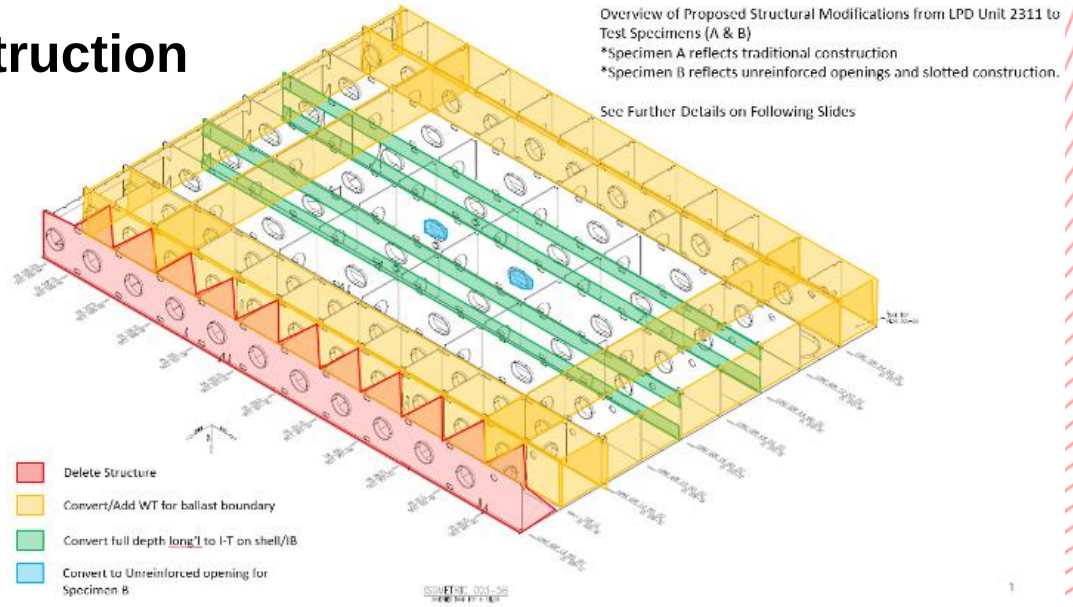
SET Test DAq Output (Sample Specimen "X")

Phase II Technical Update/Discussion

- **UNDEX / Shock Test Article Design**
  - **This project will design and build a slotted construction style UNDEX / Shock Test Article to be used for qualification post-project**

Overall Dimensions of Test Specimens A & B – Total Steel Weight as Modelled is 74LT (83 Short Tons)
Note: 8 openings for typical bolted manhole covers shown below (8 Perimeter Ballast Tanks)





(**above**) CAD rendering of the UNDEX specimen with indications of design iteration
(**left**) Overall Test article dimensions with weight attributed

SCALE INCREASE
Original UNDEX Scale: 8’ x 12’ x 1.5’
Revised UNDEX Scale: 32’ x 50’ x 4’

Transition/Implementation

- Transition Event:
  - ManTech Deliverable:
    - **This is a multi transition event project (Task 9 is scheduled to conclude by February 2025):**
      - Transition for Unreinforced Openings improvement has already started with the successful analysis in Task 9.
      - Transition of Slotted Construction methodologies will also happen after successful tests and analysis performed in task 9.
- Required Non-ManTech Transition Investments:
  - **Formal qualification of these new production designs will commence following project conclusion through UNDEX / Shock Testing**
- Implementation / Implementation Funding:
  - Target: **Under Review**
  - Time Period: **Under Review**
  - Implementation Funding Estimate, Source(s), and Status:

Next Steps

- *Project PoP extended through 11/03/2026*
- **Near Term Activities**
  - Finish Fatigue testing – **ECD 1/14/2025**
  - Procure Hardware for UNDEX Specimen build – 15% complete
  - Hold Design Review of UNDEX design – **ECD 2/20/2025**
  - Complete Analysis of Un-Reinforced opening candidates for DDG – **ECD 1/31/2025**
- **Long Term Activities**
  - Publish fatigue results – ensure design is capable (currently tracking as structurally capable)
  - Fabricate UNDEX Sample for shipment to testing facility – **ECD 7/17/2026**

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Questions?

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