



National Transportation Safety Board

Grain Car Axle Stress Analysis

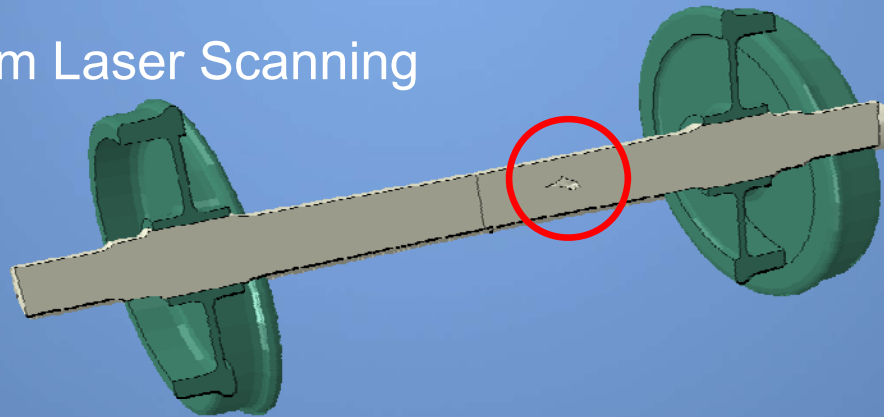
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Overview

- Stress analysis objective
 - Study locations of high stresses under simulated in-service conditions
- Key techniques
 - Laser scanning
 - Finite Element Modeling
 - 3-D printing for result visualization

Model Geometry

- Axle and wheels
 - Geometry based on AAR drawings with simplifications
- Void
 - Geometry from Laser Scanning



Modeling the Internal Void



**Laser scan both
halves of the axle**



**Point cloud
representing the void**

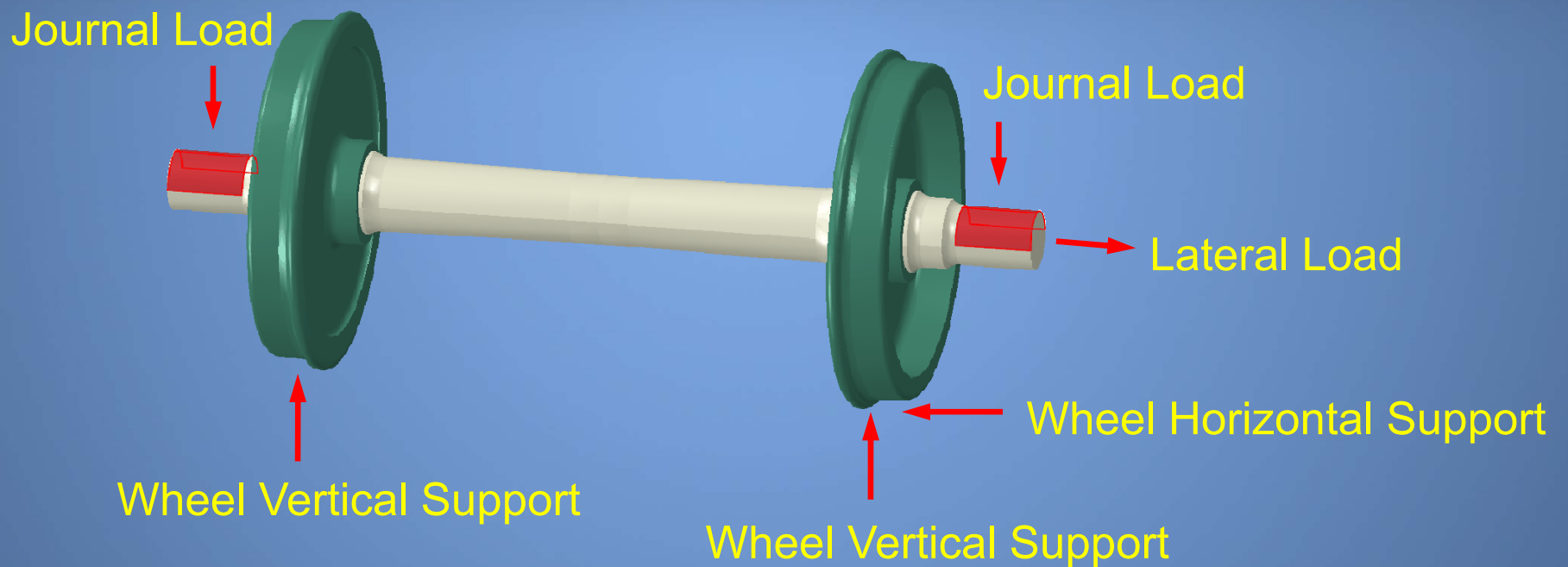


**3-D solid geometry
representing the void**



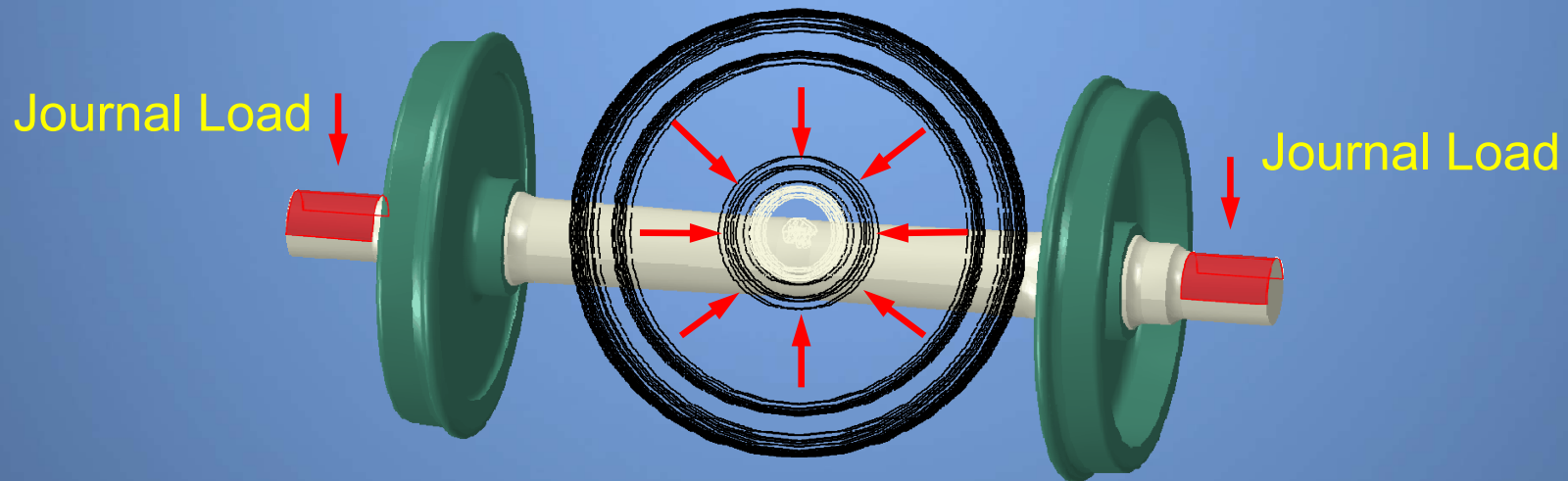
**Geometry of the axle
with internal void**

Simulated Conditions

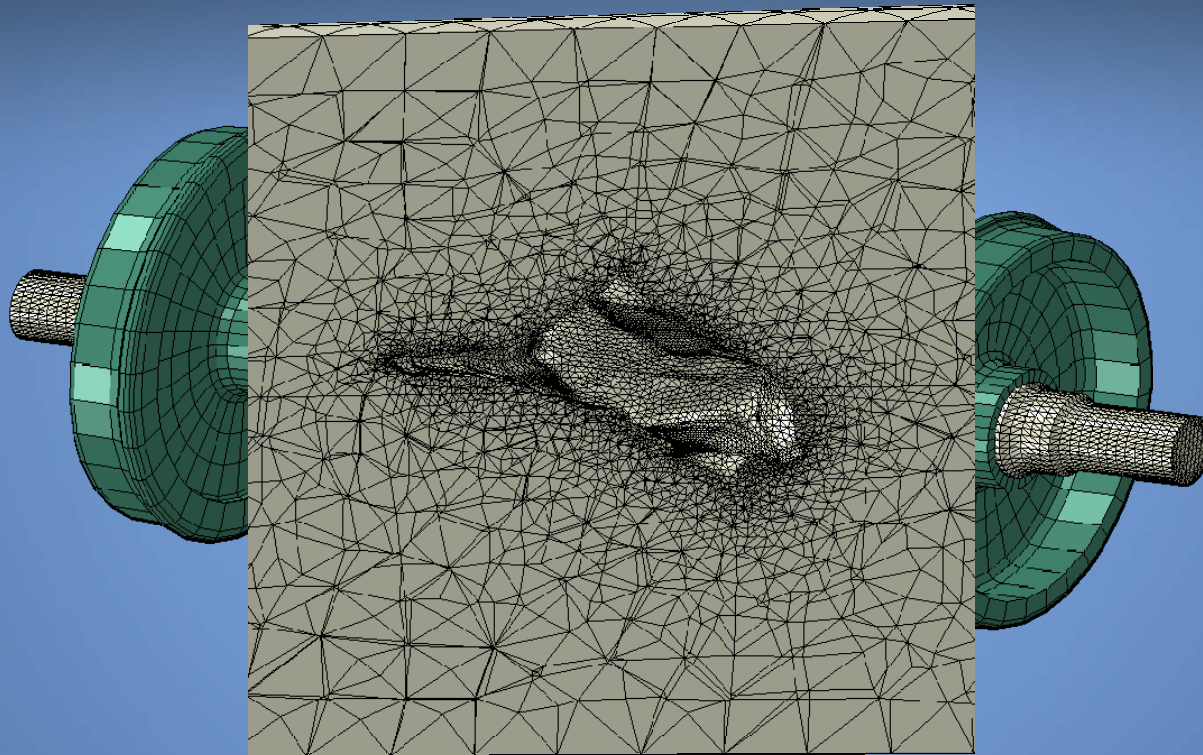


Simulated Loading on Rotating Axle

- Journal load on a rotating axle simulated as multiple static loading scenarios



Finite Element Model



Deformed Axle When Loaded

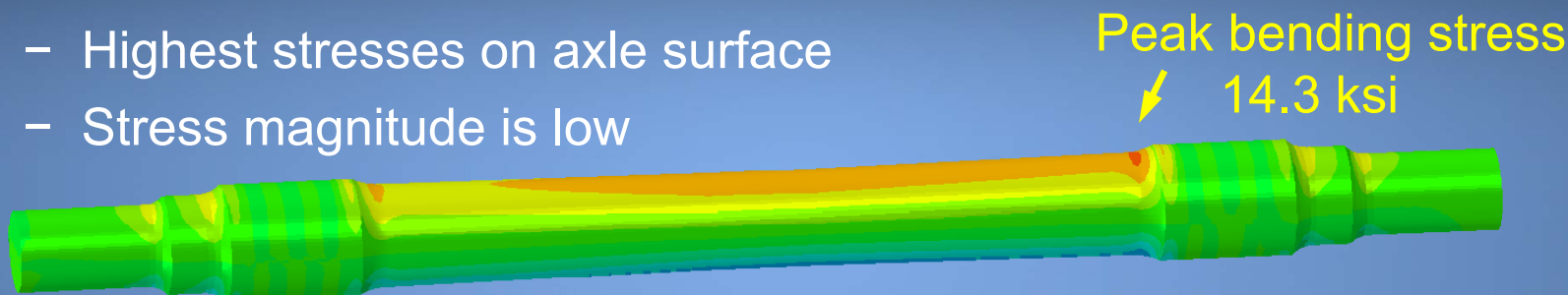


Deformation magnified 50x

Stress Analysis Results

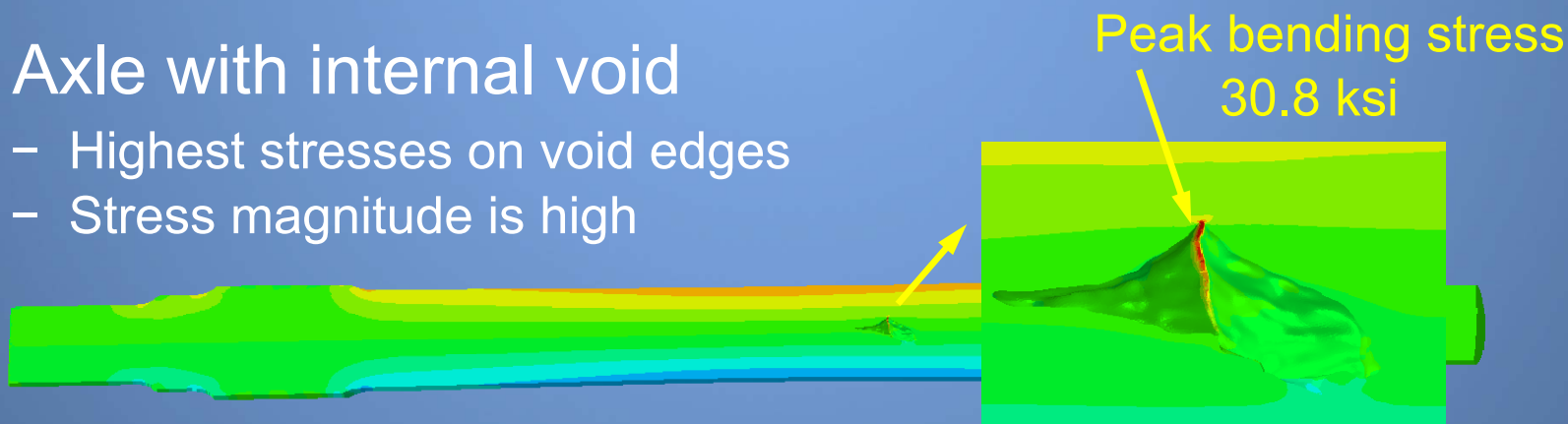
- Intact axle

- Highest stresses on axle surface
- Stress magnitude is low

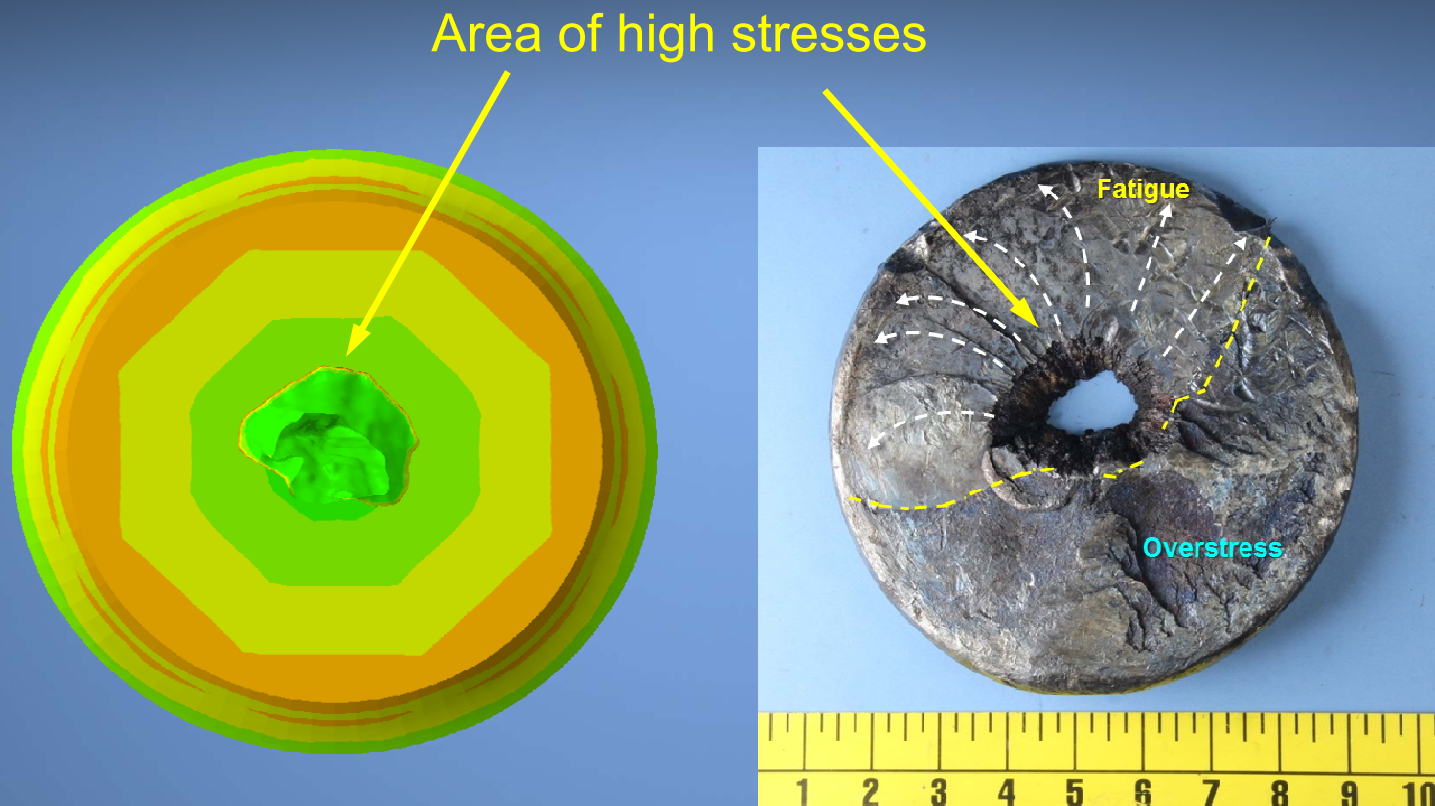


- Axle with internal void

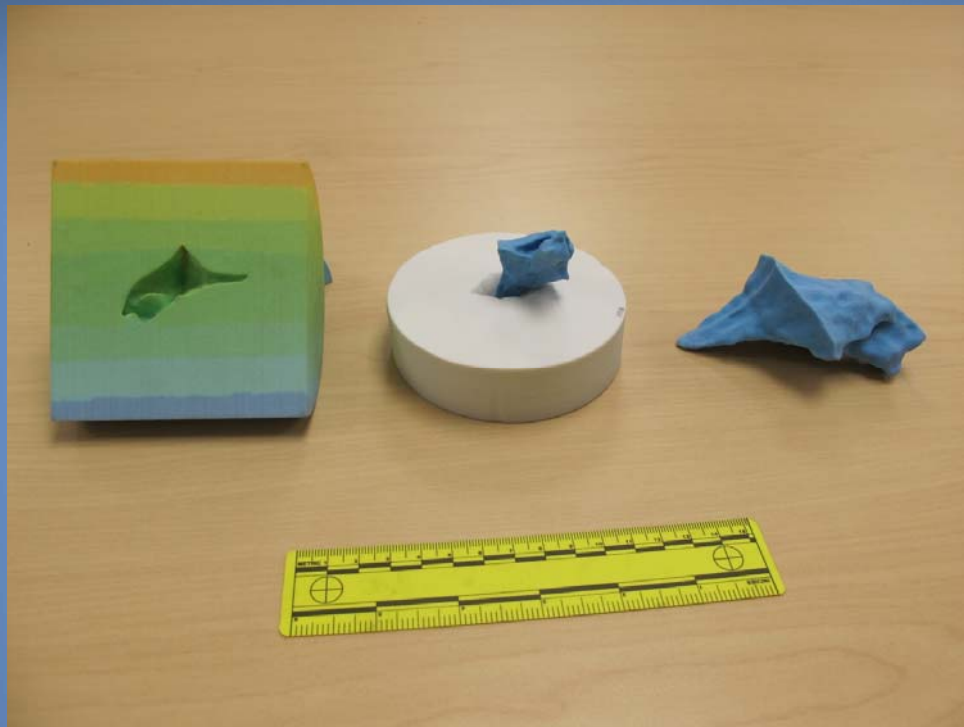
- Highest stresses on void edges
- Stress magnitude is high



Stress Analysis Results



3-D Printing for Visualization



Conclusion

- Internal void with sharp edges caused local stresses that were significantly higher than bending stresses on axle surface
- The axle was prone to fatigue cracking from inside



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