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# Implementation of Second-Order Homogenisation using Shell Elements for Woven Composites

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Textile Composites – II

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# 3D Woven Composites

## Advantages

- Ease of manufacturing
- Reduced weight
- Improved interlaminar fracture toughness
- Better delamination resistance
- Better impact performance

Weft Yarns

Warp Yarns

Binder Yarns

## Challenges

- Material behaviour dependency on manufacturing process and final geometry
- Need for **multiscale modelling**

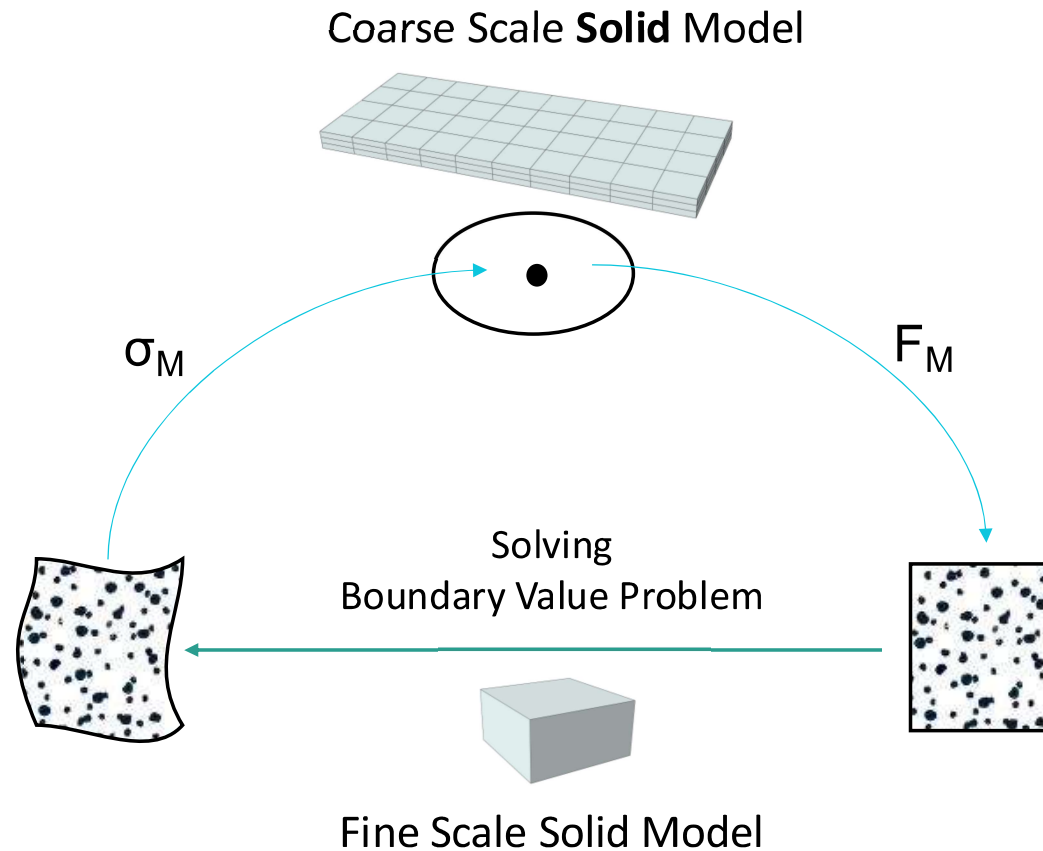
## Applications

- Complex structural joints
- Impact resistant structures



*Left:* LEAP-X fan *Right:* LEAP-X 3D woven composite fan blade

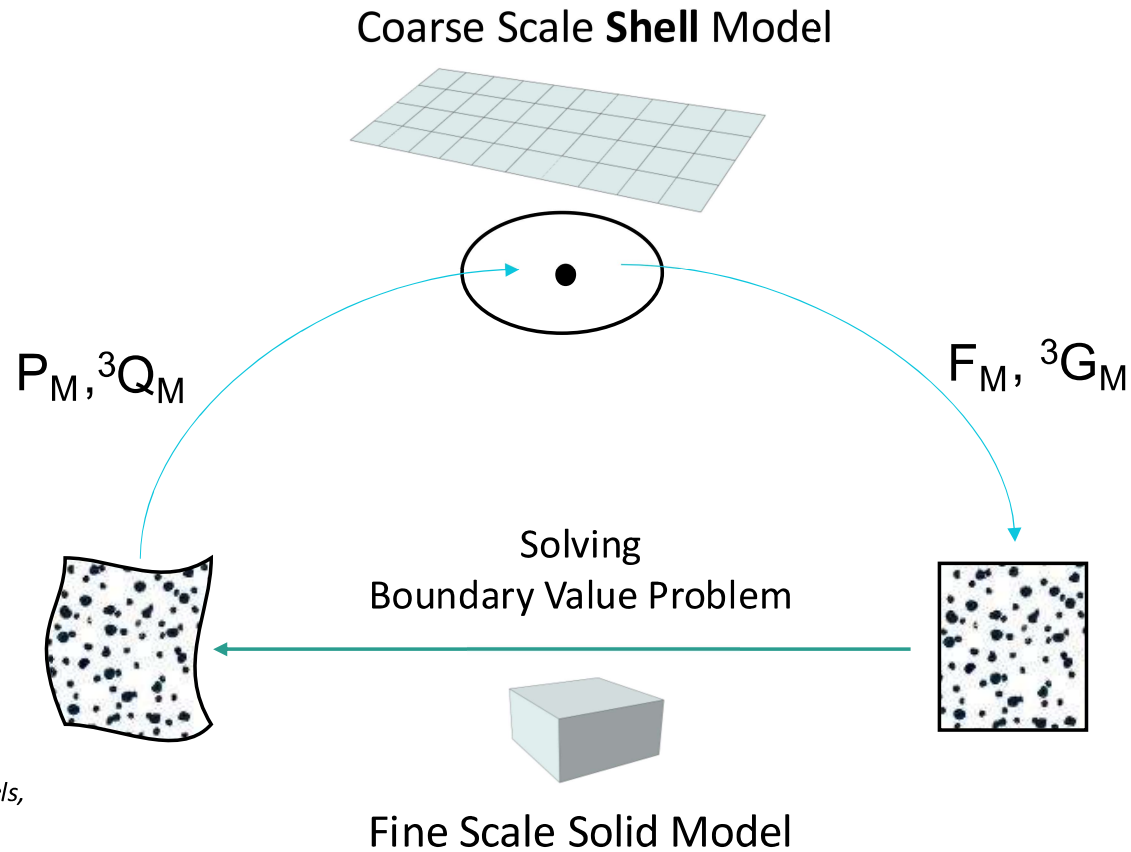
# First Order Homogenisation





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# Second Order Homogenisation



Aewis K.W. Hii, Bassam El Said, A kinematically  
consistent second-order computational  
homogenisation framework for thick shell models,  
*Computer Methods in Applied Mechanics and  
Engineering*, Volume 398, 2022.



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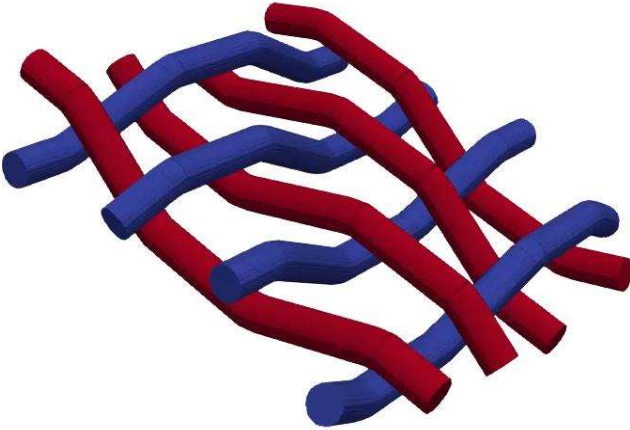
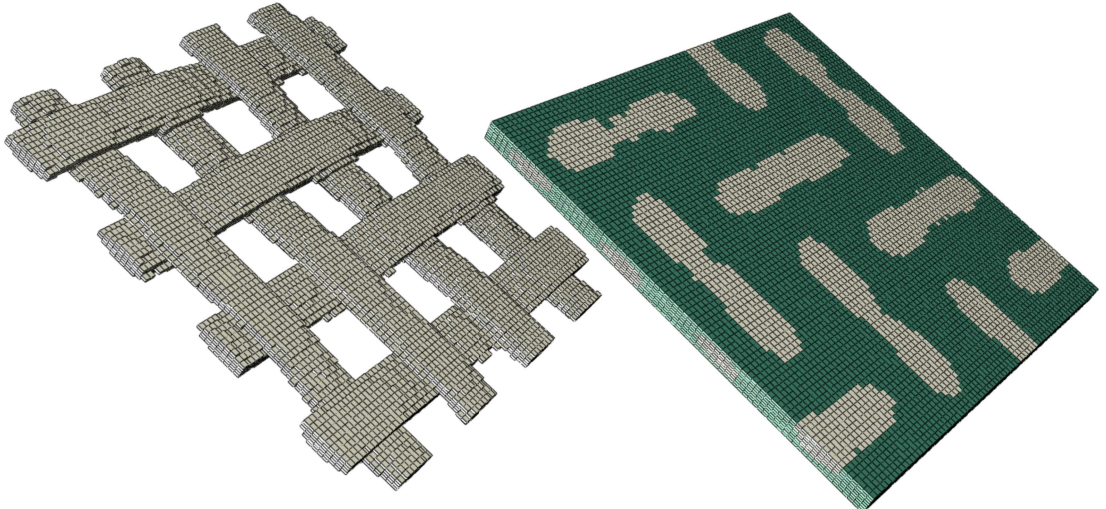
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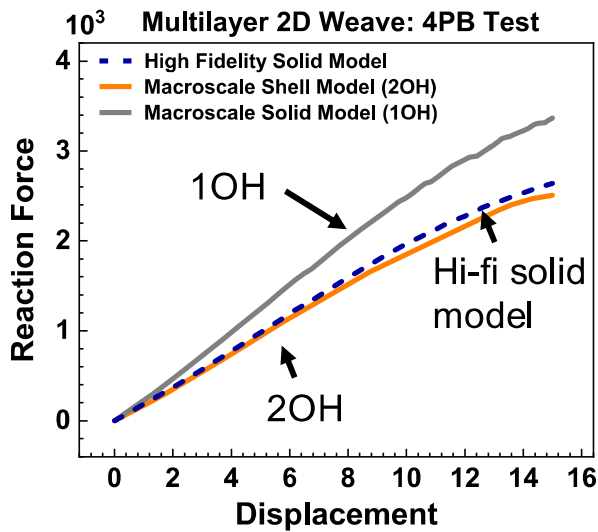
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# Development of Weave Models

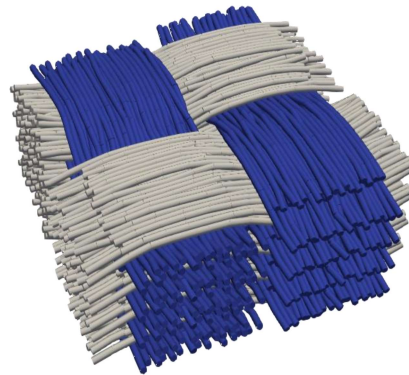
S i m T e x	Weaving Simulation	Voxelisation
	 <ul style="list-style-type: none"> <li>• Multi-filament method</li> <li>• Digital Element Simulation</li> <li>• Near-net shape</li> </ul>	 <ul style="list-style-type: none"> <li>• (left) voxelised yarn elements &amp; (right) representative volume element of 2x2 twill weave.</li> <li>• SimTex PrePost: build mechanical models for numerical homogenisation</li> </ul>



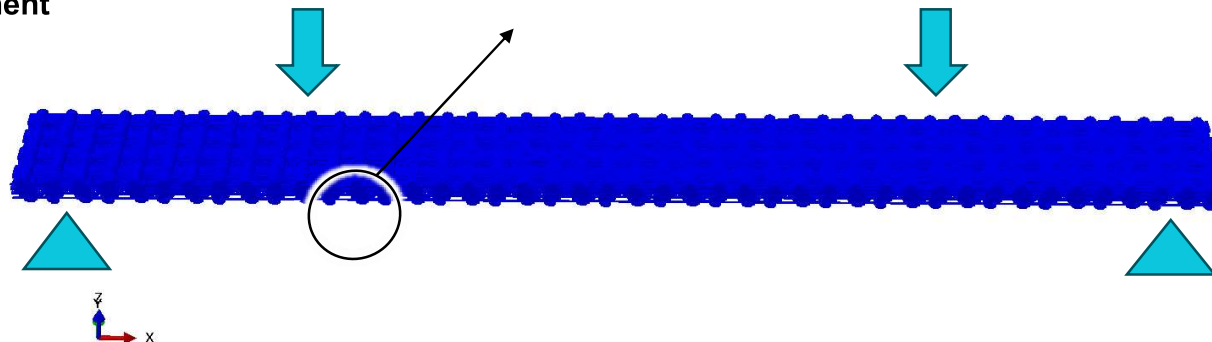
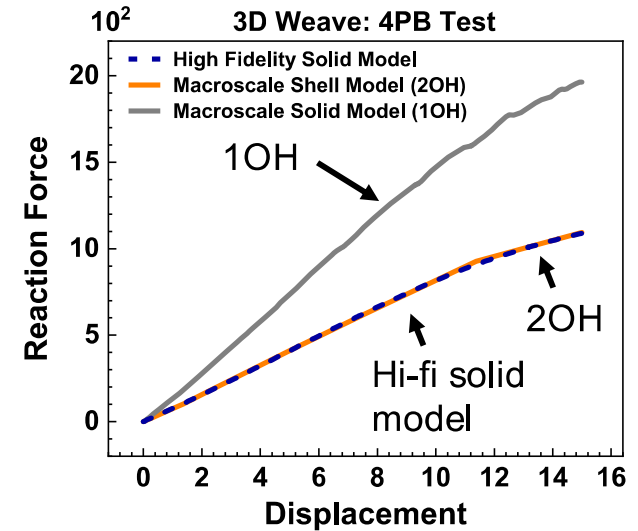
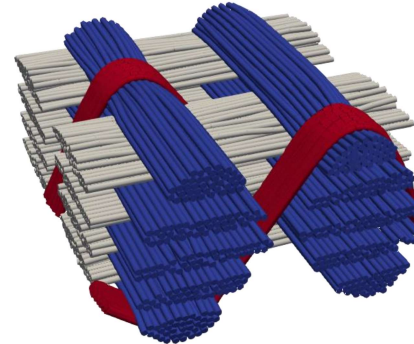
# 4 Point Bending (4PB) Test



**Multi-layer 2D Weave RVE**



**3D Woven RVE**

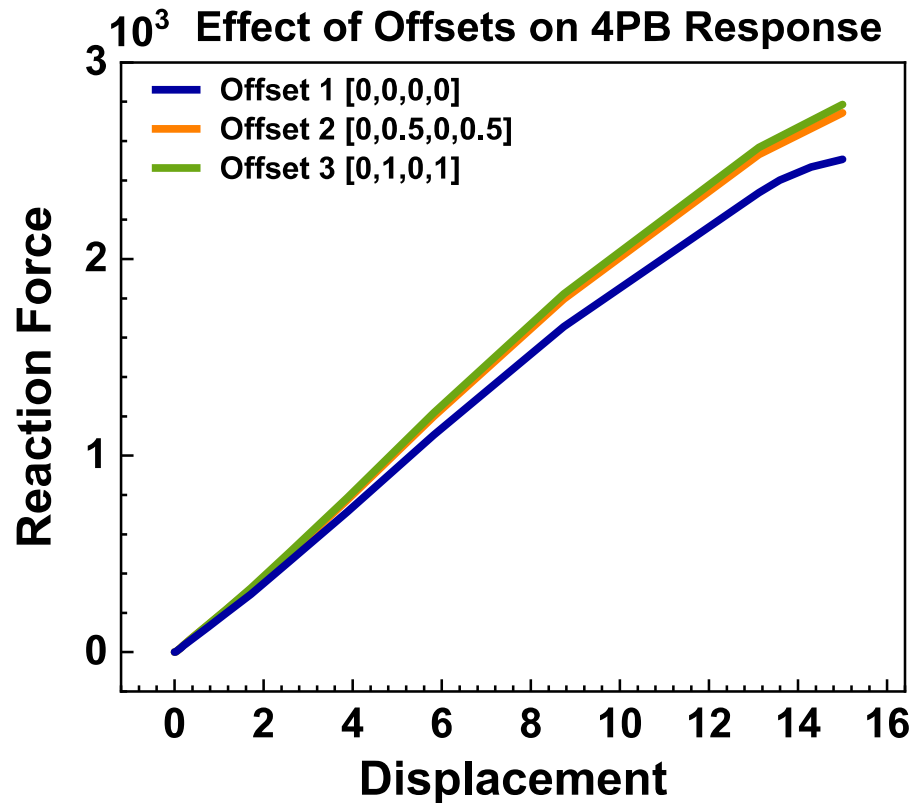


High-fidelity  
solid model  
(showing yarns  
only)

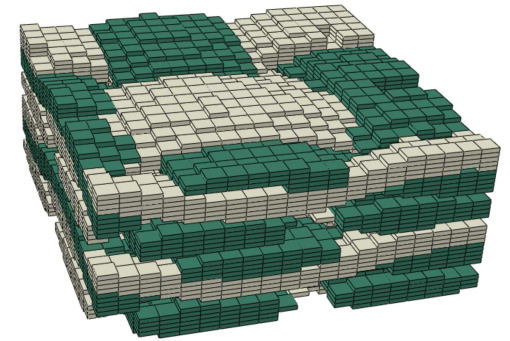


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# Second-order comparison for different offsets



Offset 1  
[0,0,0,0]



Offset 2  
[0,0.5,0,0.5]



Offset 3  
[0,1,0,1]



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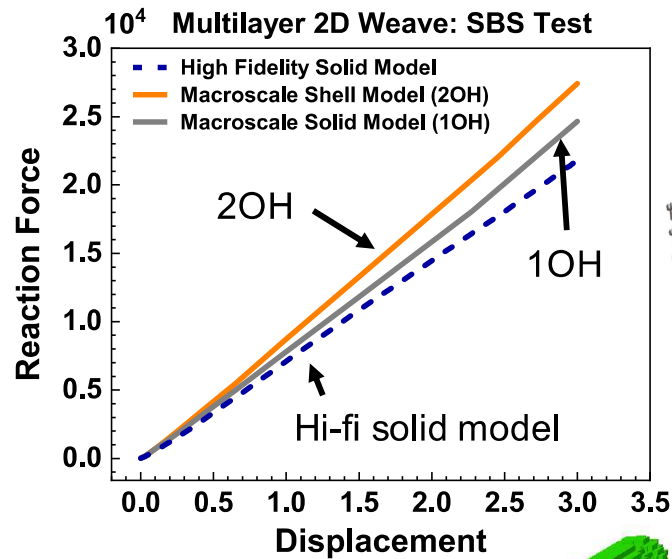
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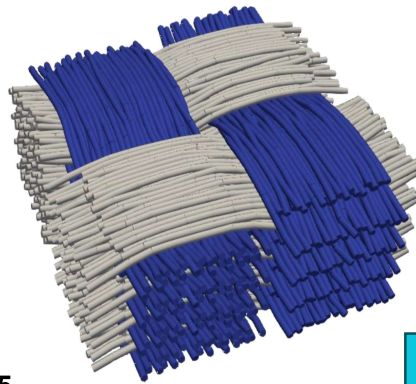
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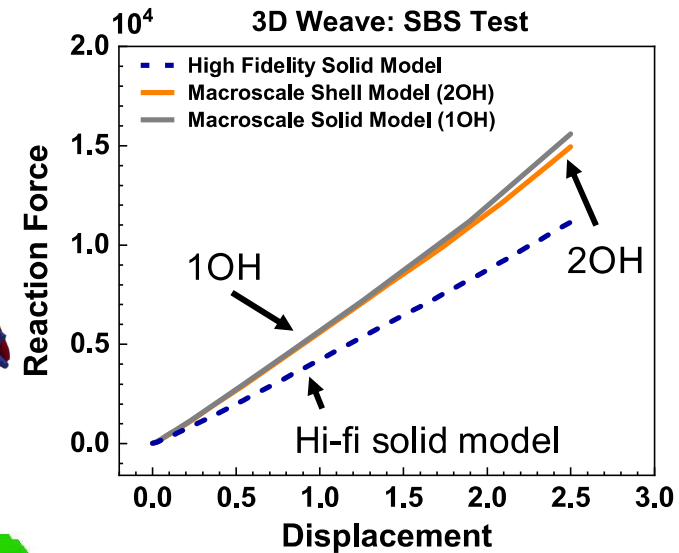
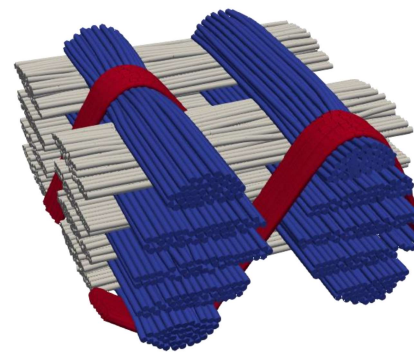
# Short beam Shear (SBS) Test



**Multi-layer 2D Weave RVE**



**3D Woven RVE**



High-fidelity  
solid model  
(showing yarns  
only)

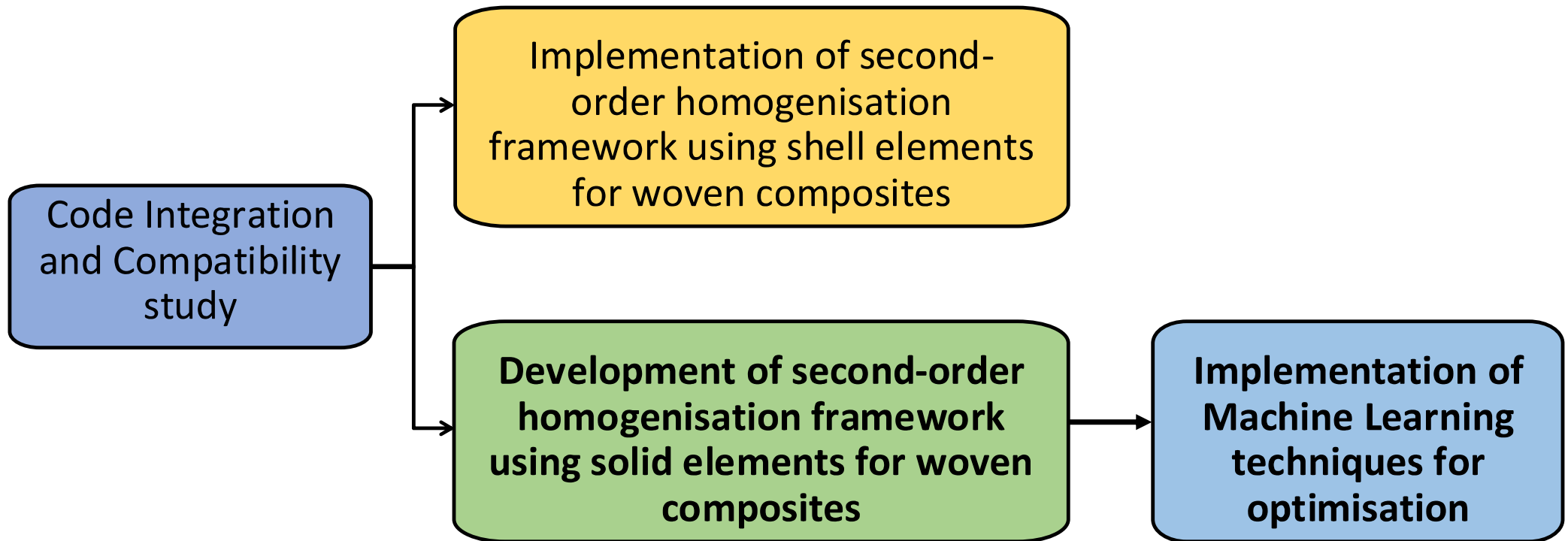




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## Future Work



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