OPTIMIZATION FOR THE APS-U MAGNET SUPPORT STRUCTURE*

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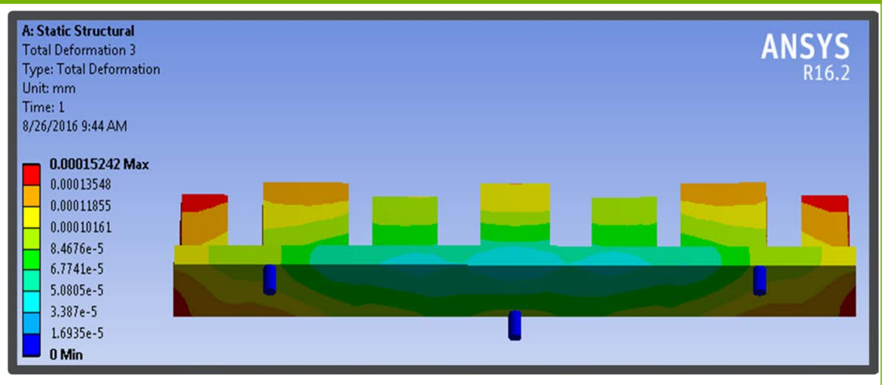
ABSTRACT

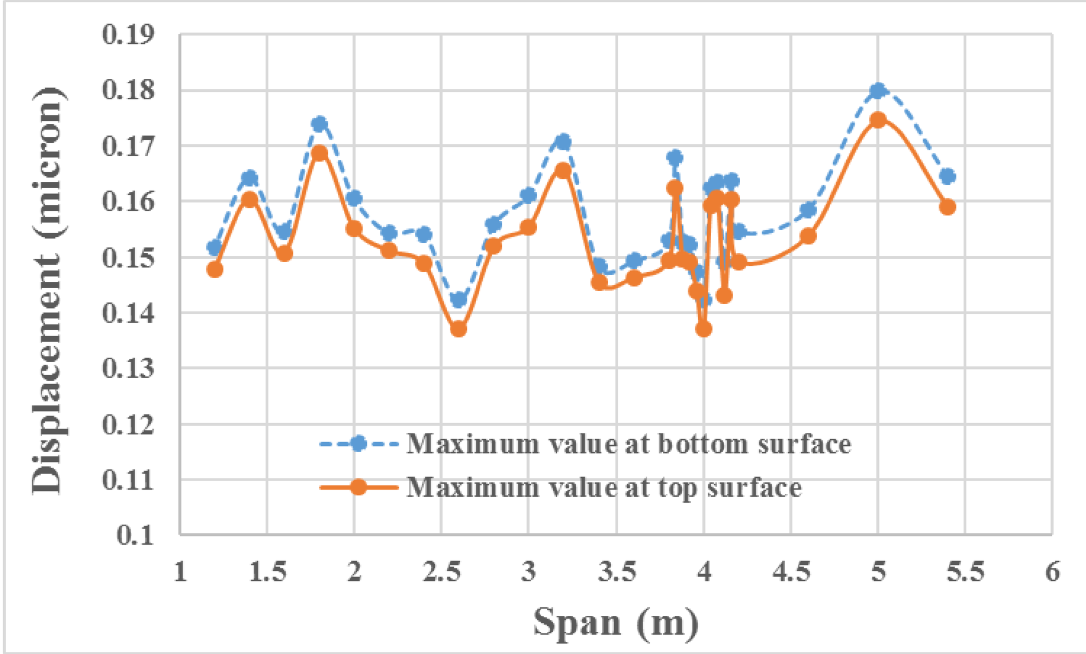
- The Advanced Photon Source Upgrade (APS-U) is to replace the existing storage ring with a multi-bend achromat (MBA) accelerator lattice.
- A three-point semi-kinematic vertical mount for the magnet modules is considered as the best approach for the APS-U removal and installation. The current planning calls for a 12-month shutdown and testing period, prior to resumption of operations. The assembly and installation alignment tolerance of 100 microns RMS for girder-to-girder alignment is specified [1].
- The APS-U specifies 9 nm RMS as magnet-to-magnet vibration tolerance and 30 microns RMS as magnet-to-magnet static tolerance within a girder [1]. These require structure optimization. Parametric studies are performed during optimization.
- This poster details the structure optimization, including three-point positioning, material selection, and topology optimization.

SPACING OPTIMIZATION OF VERTICAL SUPPORTS

- Initial geometry of FODO girder: 5.568 (L) x 1.1 (W) X 0.16 (T) m^3.
- Three supports: ϕ0.1 m and 0.2 m (L). one at central of one side, two symmetrically at the other side.



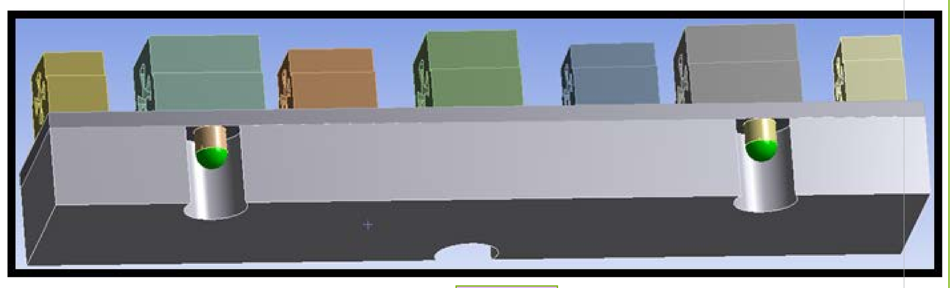
- The span along the short side ➔ Maximized and preferred from the point view of stability and the rolling mode of vibration.
- The span along long side ➔ Optimized. Maximum value of displacement vs. span ➔ 2.6 or 4 m span

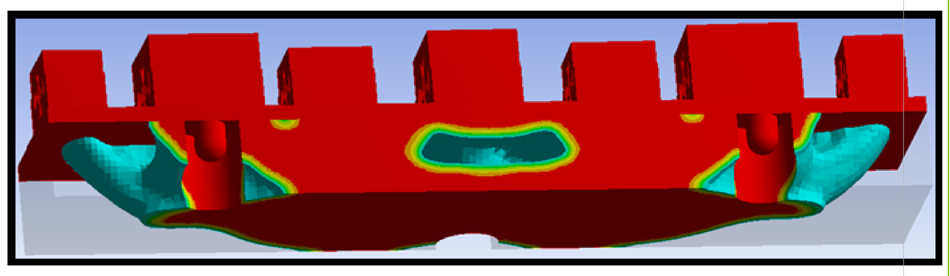


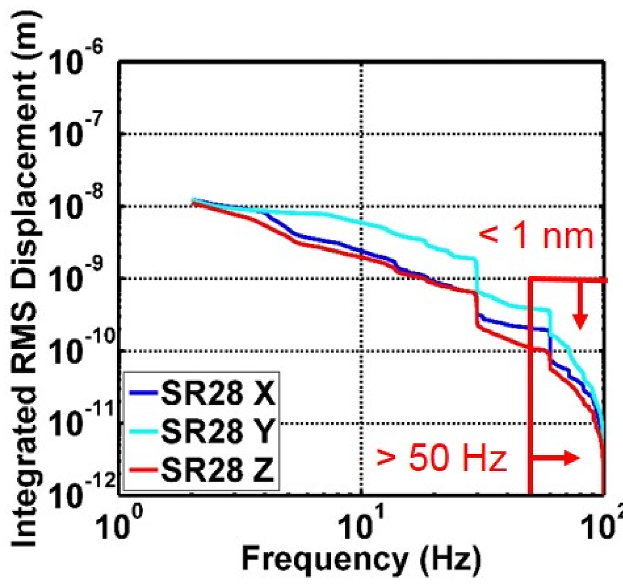
1ST TOPOLOGY OPTIMIZATION

Software: Genesis® Topology for Ansys Mechanical (GTAM) [4-6]

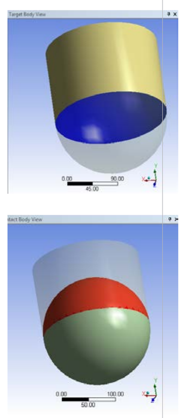
- Constraint – 1: Minimize strain energy
  ➔Minimize in-plane deflection at points along beam path
- Constraint – 2: Maximize frequency response



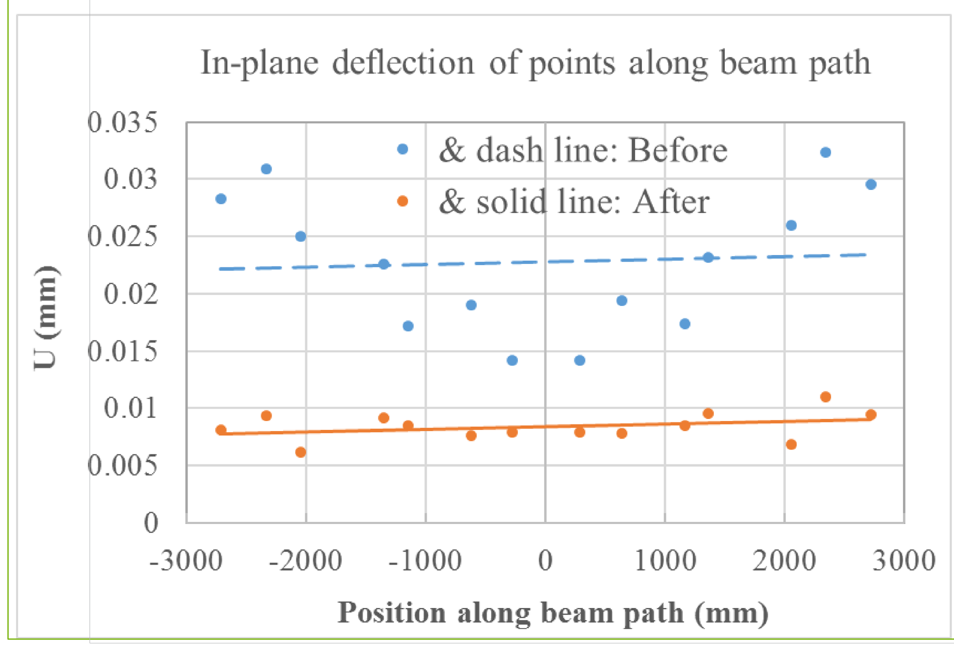


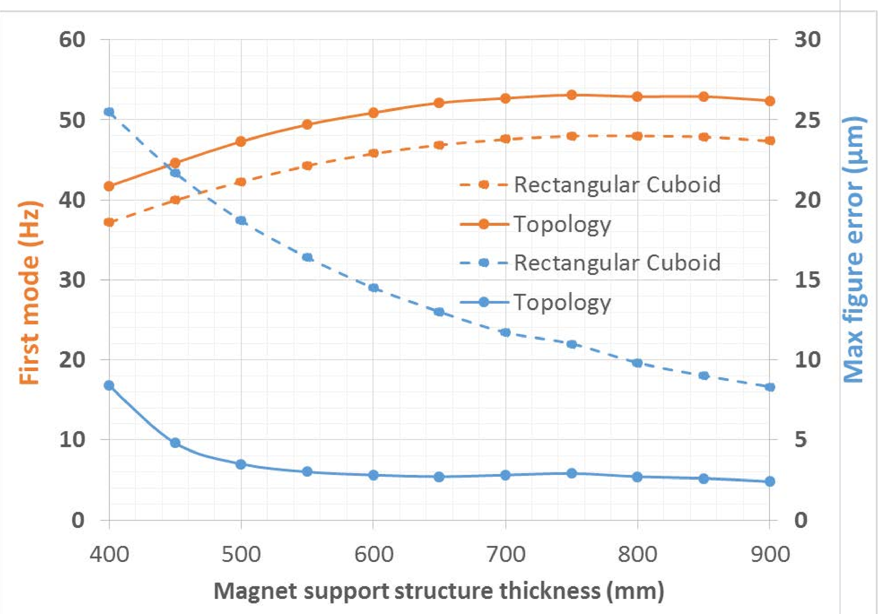


- Girder material: Cast iron
- Boundary conditions: Cups sit on fixed balls



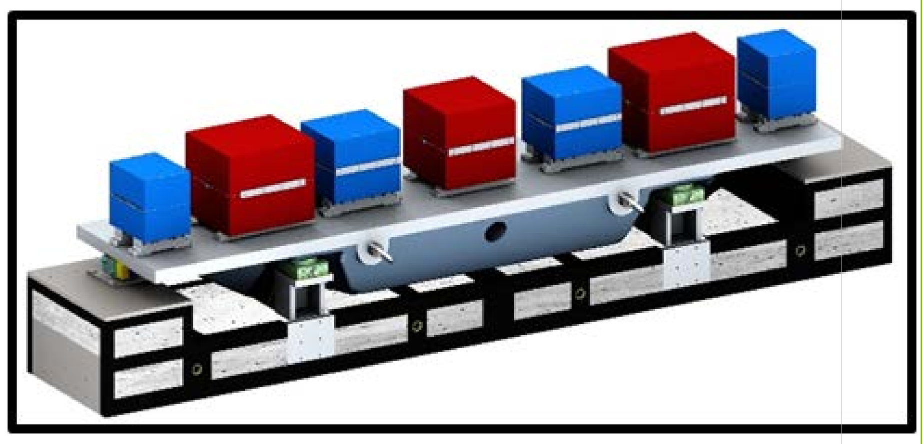
- Optimized parameters:
  - Top plate 50 mm thick
  - Total thickness 600 mm
  - Volume 3.3 ➔ 2.1 m^3





PROTOTYPE OF PRELIMINARY DESIGN

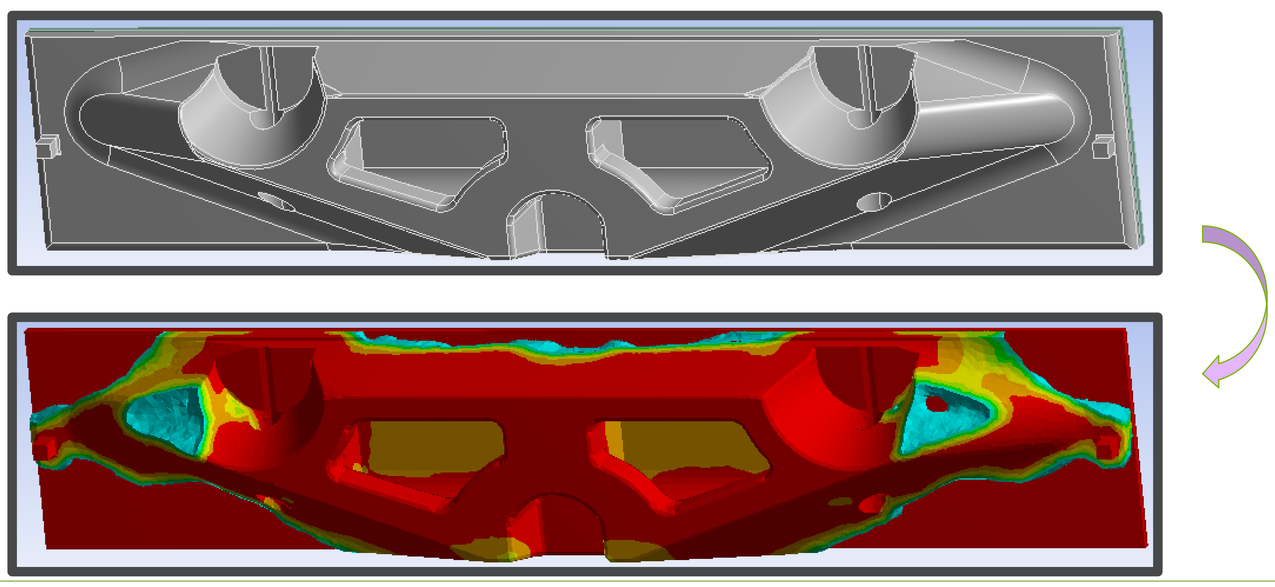
- Preliminary design is based on the optimized geometry in conceptual design phase.
  - 0.6 m thick & 3 m span
- Ductile cast iron, A536, GR 60/40/18
  - Design flexibility, low cost, vibration damping properties



- Airloc 414-KSKC wedge jacks as vertical supports [2]
- Maximum figure of error 14 microns along beam path [2]
- 1st mode frequency of assembly: 39 Hz [2]

2ND TOPOLOGY OPTIMIZATION

- The girder geometry is fed back into the model for further optimization. This simple step shows that the volume further decreases from 1.83 to 1.57 m^3



CONCLUSIONS

- Structure optimization plays an important role in the conceptual design phase. It leads to the right direction for preliminary design in terms of mass reduction and sound performance.
- Spacing optimization of vertical supports are performed. It leads to a guidance for next step.
- Topology optimization is performed. The material utilization is maximized.
- Parametric studies are performed for FODO girder design and optimization. The design specifications are met.

NEXT STEPS

- The preliminary prototype is under test.
- In case that the current prototype does not meet the specifications during test, the 2nd topology optimization results would be realized in design.
- Further iteration of optimization includes topology optimization to give optimized thickness and geometry, and material selection to further increase the girder mode frequency.

REFERENCES

[1] G. Decker, "Design Study of an MBA Lattice for the Advanced Photon Source," Synchrotron Radiation News, 27:6, 13-17, 2014, DOI: 10.1080/08940886.2014.970932.
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[6] http://www.vrand.com/GTAM.html

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