Newport News Shipbuilding
A Division of Huntington Ingalls Industries

National Shipbuilding Research Program

Implement Residual Mode – DDAM Panel Project

NSRP Joint Panel Meeting

San Diego, California

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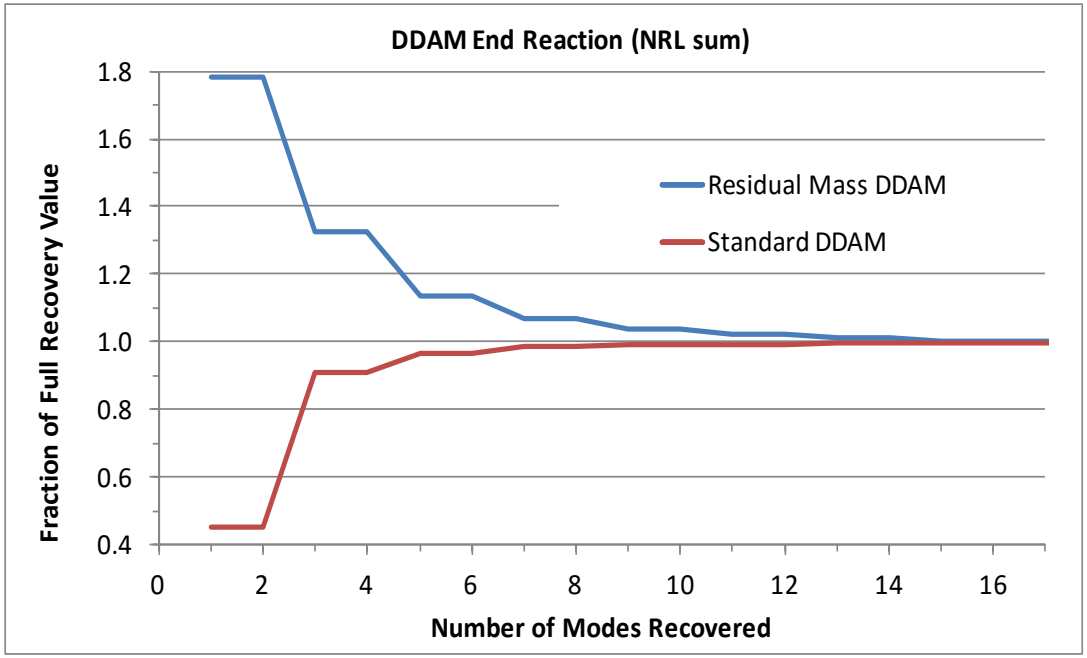
Background

- The Dynamic Design Analysis Method (DDAM)
  - Widely used naval shock analysis method via Belsheim & O'Hara, 1960
  - Variation of general Response Spectrum Analysis method
  - Significant improvement over previous static-G methods
- The DDAM
  - Reduces structure to set of orthogonal modes and
  - Distributes total structure response across these modes
  - Under a frequency/mass dependent response spectrum to
  - Define a series of static load cases whose results combine by a statistical summation method (NRL sum) to
  - Provide an estimate of peak response to a dynamic input (ship shock event)

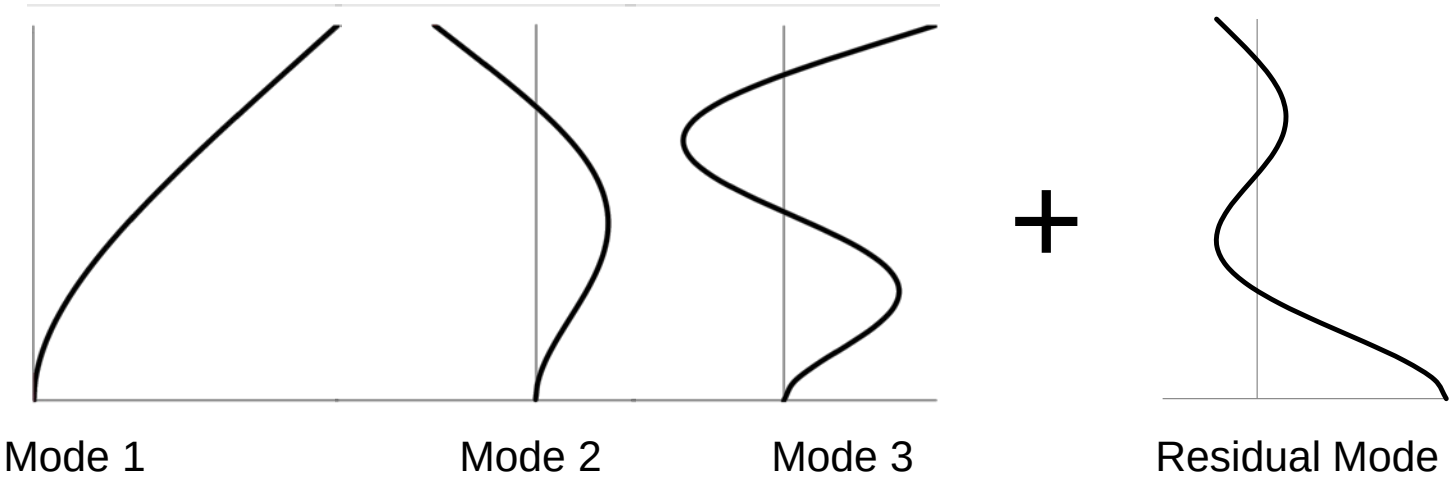
DDAM Inefficiency

- Response spectrum analysis (DDAM included) is unconservative to degree it does not include all significant model mass
- But can be difficult to include all modes in models common to naval ship analysis
- The author proposed RM-DDAM at the 84th Shock & Vibration Symposium
- Showed unconditionally conservative results and positive benefits in simple beam problems:



RM-DDAM Process

- Process calculates a synthetic N+1 “residual mode” for all remaining model mass not included in the recovered modes set



- Residual mode added to the retained modes set, assigned a design acceleration. DDAM process otherwise unchanged.
  - Always uses 100% of effective model mass
  - Excellent at capturing mass close to support points

NSRP Panel Project

- RM-DDAM
  - Resolves the disconnect in DDAM mass recovery requirements
  - Equipment design and model quality metrics
  - Improved analysis results quality
  - Reduced analysis average cost
- RM-DDAM cannot be implemented generally until demonstrated to reliably achieve appropriate results
- NSRP project to conduct this validation and acceptance effort
  - February 2015 to January 2016 (extended)

NSRP Task Milestones

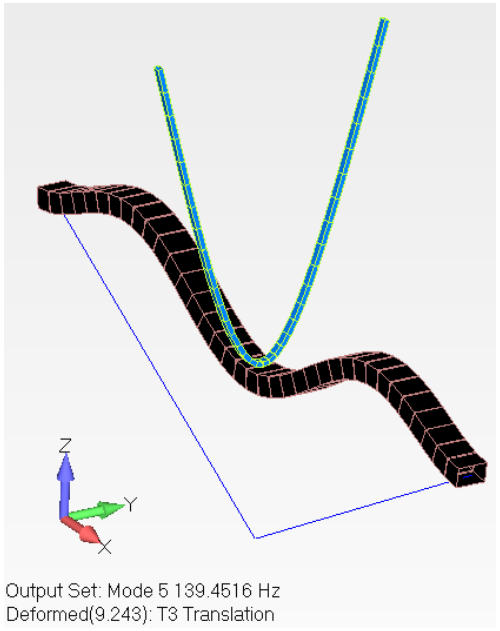
- Define NAVSEA requirements for RM-DDAM acceptance
  - ✓Identify demonstration analyses and validation exercises necessary to acceptance
  - ✓Issue validation and acceptance plan of action
- Conduct acceptable requirements efforts
  - ✓Write code/scripts to implement RM-DDAM as adjunct to commercial DDAM solver (harder than expected)
  - ❖Conduct analyses and assessments
  - ❖Develop implementation procedure
- NAVSEA approval request
  - ❖Report verification analyses findings
  - – Adjudicate recommendations
- NAVSEA endorsement
- Promote industry awareness

Challenge Problems

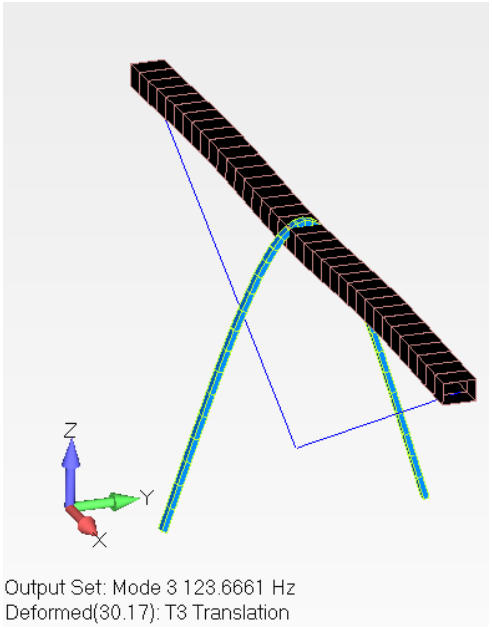
- 4 key questions to be answered
  - Does RM-DDAM give acceptable results in all situations?
  - If not, what rules are needed?
  - Can it give overly conservative results and how should that be controlled?
  - What new modeling assessment metrics are offered and provide what benefits?
- Use demonstration problems
  - Extreme-case models to try to “break” the method
  - Industry-typical models testing for positive effects
  - Favor Distribution A problems

Sample Demonstration Problems

- Simple crossed-beams model with a highly resonant mode pair (95-5% mass split)
  - a longstanding problem class in DDAM
  - Special process (labor intensive) needed to avoid excessive conservatism
  - Existing nodal condensation methods (for model size reduction) may have unconservative results
- Findings
  - Predictions always good in main beam
  - Worst case choices with RM-DDAM also unconservative for minor beam stress
  - So, no magic bullet here
  - Frequency rule avoids the underprediction
  - Adds useful *alerting* to all resonances



Output Set: Mode 5 139.4516 Hz
Deformed(9.243): T3 Translation



Output Set: Mode 3 123.6661 Hz
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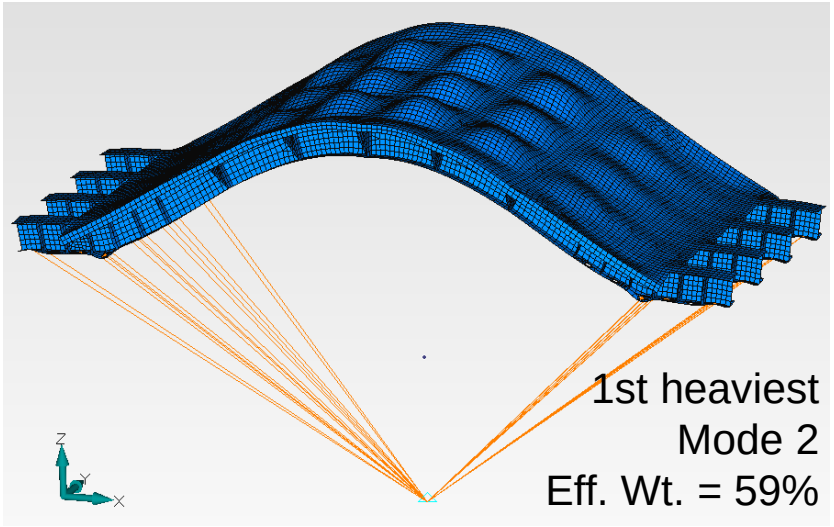
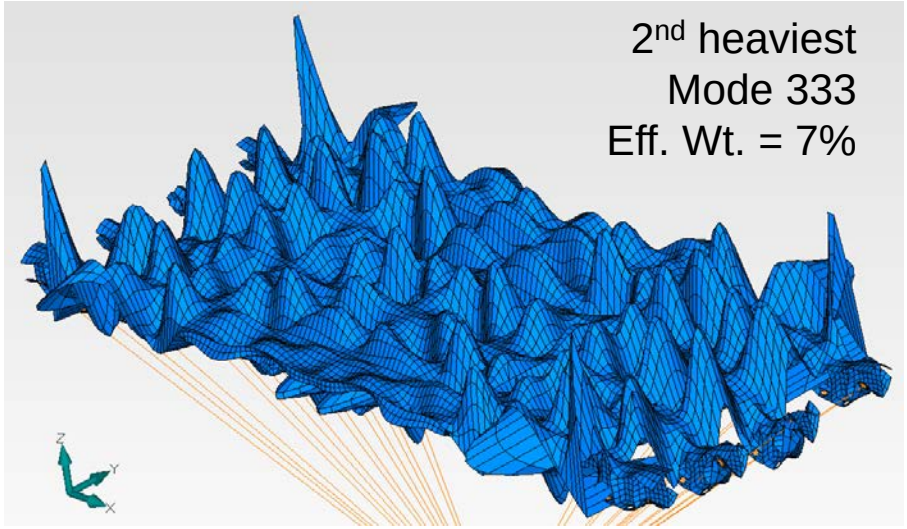
Sample Demonstration Problems

MIL-S-901 Deck Simulator - diffuse structure example

- Highly discretized and diffuse mass models now common
- Requires very large number of modes to prove no "significant" modes remain
  - May not be achievable due to round-off issues
- RM-DDAM highly effective in bounding mode recovery





Only 10 modes of first 726 exceed 1% of Z-axis effective weight

Summary

- Dynamic Design Analysis Method
  - The standard approach for naval shock design analyses
  - Often difficult to meet its best practice requirements
- NSRP panel project supporting validation and acceptance of Residual Mode DDAM as process improvement
- Findings to date: RM-DDAM is practical fix for problem models
  - Use rules required
  - Included metrics also add useful model/design insights
- NAVSEA feedback pending for final assessment requirements