Numerical analysis on stress and displacement of tapered cantilever castellated steel beam with circular openings

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Outline

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- Research Scopes
- Samples
- Analysis Method
- Result and Discussion
- Conclusion

Introduction

- Cantilever Beam: one fixed support + one free
- Material for cantilever beam: steel
  → much advantages, such as: high strength, assured quality, speed of installation.
- Optimizing usage of steel in beams: making as castellated beam (reforming shape beam's section into a half with particular section & reconnecting both parts by welding it)
- Aim of Castellated beam: doubles moment intertia while maintaining the same volume
- More advance study: making tapered shape
- This research → Castellated + tapered for cantilever steel beam

Research Scopes

- Linear condition (condition just under yield strength) and homogen material
- Excluding the buckling analysis
- Welding and section radius were not modeled
- Load: Static distributed loading
- Waste for sample creation was not calculated yet
- Limited variations for research purposes

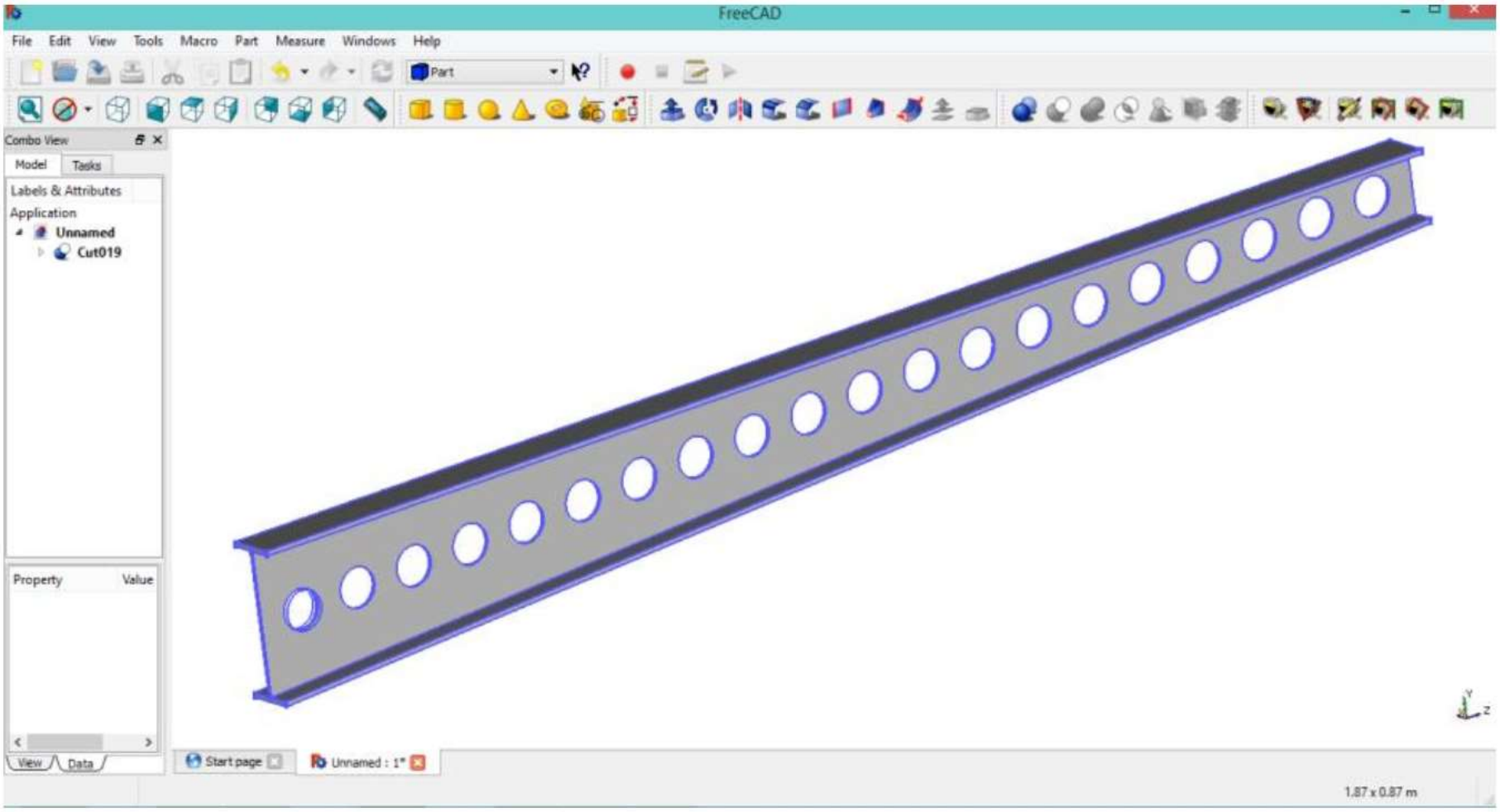
Samples

- 2 IWF Sections were checked for trial and error, then spaces openings were chosen based on the suitability for cutting and welding

IWF Section	Span Length (m)	Openings diameter (mm)	Openings space (mm)
150 x 75 x 5 x 7	2	60	40
200 x 100 x 5.5 x 8	2.5	70	45
	3	80	50
	3.5		

- f_y (yield strength) : 400 MPa
- E_s (Young's modulus) : 200,000 MPa
- 3 Dimensional solid model drawn by FreeCAD

Samples


FreeCAD
File Edit View Tools Macro Part Measure Windows Help
Part
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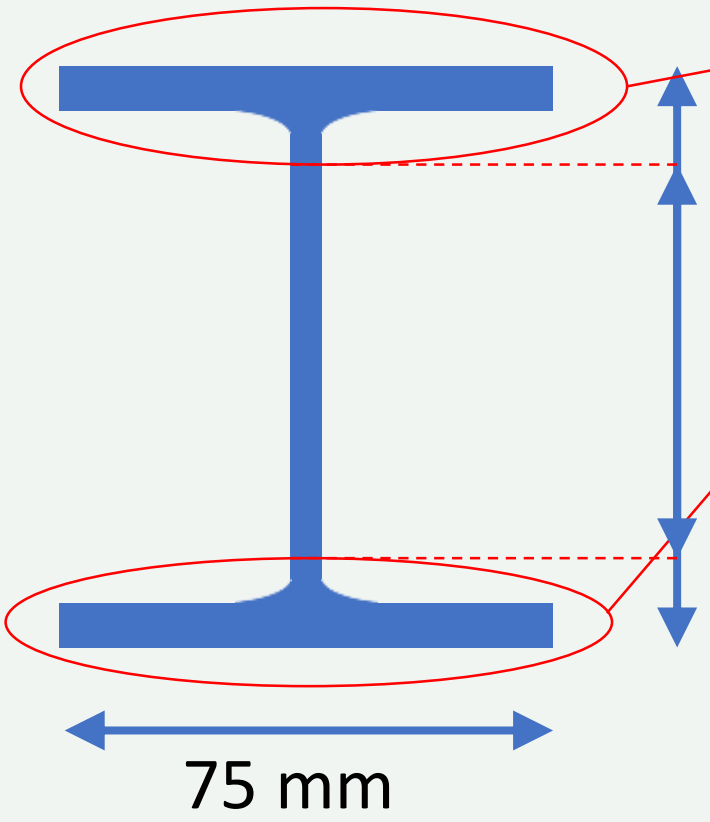
1.87 x 0.87 m

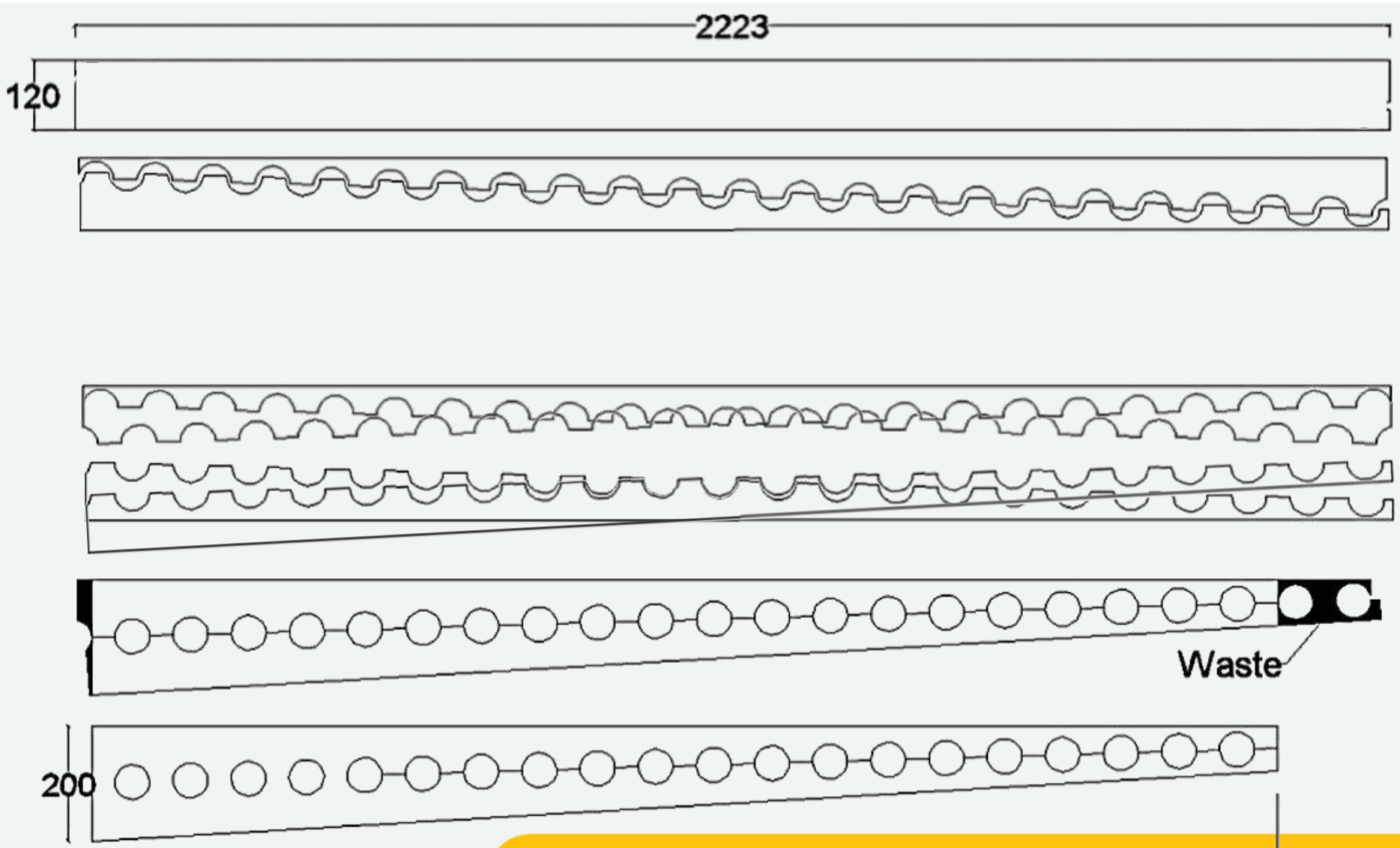
Samples creation



Parts were maintained to be original

150 mm (leftover height for modification)

Sample creation

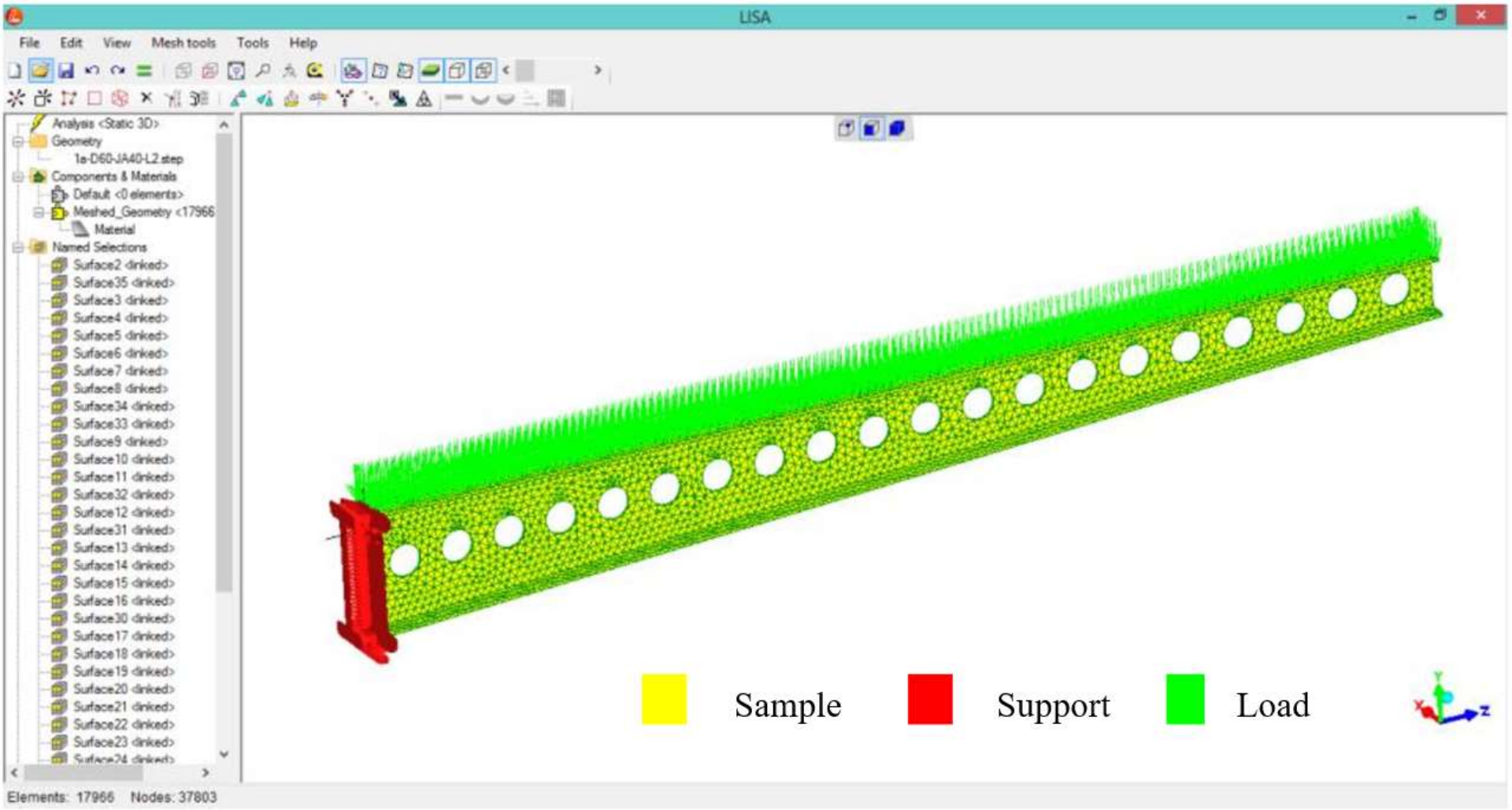


Analysis Method

- Convergence analysis was performed
- Linear Finite Element Analysis
- Performed using LisaFEA software
- Element modeled as 10-node tetrahedron solid element
- Samples were given the load until the stresses reach just under yield strength

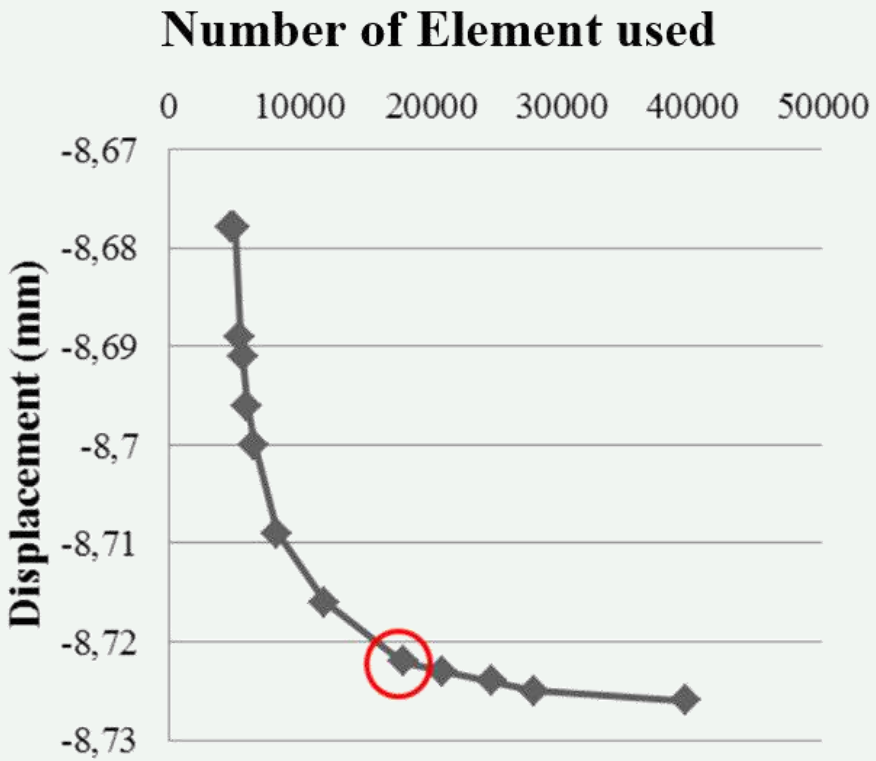
Span Length	Load for reaching yield stress (tonnes)	
	IWF 150x75x5x7	IWF 200x100x5.5x8
2.0 m	3.70	7.10
2.5 m	3.00	5.60
3.0 m	2.50	5.00
3.5 m	2.10	4.50

Analysis Method



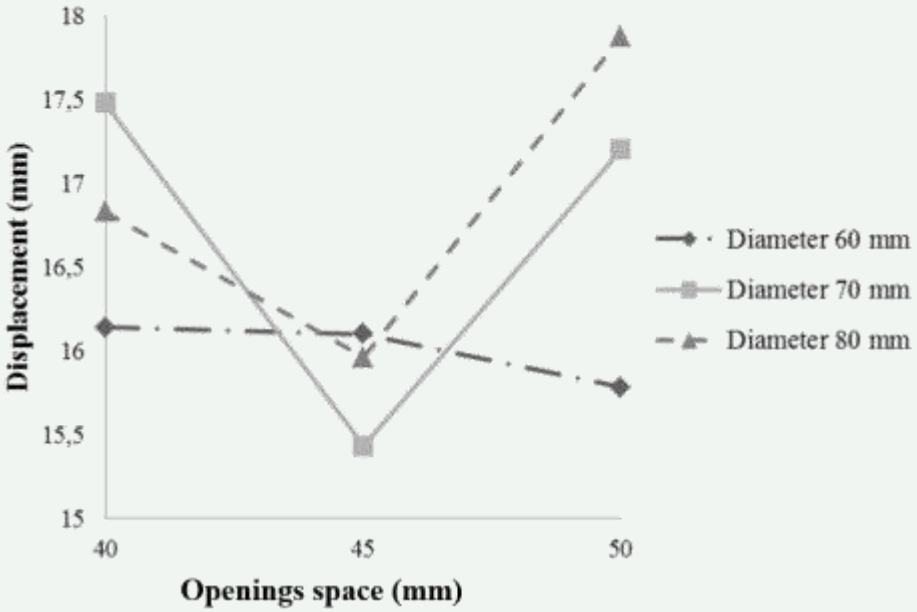
Result and Discussion

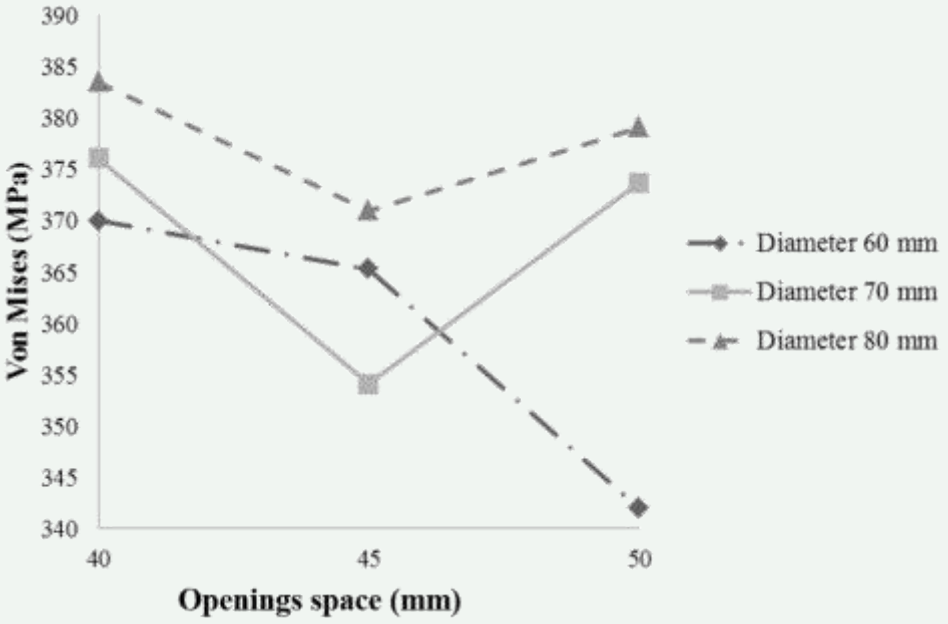
- Convergence analysis: understand how much mesh should be implemented → expected significance < 5%
- 17,966 elements were chosen based on this analysis

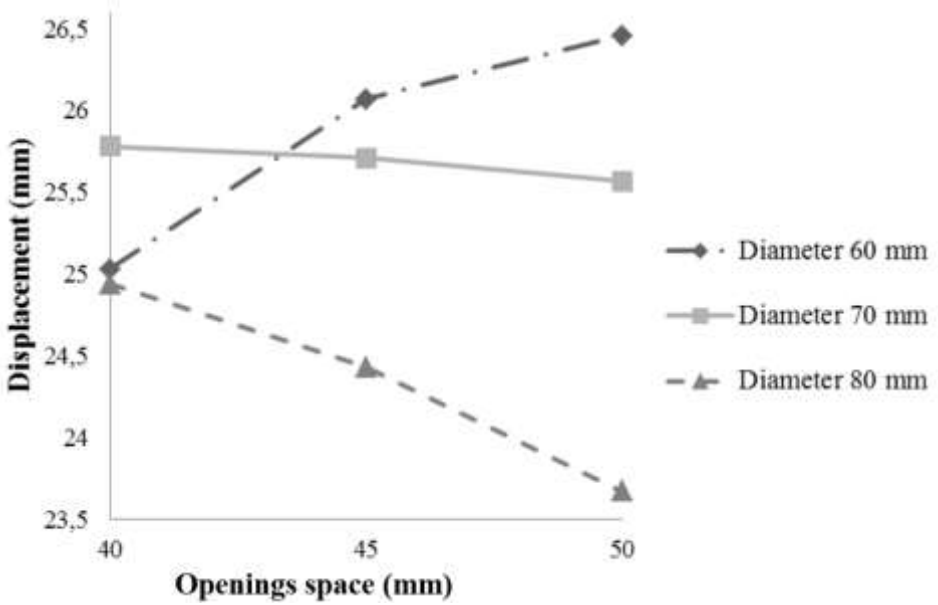


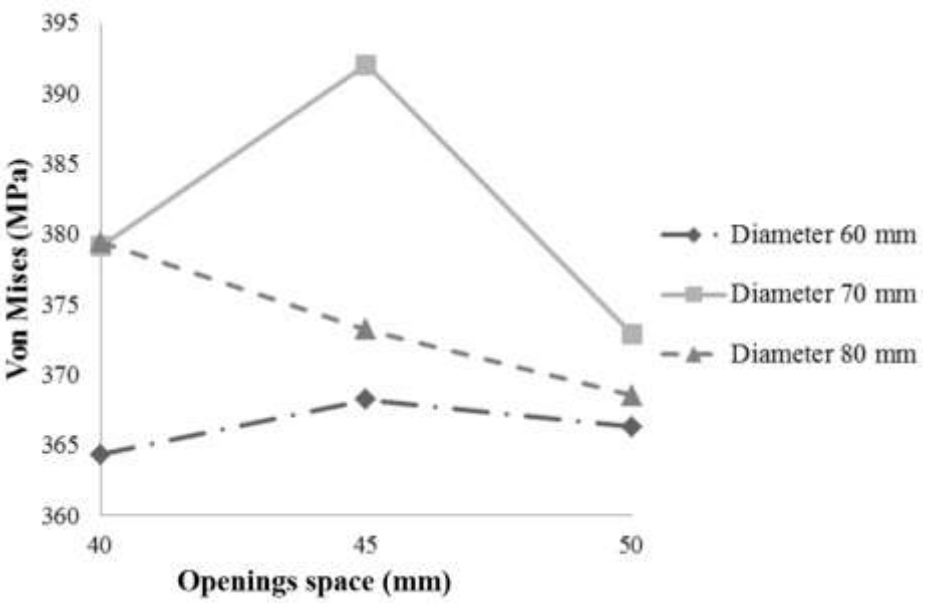
Result and Discussion

- Finite element analysis result: maximum Von-misses Stress & displacement
- Below are the result of stress and displacement for IWF 150x75x5x7 with span length of 2 m

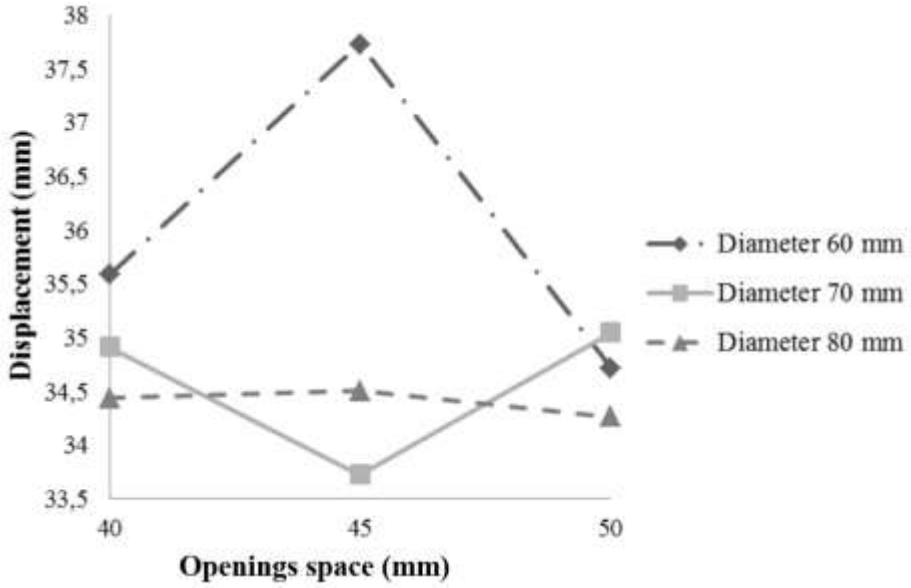


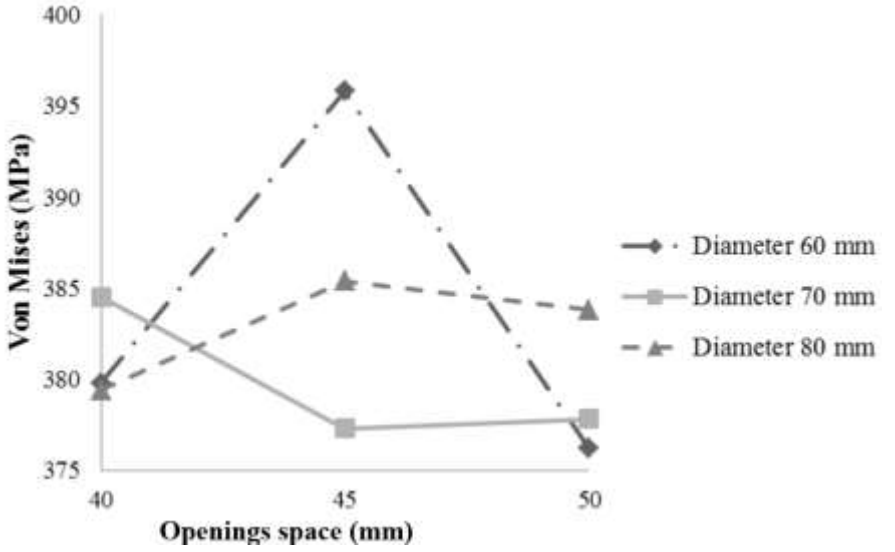




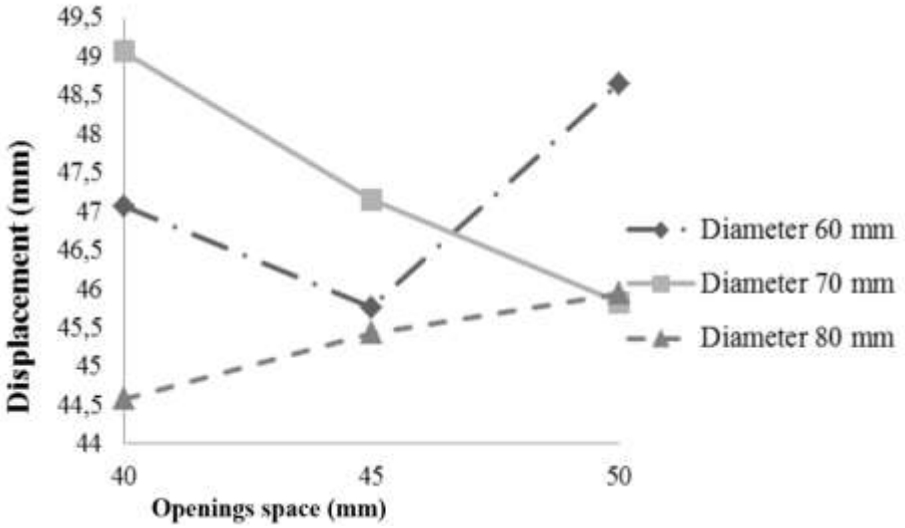


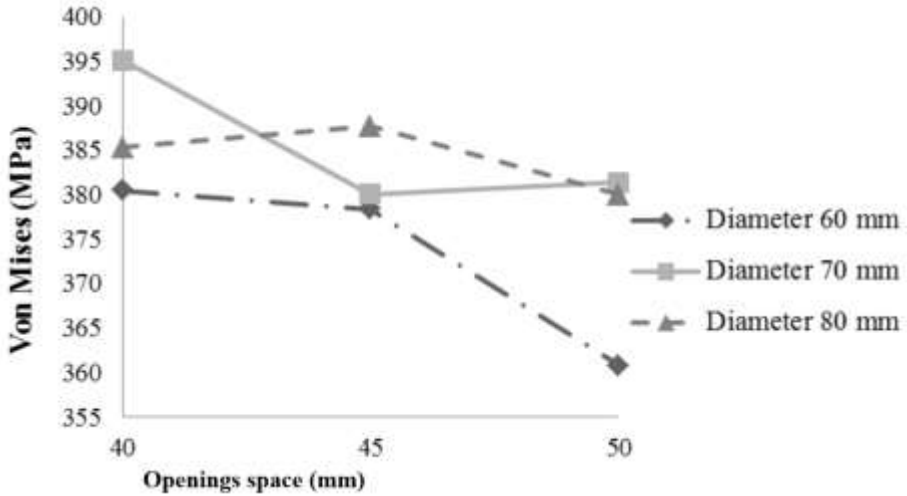
Stress and displacement for IWF 150x75x5x7 with span length of 2.5 m



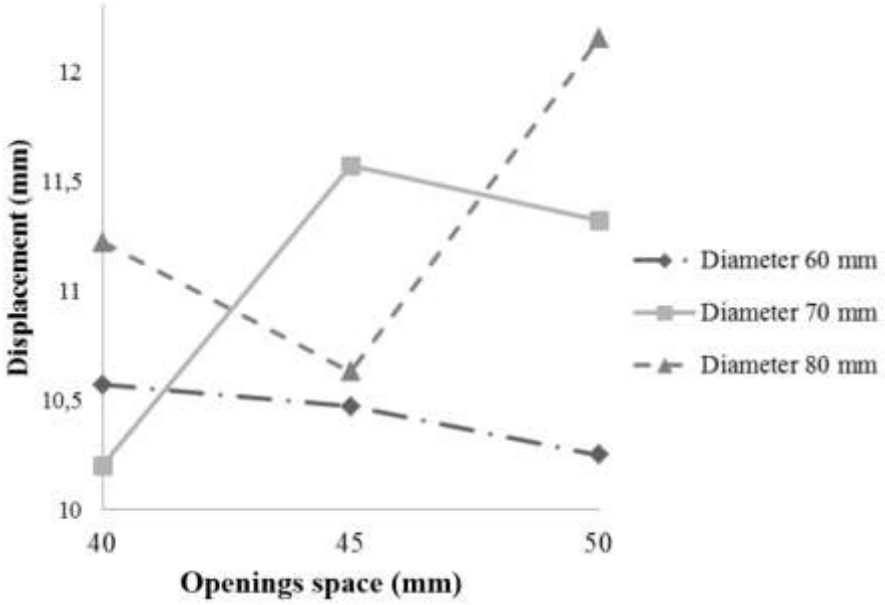


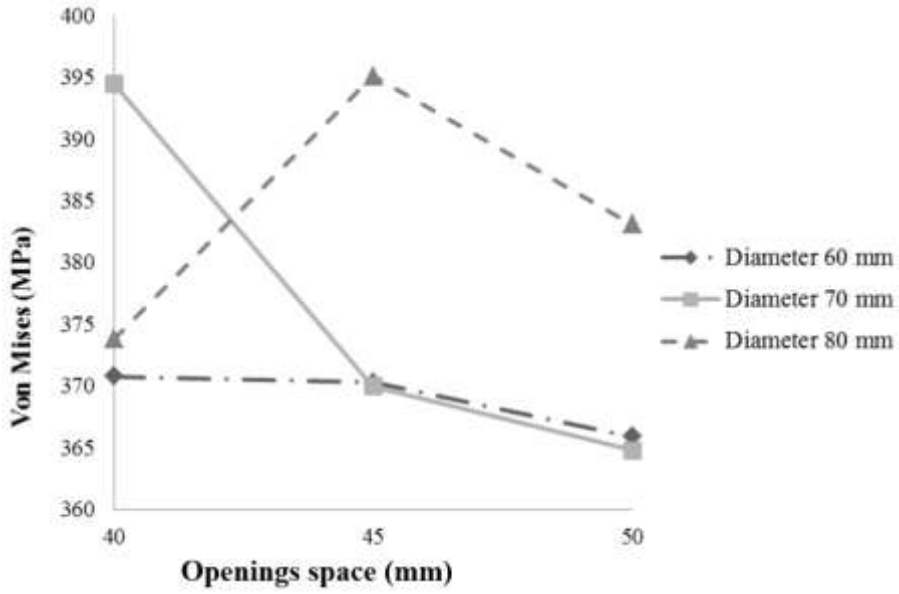
Stress and displacement for IWF 150x75x5x7 with span length of 3 m



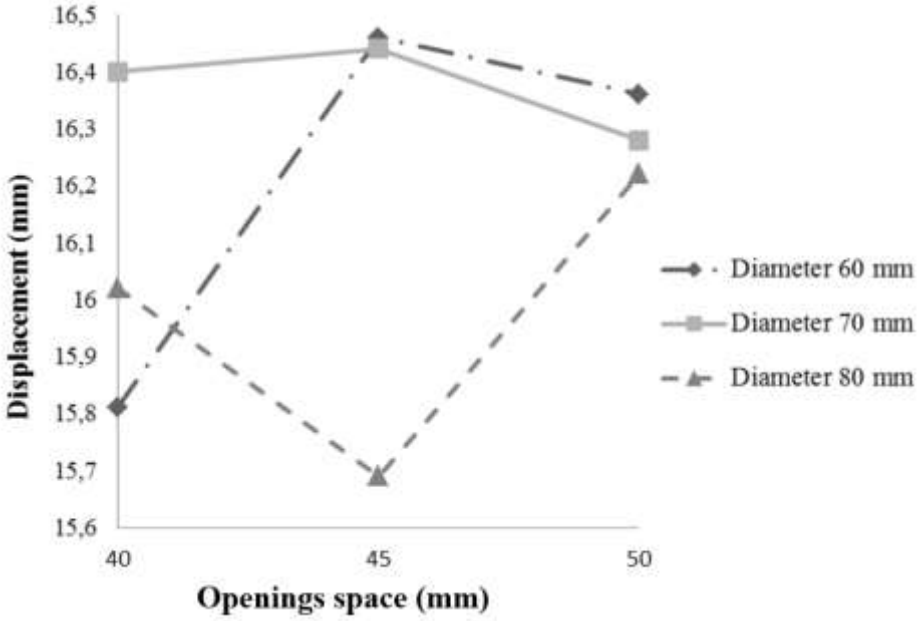


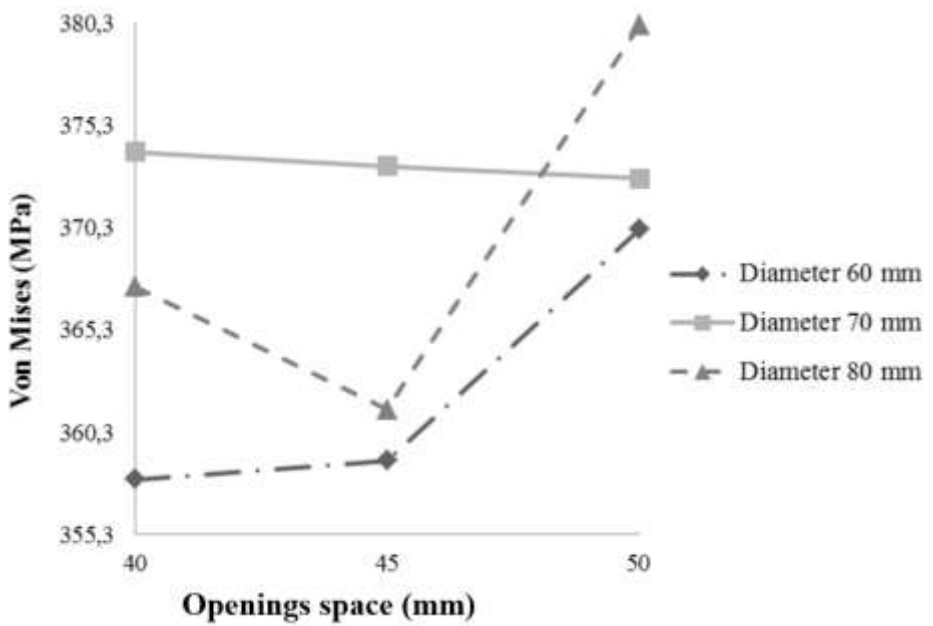
Stress and displacement for IWF 150x75x5x7 with span length of 3.5 m



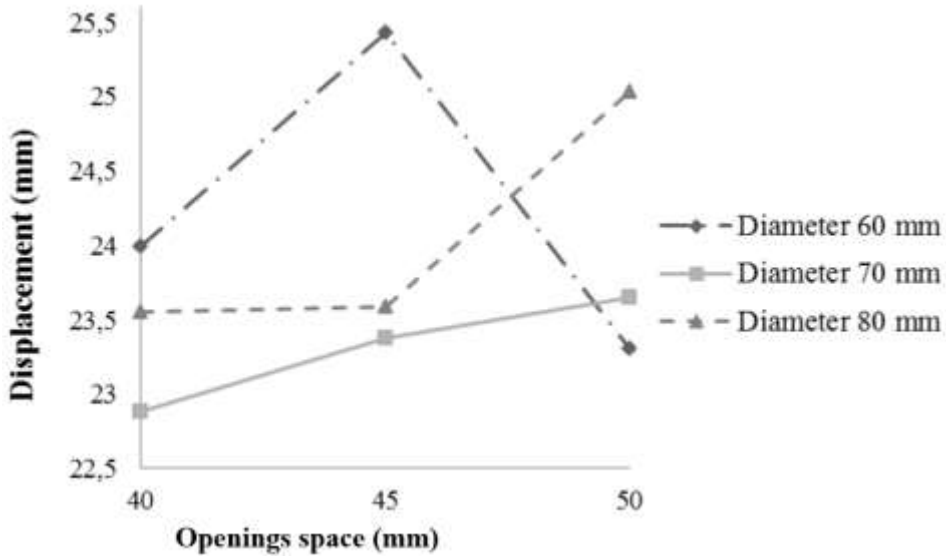


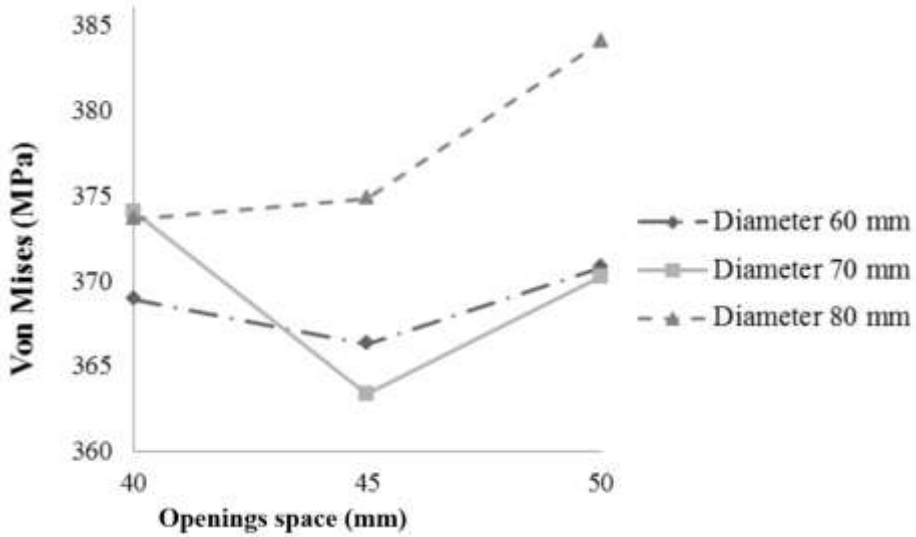
Stress and displacement for IWF 200x100x5.5x8 with span length of 2 m



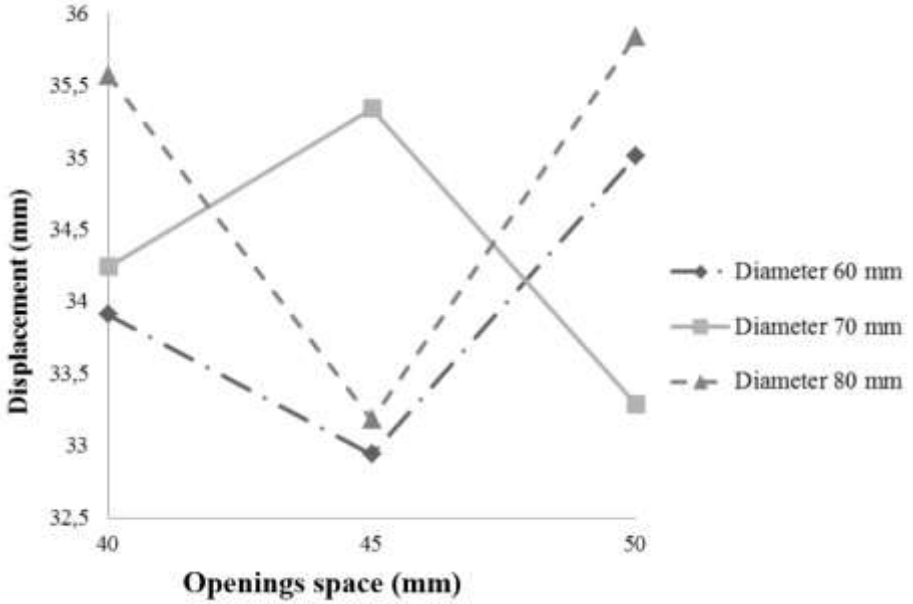


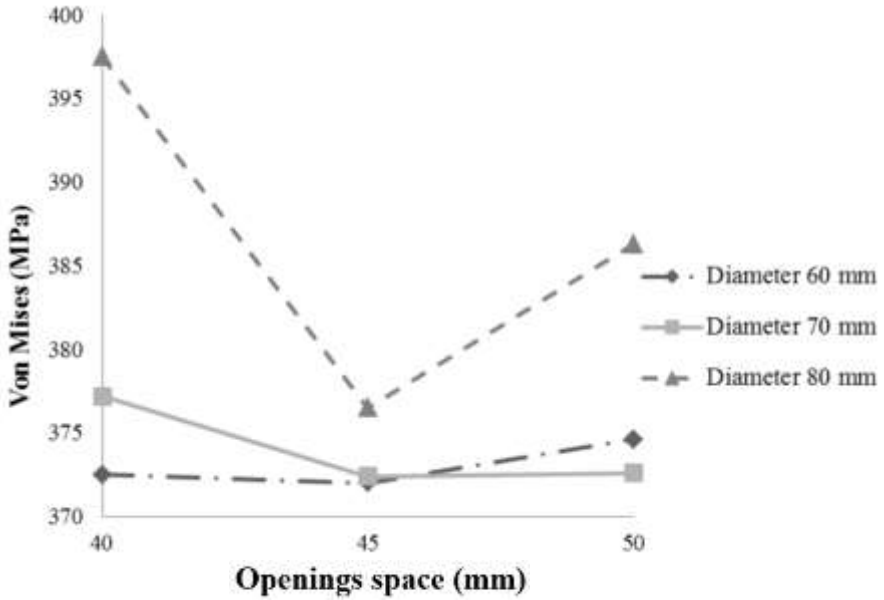
Stress and displacement for IWF 200x100x5.5x8 with span length of 2.5 m





Stress and displacement for IWF 200x100x5.5x8 with span length of 3 m





Stress and displacement for IWF 200x100x5.5x8 with span length of 3.5 m

Conclusion

- Tapered shape can be implemented as well as castellated beam on cantilever supported structure
- Values of stress & displacement for each sample fluctutate and are unique → might be caused by variating number of openings, resulting from cutting in sample creations
- Provided graph can be useful for practical structural engineers in the filed wanting to determine best option of cantilever steel beam
- Further research option: enrich the data and make several equations to quickly determine the shape using ANN or other method

Thank you for listening

If you have any further questions about this paper, feel free to ask and contact the corresponding author:

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