

## Multi-planar material interfaces

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## 1 Objective

Verify that internal material-cell boundaries do not materially change the response of a homogeneous trimmed solid, including where multiple planar interface faces meet along longitudinal edges or at cross-section corners. Six partitioned square cross-sections are compared with an unpartitioned monolithic beam using identical elastic properties in every material definition. The quantities of interest are the relative differences in tip displacement and in displacement and stress profiles sampled along the beam and across its section.

## 2 Geometry

The specimen is a prismatic cantilever with square cross-section  $b \times b$  and length  $L$ . Every internal cross-section boundary is extruded through the full beam length, producing planar material-interface faces parallel to the beam axis. Figure 1 shows the monolithic reference and the six partition patterns.



Figure 1: Normalized cross-sections used by the homogeneous material-interface study. Each color denotes a distinct retained cell and material definition; all material properties are identical.

Table 1: Geometric parameters.

| Quantity             | Symbol | Value |
|----------------------|--------|-------|
| Cross-section width  | $b$    | 10    |
| Cross-section height | $b$    | 10    |
| Beam length          | $L$    | 100   |

The first three partitions exercise rectangular inclusions that respectively touch one exterior face, touch two exterior faces, or remain completely enclosed. The zig-zag and nested-L partitions divide the square into equal-area cells and introduce non-collinear interface planes. The Tetris partition uses a  $3 \times 3$  construction: two equal four-square L cells surround a one-square central cell, so three materials meet at the central square's corners.

### 3 Material

The partitioned models use distinct Abaqus material and solid-section definitions for each colored cell: two definitions in the first five cases and three in the Tetris case. Every definition has the same isotropic, linear-elastic properties, so the internal boundaries are physically invisible in the continuum problem.

Table 2: Properties assigned independently to every material definition.

| Property        | Symbol | Value             |
|-----------------|--------|-------------------|
| Young's modulus | $E$    | $100 \times 10^9$ |
| Poisson's ratio | $\nu$  | 0.3               |

## 4 Loading & boundary conditions

The  $z = 0$  end face is pinned in all three translational directions. A uniform surface traction of magnitude  $t_y$  acts in the negative  $y$  direction over every cell face at  $z = L$ . Applying the same traction to the full partitioned end face produces resultant shear force  $P = t_y b^2$  and exercises bending and transverse shear without introducing density as another material parameter.

Table 3: Applied loading.

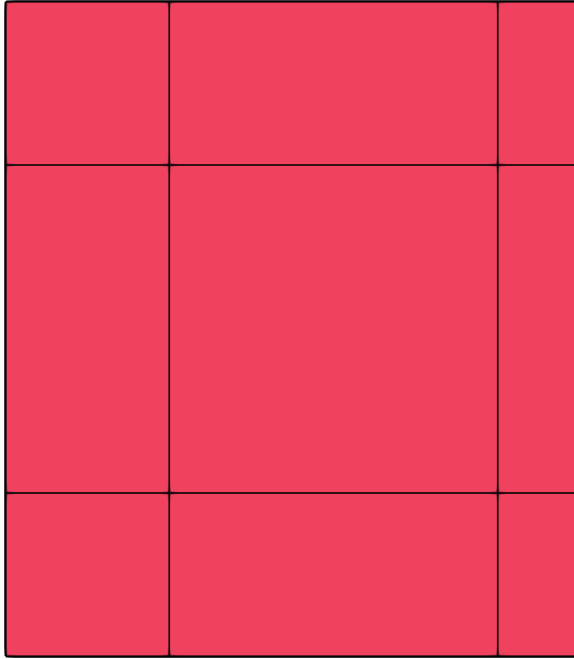
| Quantity           | Symbol | Value                 |
|--------------------|--------|-----------------------|
| End shear traction | $t_y$  | $10.0 \times 10^{-3}$ |
| Resultant force    | $P$    | 1                     |
| Direction          | —      | Negative $y$          |

## 5 Mesh & discretization

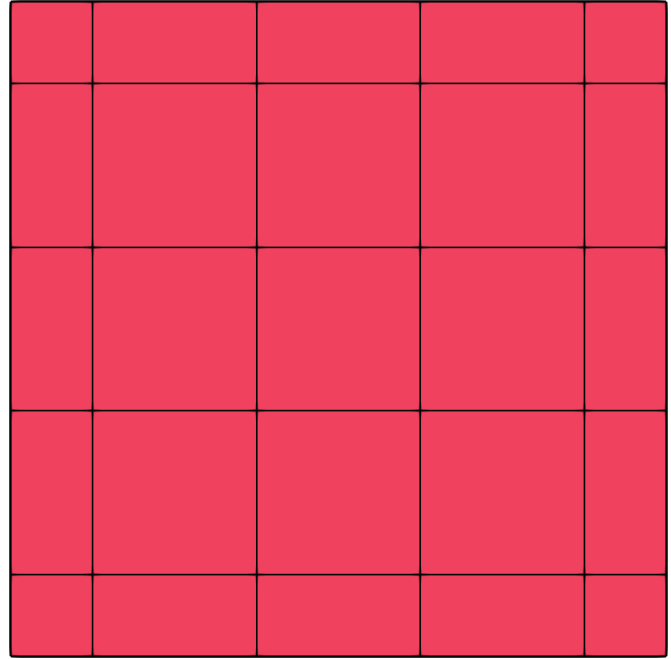
Each model uses the same immersed rectilinear background grid, outer geometry, grid origin, and  $h/p$  coordinates. The background element sizes are  $(5, 5, 10)/2^k$  in  $(x, y, z)$  for  $k = 0, \dots, 3$ , at degrees  $p = 1, 2$ , and  $3$  with maximum continuity  $C^{p-1}$ . Only the retained internal cell topology changes between the monolithic and partitioned models. The complete study contains 84 independently schedulable simulations: seven cross-sections, four refinement levels, and three degrees. The following views look along the beam axis and use the  $p = 2$  results databases. Retained cells are colored categorically by `part_id` using the Coreform primary palette in index order; each 2-by-2 figure progresses from the coarsest to the finest cross-sectional background mesh.

## 5.1 Monolithic reference

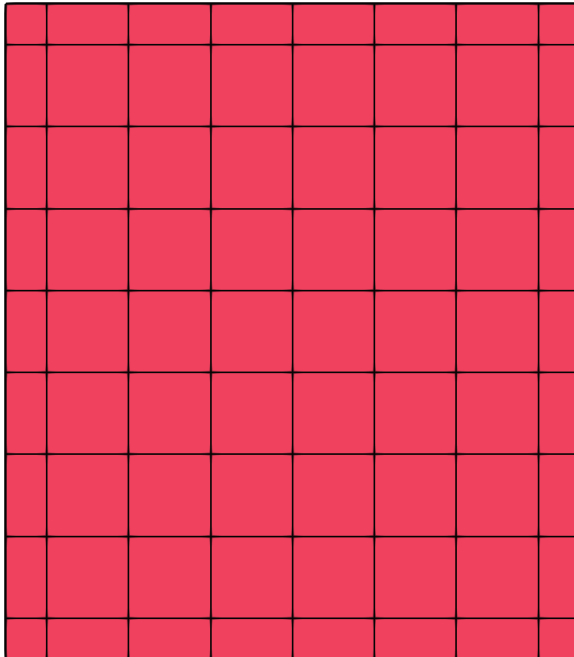




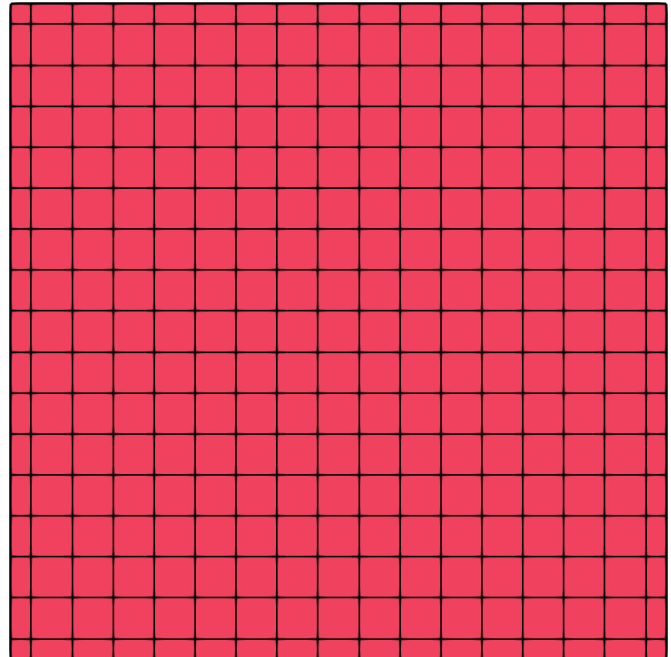
(a)  $h_{xy} = 5$



(b)  $h_{xy} = 2.5$



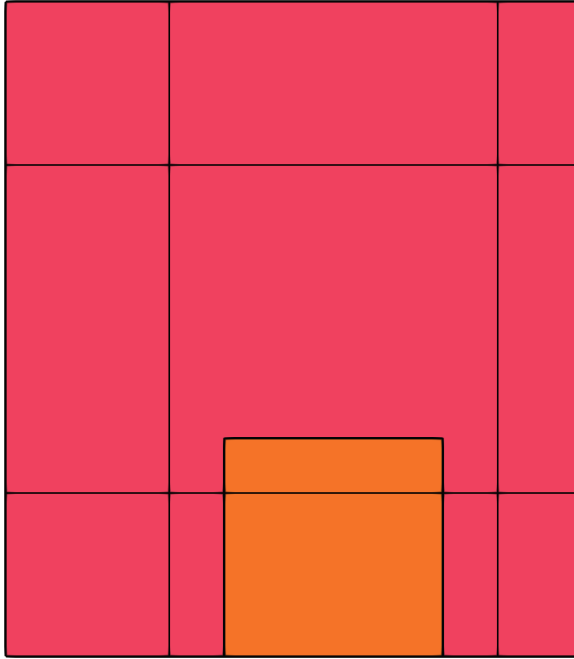
(c)  $h_{xy} = 1.25$



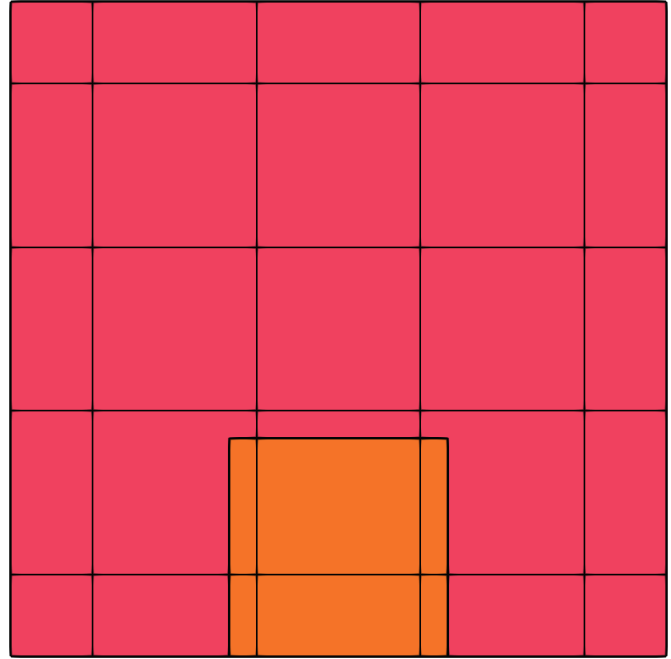
(d)  $h_{xy} = 0.625$

Figure 2: Monolithic reference cross-section meshes.

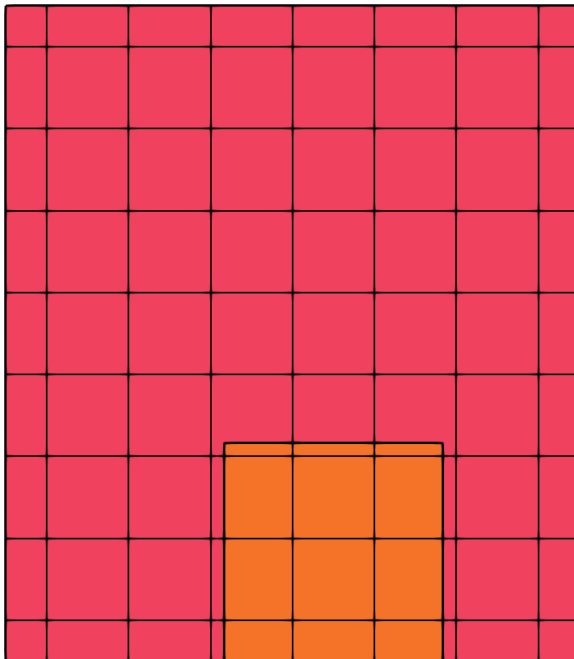
## 5.2 Bottom-centered one-third square



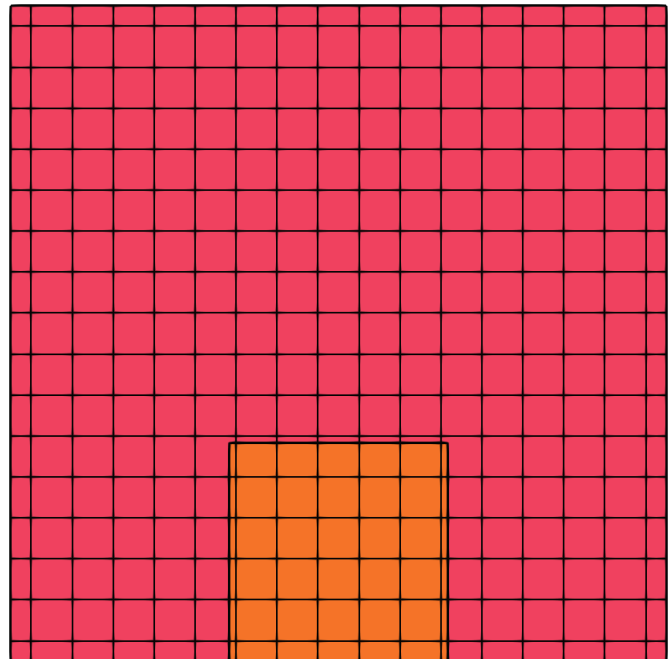
(a)  $h_{xy} = 5$



(b)  $h_{xy} = 2.5$



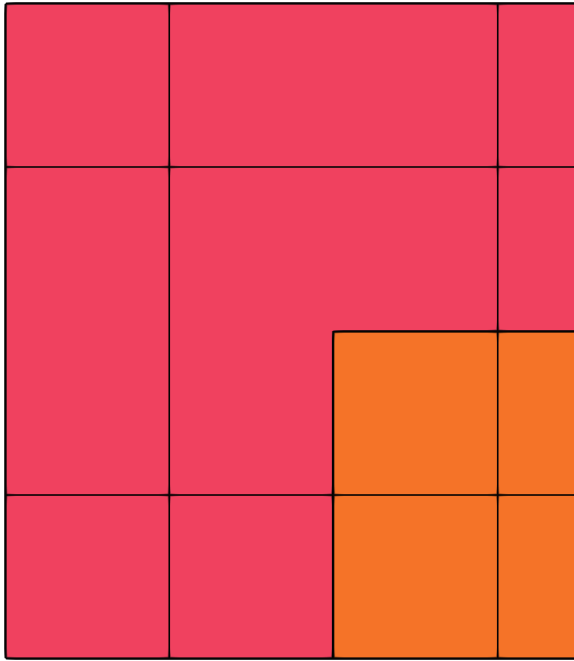
(c)  $h_{xy} = 1.25$



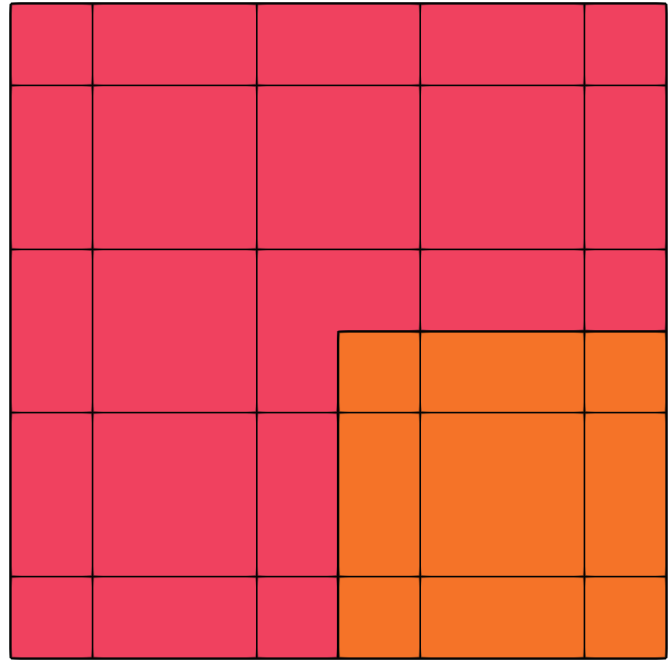
(d)  $h_{xy} = 0.625$

Figure 3: Bottom-centered one-third-square partition meshes.

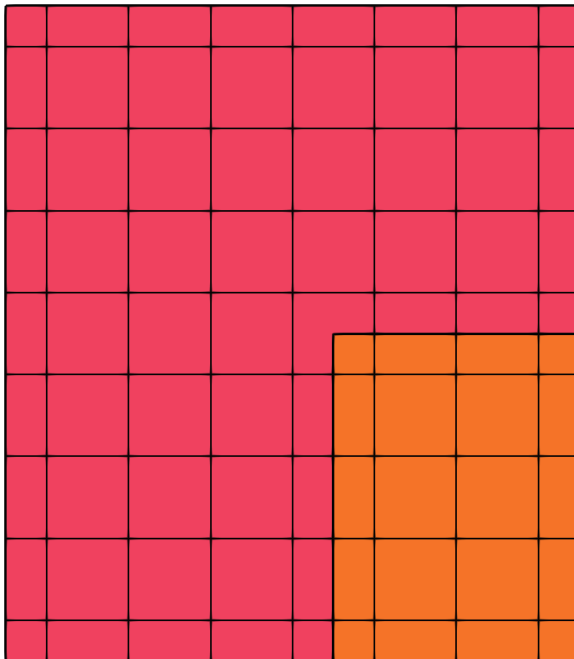
### 5.3 Bottom-left one-half square



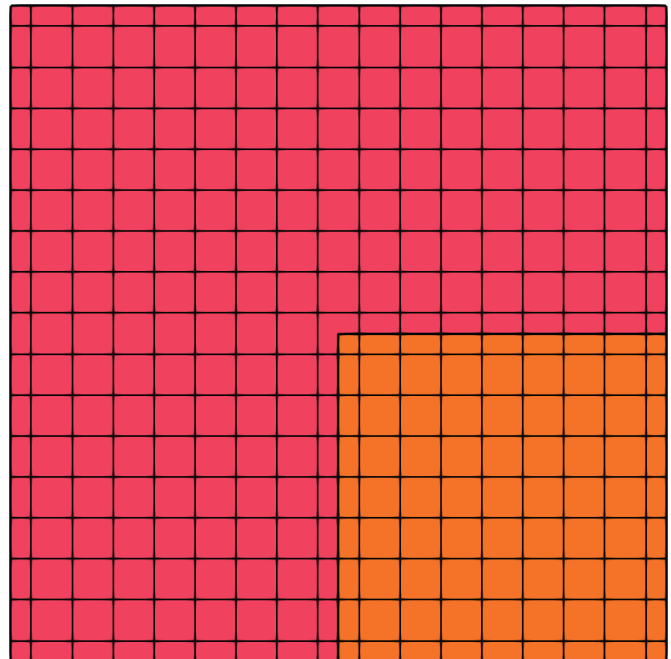
(a)  $h_{xy} = 5$



(b)  $h_{xy} = 2.5$



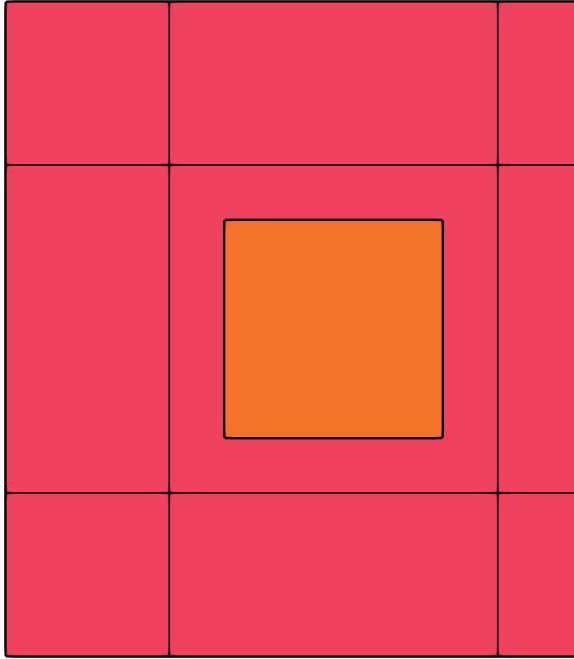
(c)  $h_{xy} = 1.25$



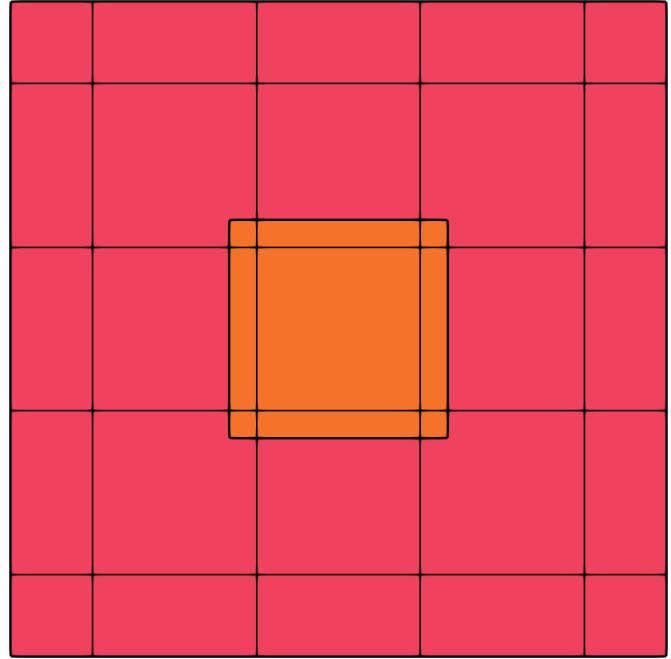
(d)  $h_{xy} = 0.625$

Figure 4: Bottom-left one-half-square partition meshes.

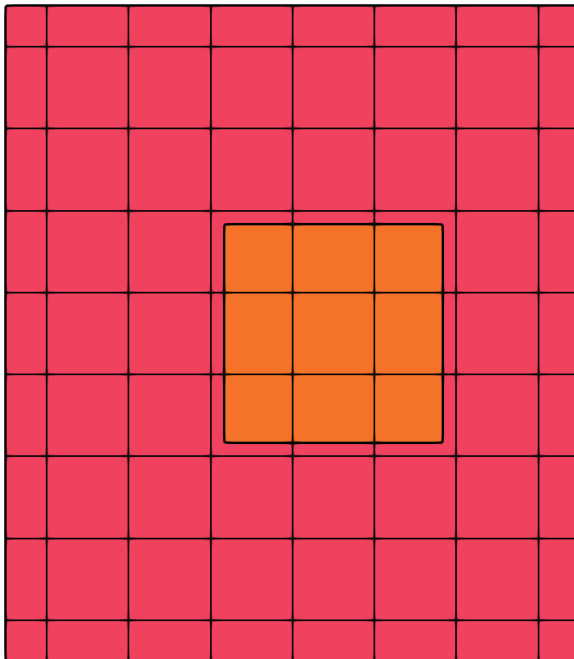
## 5.4 Centered one-third square



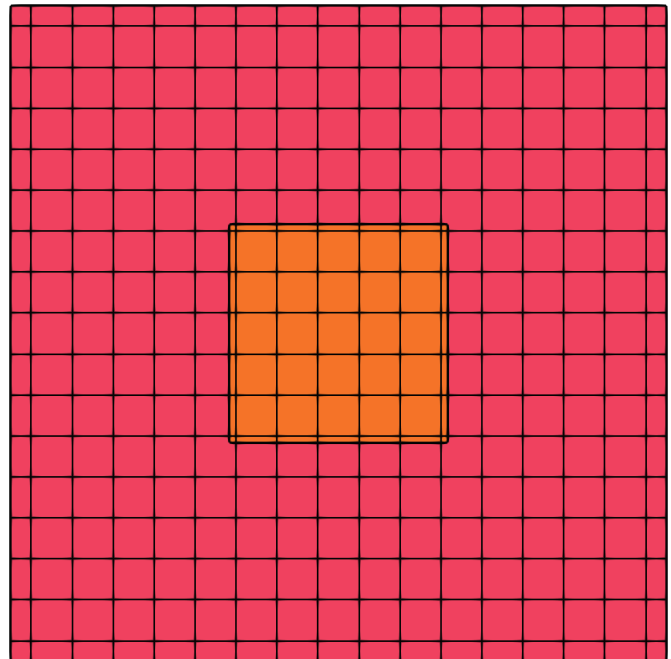
(a)  $h_{xy} = 5$



(b)  $h_{xy} = 2.5$



(c)  $h_{xy} = 1.25$

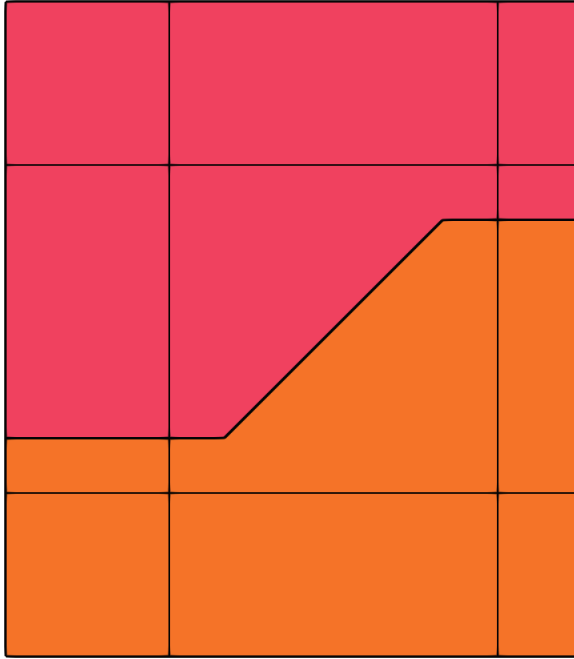


(d)  $h_{xy} = 0.625$

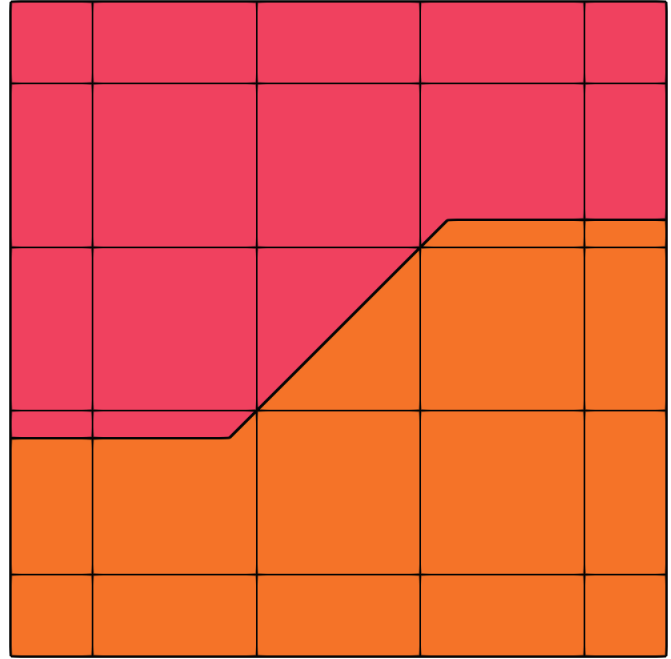
Figure 5: Centered one-third-square partition meshes.

## 5.5 Zig-zag interface

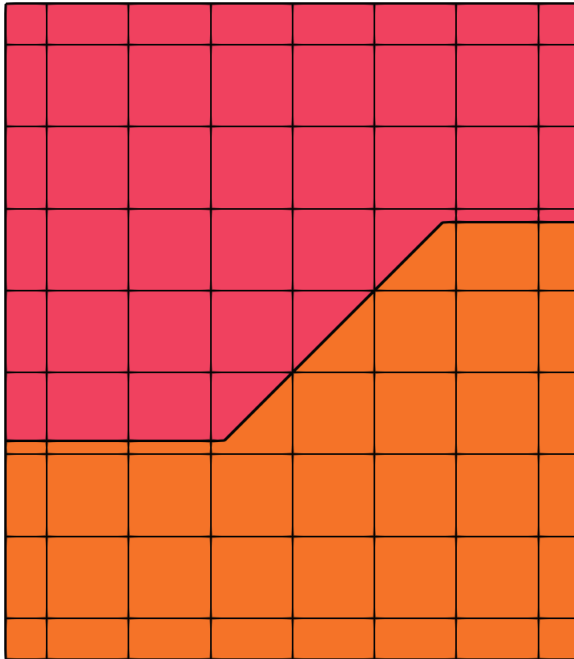




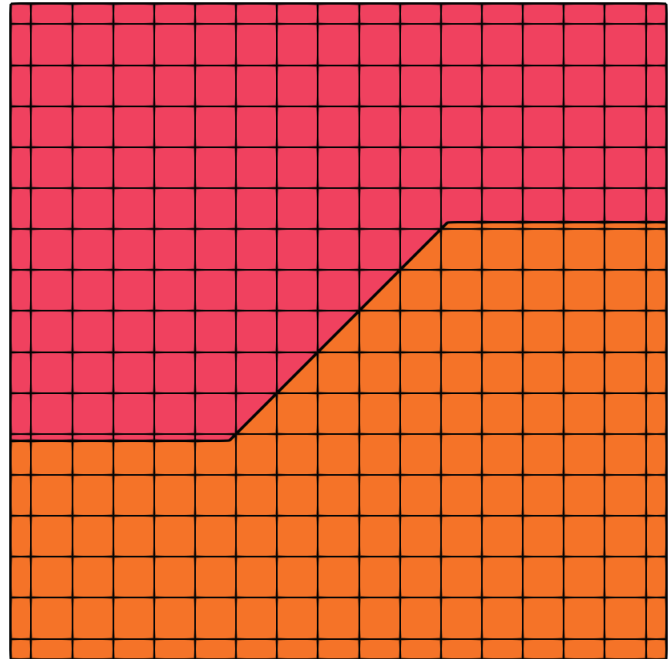
(a)  $h_{xy} = 5$



(b)  $h_{xy} = 2.5$



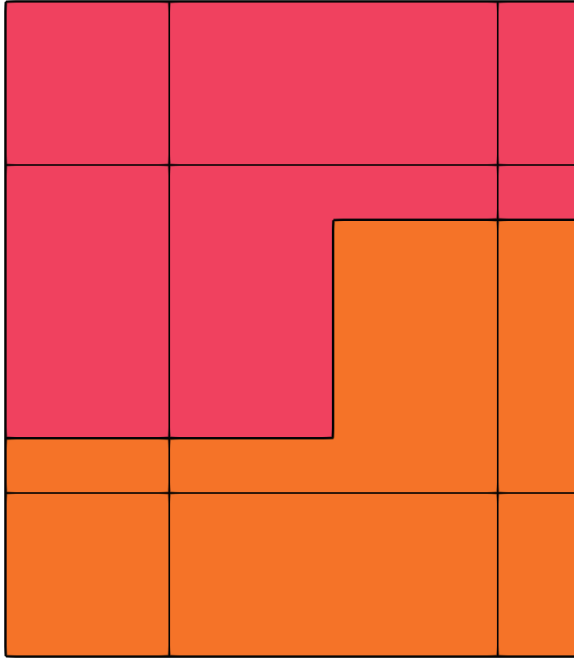
(c)  $h_{xy} = 1.25$



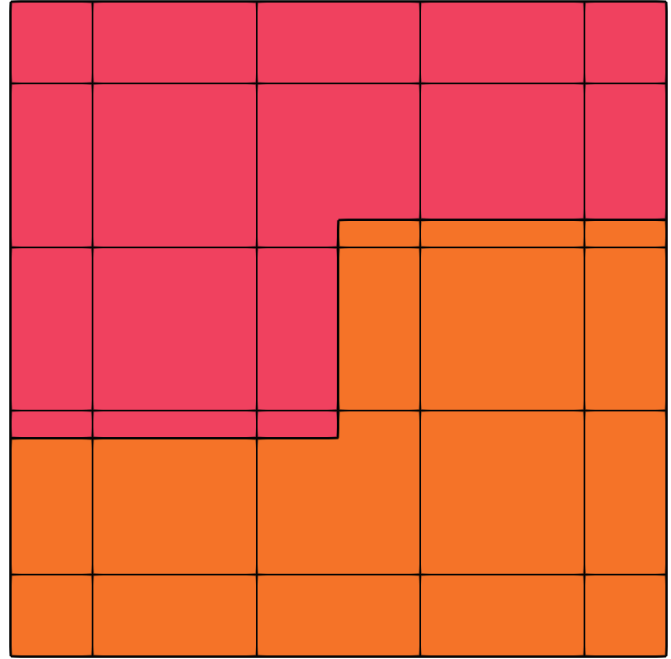
(d)  $h_{xy} = 0.625$

Figure 6: Zig-zag partition meshes.

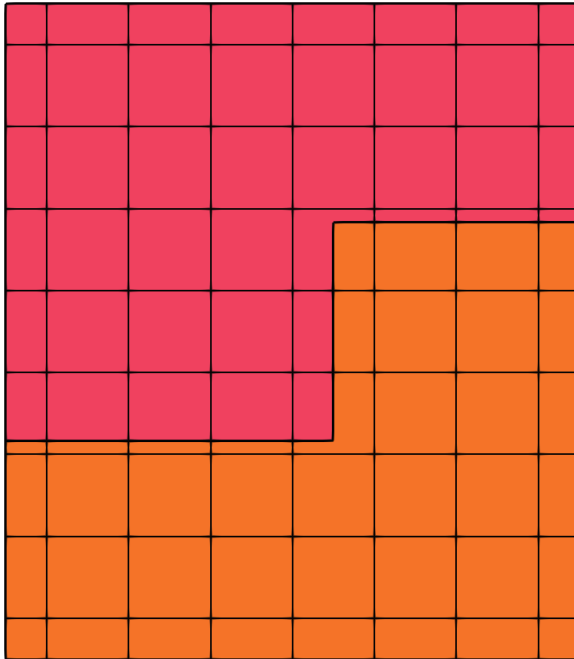
## 5.6 Nested L interface



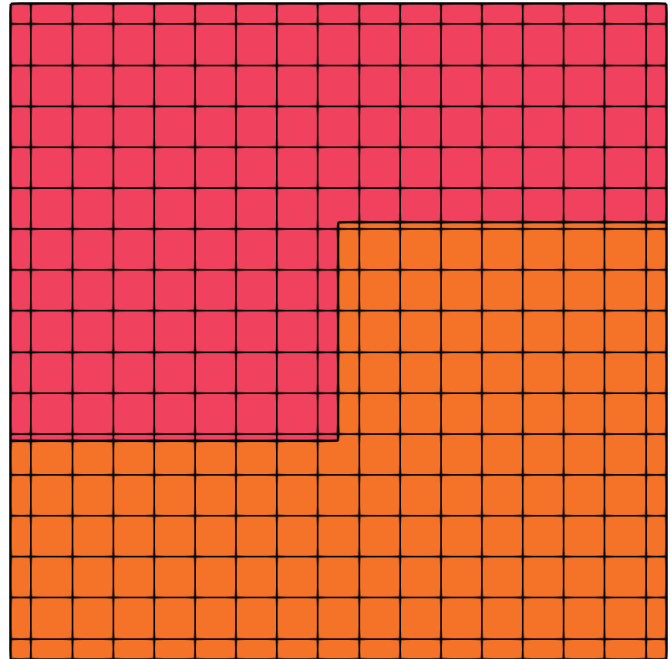
(a)  $h_{xy} = 5$



(b)  $h_{xy} = 2.5$



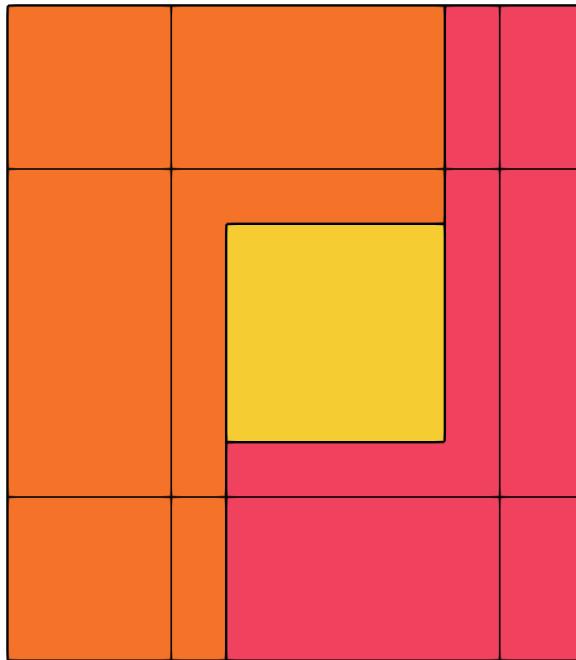
(c)  $h_{xy} = 1.25$



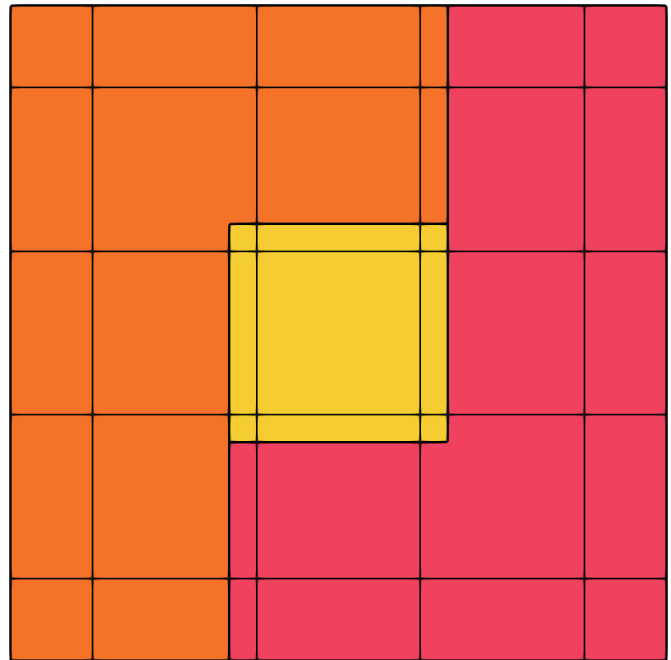
(d)  $h_{xy} = 0.625$

Figure 7: Nested-L partition meshes.

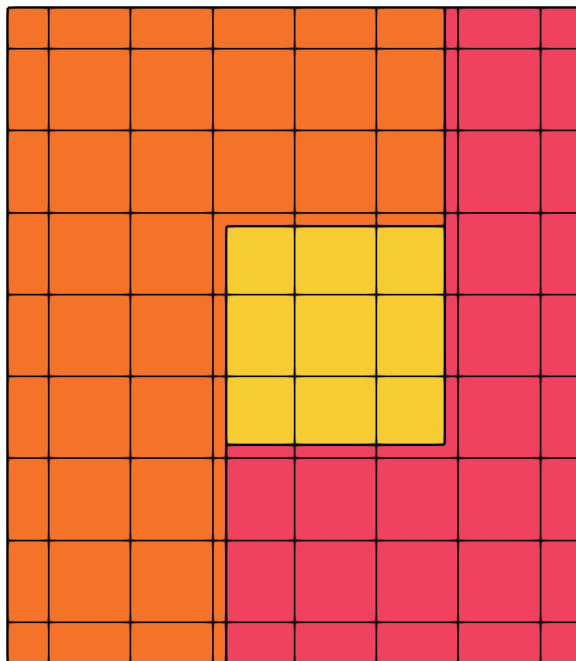
## 5.7 Tetris partition



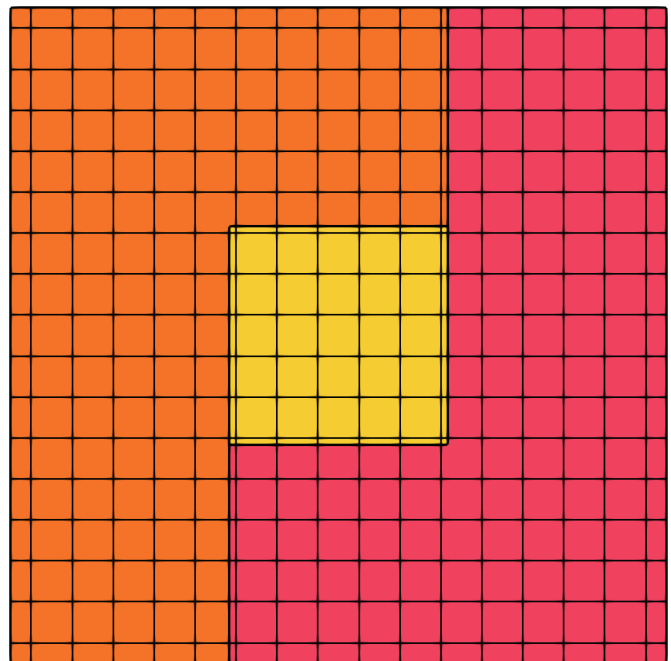
(a)  $h_{xy} = 5$



(b)  $h_{xy} = 2.5$



(c)  $h_{xy} = 1.25$



(d)  $h_{xy} = 0.625$

Figure 8: Three-cell Tetris partition meshes.

## 6 Reference & accepted solutions

The primary numerical reference for every partitioned result is the monolithic beam at the identical degree, refinement level, background-grid placement, loading, and material properties. This same- $h$ , same- $p$  pairing removes ordinary discretization error from the comparison and isolates the effect of creating and coupling retained material cells.

Six response differences are recorded for every pairing: tip  $u_y$ ; relative  $L^2$  differences in  $u_y$  along an axial line; and relative  $L^2$  differences in  $\sigma_{zz}$  and  $\tau_{yz}$  along vertical and horizontal midspan probes. The study-level CTest takes the maximum of those six quantities at the finest level and enforces the calibrated acceptance tolerance. The homogeneous Euler—Bernoulli cantilever solution [1] is also recorded by each simulation as a secondary, record-only diagnostic; it is not used to judge interface invariance because it carries independent beam-theory modeling error.

## 7 Results

Each partition geometry below is presented independently. The case-tabbed table reports the measured partitioned response, the same- $h$ , same- $p$  monolithic reference response, and their relative difference for every mesh size and degree. For the tip displacement these are scalar values. For each line probe the measured and reference values are the profile  $L^2$  norms, while the relative difference is the  $L^2$  norm of the pointwise profile difference normalized by the reference norm. The three probe figures use one subfigure per degree and overlay every partitioned mesh size against the finest matching-degree monolithic result; the final figure tracks the maximum same-mesh relative difference across all six verification quantities under refinement.

### 7.1 Bottom-centered one-third square

7.1.a  $h=10$ ,  $p=1$

| Quantity   |                         | Measured value         | Reference value        | Relative difference |
|------------|-------------------------|------------------------|------------------------|---------------------|
| Tip        | displacement            | $-1.89 \times 10^{-9}$ | $-2.09 \times 10^{-9}$ | 9.44%               |
| $u_y$      |                         |                        |                        |                     |
| Centerline | dis-                    | $9.28 \times 10^{-9}$  | $10.2 \times 10^{-9}$  | 9.26%               |
| placement  | $\ u_y\ _{L^2}$         |                        |                        |                     |
| Vertical   | normal                  | 0.25                   | 0.279                  | 10.4%               |
| stress     | $\ \sigma_{zz}\ _{L^2}$ |                        |                        |                     |
| Vertical   | shear                   | $31.8 \times 10^{-3}$  | $31.3 \times 10^{-3}$  | 11.9%               |
| stress     | $\ \tau_{yz}\ _{L^2}$   |                        |                        |                     |
| Horizontal | normal                  | $48.4 \times 10^{-3}$  | $53.6 \times 10^{-3}$  | 9.76%               |
| stress     | $\ \sigma_{zz}\ _{L^2}$ |                        |                        |                     |

| Quantity                                      | Measured value        | Reference value       | Relative difference |
|-----------------------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$ | $38.9 \times 10^{-3}$ | $36.1 \times 10^{-3}$ | 8.09%               |

#### 7.1.b h=5, p=1

| Quantity                                         | Measured value         | Reference value        | Relative difference |
|--------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$                           | $-3.32 \times 10^{-9}$ | $-3.41 \times 10^{-9}$ | 2.67%               |
| Centerline displacement $\ u_y\ _{L^2}$          | $16.2 \times 10^{-9}$  | $16.6 \times 10^{-9}$  | 2.63%               |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.457                  | 0.471                  | 2.96%               |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $30.9 \times 10^{-3}$  | $30.6 \times 10^{-3}$  | 6.39%               |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $91.0 \times 10^{-3}$  | $94.4 \times 10^{-3}$  | 3.64%               |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $43.9 \times 10^{-3}$  | $43.9 \times 10^{-3}$  | 0.967%              |

#### 7.1.c h=2.5, p=1

| Quantity                                         | Measured value         | Reference value        | Relative difference |
|--------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$                           | $-3.87 \times 10^{-9}$ | $-3.88 \times 10^{-9}$ | 0.238%              |
| Centerline displacement $\ u_y\ _{L^2}$          | $18.8 \times 10^{-9}$  | $18.8 \times 10^{-9}$  | 0.236%              |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.531                  | 0.533                  | 0.46%               |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $31.8 \times 10^{-3}$  | $31.8 \times 10^{-3}$  | 1.08%               |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | 0.108                  | 0.108                  | 0.292%              |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $46.6 \times 10^{-3}$  | $46.8 \times 10^{-3}$  | 0.375%              |

7.1.d h=1.25, p=1

| Quantity                                            | Measured value         | Reference value        | Relative difference |
|-----------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement<br>$u_y$                           | $-3.97 \times 10^{-9}$ | $-3.97 \times 10^{-9}$ | 0.036%              |
| Centerline displacement<br>$\ u_y\ _{L^2}$          | $19.3 \times 10^{-9}$  | $19.3 \times 10^{-9}$  | 0.0361%             |
| Vertical normal stress<br>$\ \sigma_{zz}\ _{L^2}$   | 0.544                  | 0.544                  | 0.219%              |
| Vertical shear stress<br>$\ \tau_{yz}\ _{L^2}$      | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 0.936%              |
| Horizontal normal stress<br>$\ \sigma_{zz}\ _{L^2}$ | $90.1 \times 10^{-3}$  | $90.1 \times 10^{-3}$  | 0.0398%             |
| Horizontal shear stress<br>$\ \tau_{yz}\ _{L^2}$    | $46.7 \times 10^{-3}$  | $46.7 \times 10^{-3}$  | 0.0783%             |

7.1.e h=10, p=2

| Quantity                                            | Measured value         | Reference value        | Relative difference |
|-----------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement<br>$u_y$                           | $-3.99 \times 10^{-9}$ | $-3.99 \times 10^{-9}$ | 0.00453%            |
| Centerline displacement<br>$\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.0079%             |
| Vertical normal stress<br>$\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.162%              |
| Vertical shear stress<br>$\ \tau_{yz}\ _{L^2}$      | $26.5 \times 10^{-3}$  | $26.7 \times 10^{-3}$  | 2.69%               |
| Horizontal normal stress<br>$\ \sigma_{zz}\ _{L^2}$ | $95.6 \times 10^{-3}$  | $95.0 \times 10^{-3}$  | 0.83%               |
| Horizontal shear stress<br>$\ \tau_{yz}\ _{L^2}$    | $37.5 \times 10^{-3}$  | $37.5 \times 10^{-3}$  | 0.291%              |

7.1.f h=5, p=2

| Quantity                  | Measured value         | Reference value        | Relative difference |
|---------------------------|------------------------|------------------------|---------------------|
| Tip displacement<br>$u_y$ | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00549%            |



| Quantity                |                                   | Measured value        | Reference value       | Relative difference |
|-------------------------|-----------------------------------|-----------------------|-----------------------|---------------------|
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$           | $19.4 \times 10^{-9}$ | $19.4 \times 10^{-9}$ | 0.00672%            |
| Vertical stress         | normal<br>$\ \sigma_{zz}\ _{L^2}$ | 0.548                 | 0.548                 | 0.0237%             |
| Vertical stress         | shear<br>$\ \tau_{yz}\ _{L^2}$    | $30.8 \times 10^{-3}$ | $30.8 \times 10^{-3}$ | 2.64%               |
| Horizontal stress       | normal<br>$\ \sigma_{zz}\ _{L^2}$ | $94.7 \times 10^{-3}$ | $94.8 \times 10^{-3}$ | 0.0817%             |
| Horizontal stress       | shear<br>$\ \tau_{yz}\ _{L^2}$    | $45.2 \times 10^{-3}$ | $45.2 \times 10^{-3}$ | 0.0854%             |

#### 7.1.g h=2.5, p=2

| Quantity                |                                   | Measured value         | Reference value        | Relative difference    |
|-------------------------|-----------------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                             | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $341 \times 10^{-6}\%$ |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$           | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $427 \times 10^{-6}\%$ |
| Vertical stress         | normal<br>$\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.00854%               |
| Vertical stress         | shear<br>$\ \tau_{yz}\ _{L^2}$    | $31.8 \times 10^{-3}$  | $31.8 \times 10^{-3}$  | 0.223%                 |
| Horizontal stress       | normal<br>$\ \sigma_{zz}\ _{L^2}$ | $94.8 \times 10^{-3}$  | $94.8 \times 10^{-3}$  | 0.0278%                |
| Horizontal stress       | shear<br>$\ \tau_{yz}\ _{L^2}$    | $46.9 \times 10^{-3}$  | $46.9 \times 10^{-3}$  | 0.133%                 |

#### 7.1.h h=1.25, p=2

| Quantity                |                         | Measured value         | Reference value        | Relative difference    |
|-------------------------|-------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                   | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $335 \times 10^{-6}\%$ |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$ | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $403 \times 10^{-6}\%$ |

| Quantity                       |        | Measured value        | Reference value       | Relative difference    |
|--------------------------------|--------|-----------------------|-----------------------|------------------------|
| Vertical                       | normal | 0.548                 | 0.548                 | 0.00519%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                        |
| Vertical                       | shear  | $32.1 \times 10^{-3}$ | $32.1 \times 10^{-3}$ | 0.228%                 |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                        |
| Horizontal                     | normal | $94.9 \times 10^{-3}$ | $94.9 \times 10^{-3}$ | $395 \times 10^{-6}\%$ |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                        |
| Horizontal                     | shear  | $46.9 \times 10^{-3}$ | $46.9 \times 10^{-3}$ | 0.00364%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                        |

#### 7.1.i h=10, p=3

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00555%            |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00642%            |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.147%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $32.0 \times 10^{-3}$  | $32.0 \times 10^{-3}$  | 2.41%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |
| Horizontal                     | normal       | $94.7 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.248%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Horizontal                     | shear        | $46.4 \times 10^{-3}$  | $47.0 \times 10^{-3}$  | 1.53%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

#### 7.1.j h=5, p=3

| Quantity                       |              | Measured value         | Reference value        | Relative difference     |
|--------------------------------|--------------|------------------------|------------------------|-------------------------|
| Tip                            | displacement | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $86.9 \times 10^{-6}\%$ |
| $u_y$                          |              |                        |                        |                         |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $121 \times 10^{-6}\%$  |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                         |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.0153%                 |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                         |

| Quantity          |                                | Measured value        | Reference value       | Relative difference |
|-------------------|--------------------------------|-----------------------|-----------------------|---------------------|
| Vertical stress   | shear $\ \tau_{yz}\ _{L^2}$    | $32.2 \times 10^{-3}$ | $32.2 \times 10^{-3}$ | 0.0333%             |
| Horizontal stress | normal $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$ | $94.9 \times 10^{-3}$ | 0.00664%            |
| Horizontal stress | shear $\ \tau_{yz}\ _{L^2}$    | $47.0 \times 10^{-3}$ | $47.0 \times 10^{-3}$ | 0.147%              |

#### 7.1.k h=2.5, p=3

| Quantity                |                                | Measured value         | Reference value        | Relative difference    |
|-------------------------|--------------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $903 \times 10^{-6}\%$ |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00107%               |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.00818%               |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.146%                 |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.0246%                |
| Horizontal stress       | shear $\ \tau_{yz}\ _{L^2}$    | $47.0 \times 10^{-3}$  | $47.1 \times 10^{-3}$  | 0.0148%                |

#### 7.1.l h=1.25, p=3

| Quantity                |                                | Measured value         | Reference value        | Relative difference    |
|-------------------------|--------------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $274 \times 10^{-6}\%$ |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $328 \times 10^{-6}\%$ |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | $198 \times 10^{-6}\%$ |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.0455%                |

| Quantity                                         |        | Measured value        | Reference value       | Relative difference |
|--------------------------------------------------|--------|-----------------------|-----------------------|---------------------|
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | normal | $94.9 \times 10^{-3}$ | $94.9 \times 10^{-3}$ | 0.00405%            |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | shear  | $47.1 \times 10^{-3}$ | $47.1 \times 10^{-3}$ | 0.00211%            |

### 7.1.m Centerline displacement profile

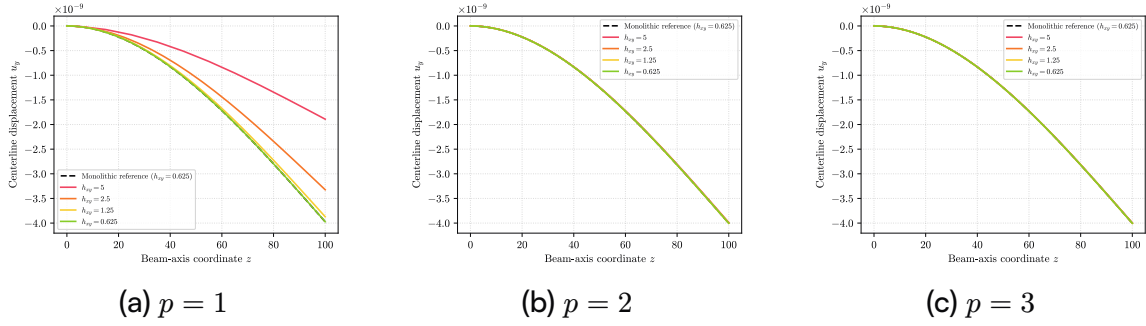


Figure 9: Bottom-centered one-third square: centerline displacement profiles under mesh refinement.

### 7.1.n Transverse normal-stress profile

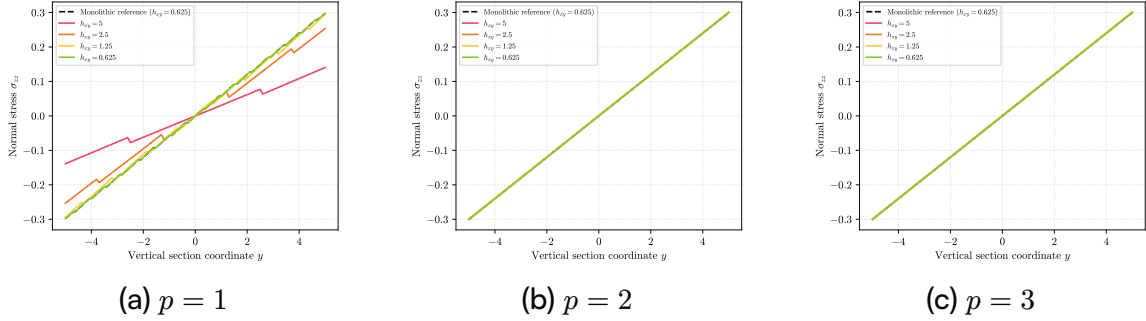


Figure 10: Bottom-centered one-third square: transverse normal-stress profiles under mesh refinement.

### 7.1.o Transverse shear-stress profile

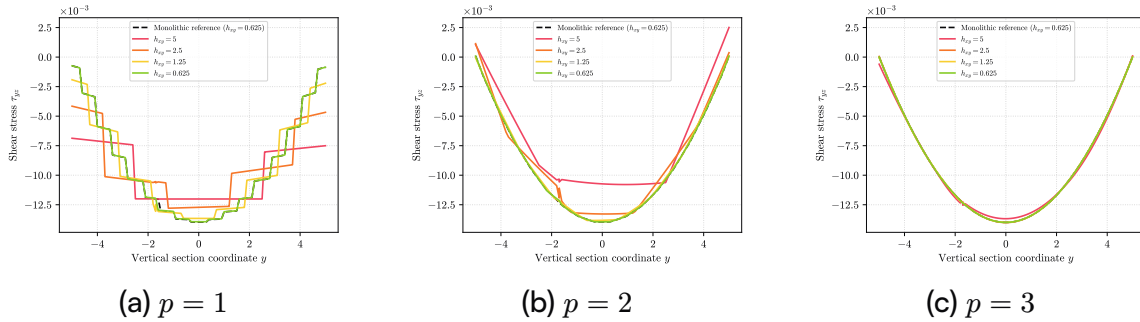


Figure 11: Bottom-centered one-third square: transverse shear-stress profiles under mesh refinement.

### 7.1.p Relative differences under refinement

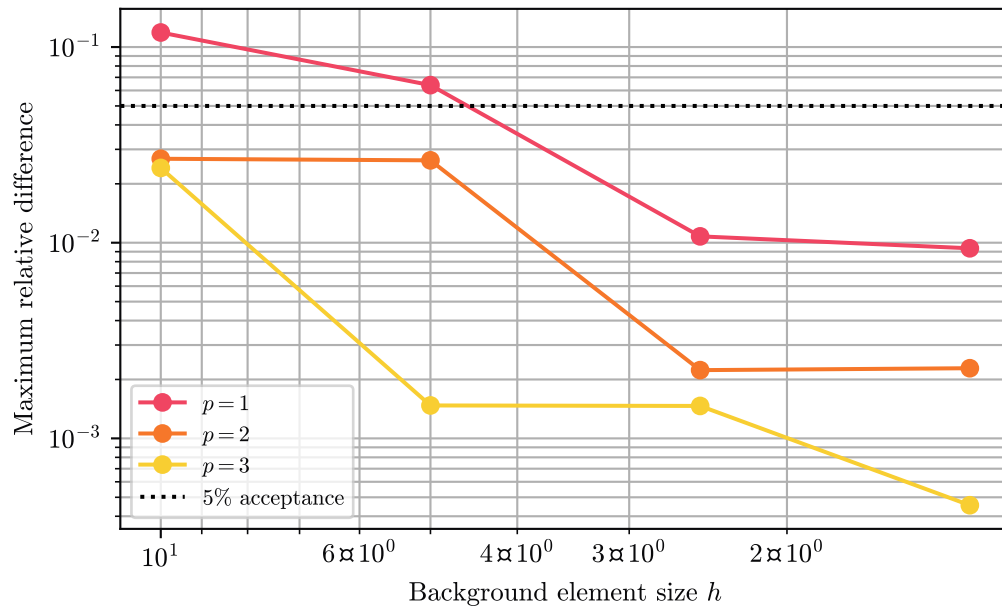


Figure 12: Bottom-centered one-third square: maximum homogeneous-response difference under refinement.

## 7.2 Bottom-left one-half square

### 7.2.a $h=10, p=1$

| Quantity               | Measured value         | Reference value        | Relative difference |
|------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$ | $-1.95 \times 10^{-9}$ | $-2.09 \times 10^{-9}$ | 6.52%               |

| Quantity                |                                   | Measured value        | Reference value       | Relative difference |
|-------------------------|-----------------------------------|-----------------------|-----------------------|---------------------|
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$           | $9.59 \times 10^{-9}$ | $10.2 \times 10^{-9}$ | 6.26%               |
| Vertical stress         | normal<br>$\ \sigma_{zz}\ _{L^2}$ | 0.256                 | 0.279                 | 8.35%               |
| Vertical stress         | shear<br>$\ \tau_{yz}\ _{L^2}$    | $32.0 \times 10^{-3}$ | $31.3 \times 10^{-3}$ | 7.75%               |
| Horizontal stress       | normal<br>$\ \sigma_{zz}\ _{L^2}$ | $45.4 \times 10^{-3}$ | $53.6 \times 10^{-3}$ | 18.6%               |
| Horizontal stress       | shear<br>$\ \tau_{yz}\ _{L^2}$    | $37.9 \times 10^{-3}$ | $36.1 \times 10^{-3}$ | 5.92%               |

#### 7.2.b h=5, p=1

| Quantity                |                                   | Measured value         | Reference value        | Relative difference |
|-------------------------|-----------------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                             | $-3.34 \times 10^{-9}$ | $-3.41 \times 10^{-9}$ | 2.13%               |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$           | $16.2 \times 10^{-9}$  | $16.6 \times 10^{-9}$  | 2.1%                |
| Vertical stress         | normal<br>$\ \sigma_{zz}\ _{L^2}$ | 0.459                  | 0.471                  | 2.74%               |
| Vertical stress         | shear<br>$\ \tau_{yz}\ _{L^2}$    | $31.1 \times 10^{-3}$  | $30.6 \times 10^{-3}$  | 8.78%               |
| Horizontal stress       | normal<br>$\ \sigma_{zz}\ _{L^2}$ | $87.2 \times 10^{-3}$  | $94.4 \times 10^{-3}$  | 10.2%               |
| Horizontal stress       | shear<br>$\ \tau_{yz}\ _{L^2}$    | $43.7 \times 10^{-3}$  | $43.9 \times 10^{-3}$  | 2.8%                |

#### 7.2.c h=2.5, p=1

| Quantity                |                         | Measured value         | Reference value        | Relative difference |
|-------------------------|-------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                   | $-3.87 \times 10^{-9}$ | $-3.88 \times 10^{-9}$ | 0.186%              |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$ | $18.8 \times 10^{-9}$  | $18.8 \times 10^{-9}$  | 0.184%              |

| Quantity                       |        | Measured value        | Reference value       | Relative difference |
|--------------------------------|--------|-----------------------|-----------------------|---------------------|
| Vertical                       | normal | 0.531                 | 0.533                 | 0.429%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Vertical                       | shear  | $31.8 \times 10^{-3}$ | $31.8 \times 10^{-3}$ | 0.828%              |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |
| Horizontal                     | normal | 0.104                 | 0.108                 | 6.01%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Horizontal                     | shear  | $46.7 \times 10^{-3}$ | $46.8 \times 10^{-3}$ | 0.698%              |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |

#### 7.2.d h=1.25, p=1

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.97 \times 10^{-9}$ | $-3.97 \times 10^{-9}$ | 0.0198%             |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.3 \times 10^{-9}$  | $19.3 \times 10^{-9}$  | 0.0197%             |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.544                  | 0.544                  | 0.119%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 0.48%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |
| Horizontal                     | normal       | $88.6 \times 10^{-3}$  | $90.1 \times 10^{-3}$  | 2.29%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Horizontal                     | shear        | $46.6 \times 10^{-3}$  | $46.7 \times 10^{-3}$  | 0.43%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

#### 7.2.e h=10, p=2

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.99 \times 10^{-9}$ | $-3.99 \times 10^{-9}$ | 0.0227%             |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.0278%             |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.0297%             |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |

| Quantity          |                                | Measured value        | Reference value       | Relative difference |
|-------------------|--------------------------------|-----------------------|-----------------------|---------------------|
| Vertical stress   | shear $\ \tau_{yz}\ _{L^2}$    | $26.6 \times 10^{-3}$ | $26.7 \times 10^{-3}$ | 4.83%               |
| Horizontal stress | normal $\ \sigma_{zz}\ _{L^2}$ | $94.5 \times 10^{-3}$ | $95.0 \times 10^{-3}$ | 0.793%              |
| Horizontal stress | shear $\ \tau_{yz}\ _{L^2}$    | $38.2 \times 10^{-3}$ | $37.5 \times 10^{-3}$ | 5.28%               |

#### 7.2.f h=5, p=2

| Quantity                |                                | Measured value         | Reference value        | Relative difference |
|-------------------------|--------------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00958%            |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.0116%             |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.0357%             |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $30.8 \times 10^{-3}$  | $30.8 \times 10^{-3}$  | 2.17%               |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $95.0 \times 10^{-3}$  | $94.8 \times 10^{-3}$  | 0.306%              |
| Horizontal stress       | shear $\ \tau_{yz}\ _{L^2}$    | $45.3 \times 10^{-3}$  | $45.2 \times 10^{-3}$  | 0.663%              |

#### 7.2.g h=2.5, p=2

| Quantity                |                                | Measured value         | Reference value        | Relative difference    |
|-------------------------|--------------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $750 \times 10^{-6}\%$ |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $915 \times 10^{-6}\%$ |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.0309%                |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $31.8 \times 10^{-3}$  | $31.8 \times 10^{-3}$  | 0.357%                 |



| Quantity          |                                | Measured value        | Reference value       | Relative difference |
|-------------------|--------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal stress | normal $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$ | $94.8 \times 10^{-3}$ | 0.079%              |
| Horizontal stress | shear $\ \tau_{yz}\ _{L^2}$    | $46.9 \times 10^{-3}$ | $46.9 \times 10^{-3}$ | 0.261%              |

#### 7.2.h h=1.25, p=2

| Quantity                |                                | Measured value         | Reference value        | Relative difference    |
|-------------------------|--------------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $177 \times 10^{-6}\%$ |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $210 \times 10^{-6}\%$ |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.00386%               |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 0.149%                 |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.00786%               |
| Horizontal stress       | shear $\ \tau_{yz}\ _{L^2}$    | $46.9 \times 10^{-3}$  | $46.9 \times 10^{-3}$  | 0.124%                 |

#### 7.2.i h=10, p=3

| Quantity                |                                | Measured value         | Reference value        | Relative difference |
|-------------------------|--------------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00183%            |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.0021%             |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.201%              |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $32.0 \times 10^{-3}$  | $32.0 \times 10^{-3}$  | 0.802%              |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $94.6 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.602%              |

| Quantity                                      | Measured value        | Reference value       | Relative difference |
|-----------------------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$ | $46.6 \times 10^{-3}$ | $47.0 \times 10^{-3}$ | 1.35%               |

#### 7.2.j h=5, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference |
|--------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00134%            |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00157%            |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.028%              |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.0406%             |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.135%              |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.0 \times 10^{-3}$  | $47.0 \times 10^{-3}$  | 0.0564%             |

#### 7.2.k h=2.5, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $227 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $269 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.00916%               |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.114%                 |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.0458%                |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.1 \times 10^{-3}$  | $47.1 \times 10^{-3}$  | 0.0515%                |

### 7.2.l $h=1.25, p=3$

| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $317 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $378 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | $651 \times 10^{-6}\%$ |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.0171%                |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.0092%                |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.1 \times 10^{-3}$  | $47.1 \times 10^{-3}$  | 0.00986%               |

### 7.2.m Centerline displacement profile

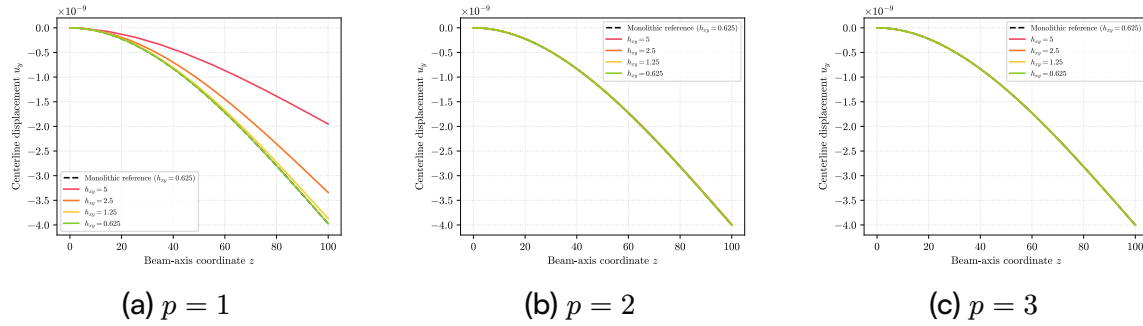


Figure 13: Bottom-left one-half square: centerline displacement profiles under mesh refinement.

### 7.2.n Transverse normal-stress profile

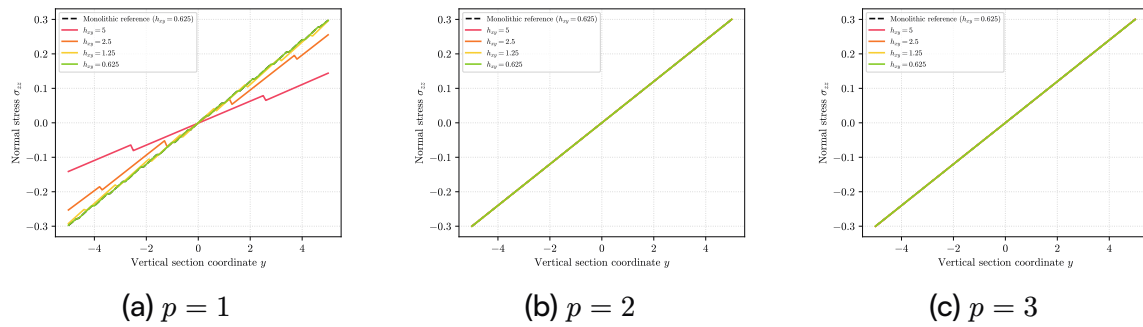


Figure 14: Bottom-left one-half square: transverse normal-stress profiles under mesh refinement.

## 7.2.o Transverse shear-stress profile

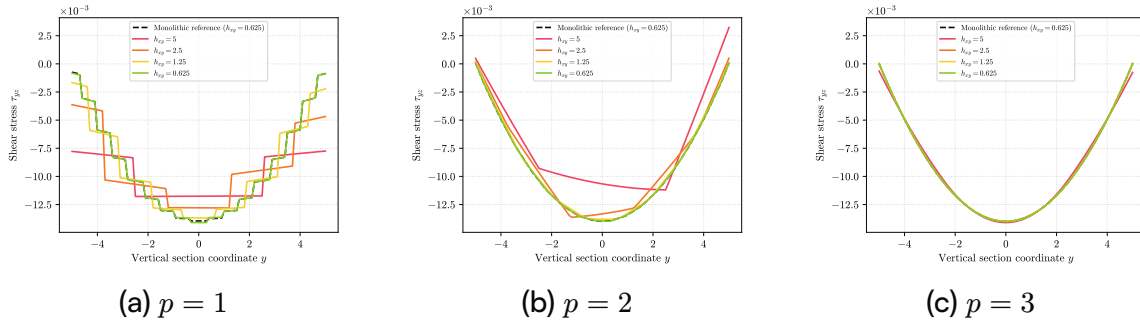


Figure 15: Bottom-left one-half square: transverse shear-stress profiles under mesh refinement.

## 7.2.p Relative differences under refinement

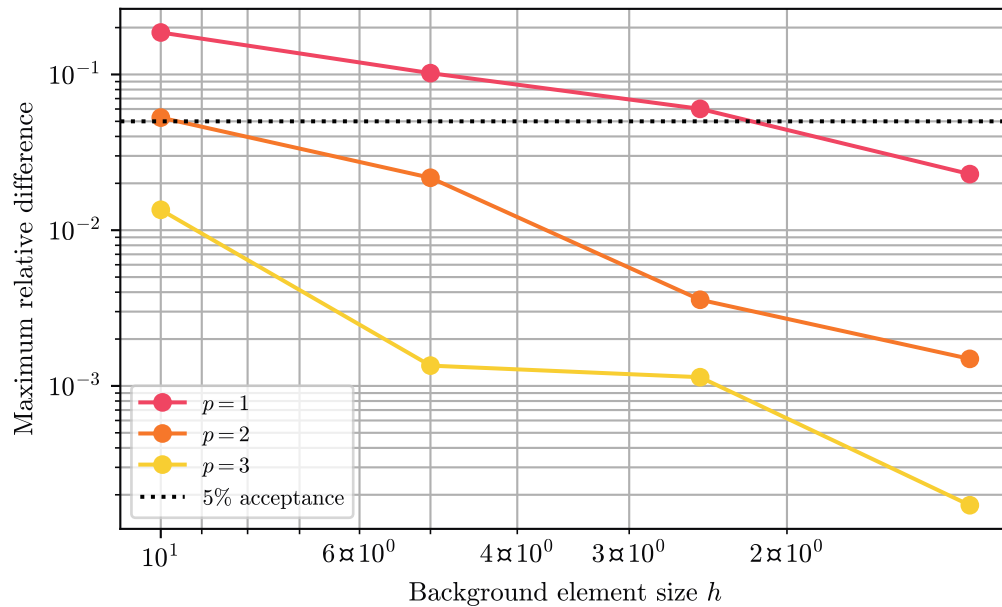


Figure 16: Bottom-left one-half square: maximum homogeneous-response difference under refinement.

## 7.3 Centered one-third square

### 7.3.a $h=10, p=1$

| Quantity               | Measured value         | Reference value        | Relative difference |
|------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$ | $-1.92 \times 10^{-9}$ | $-2.09 \times 10^{-9}$ | 7.89%               |

| Quantity                |                                   | Measured value        | Reference value       | Relative difference |
|-------------------------|-----------------------------------|-----------------------|-----------------------|---------------------|
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$           | $9.46 \times 10^{-9}$ | $10.2 \times 10^{-9}$ | 7.57%               |
| Vertical stress         | normal<br>$\ \sigma_{zz}\ _{L^2}$ | 0.251                 | 0.279                 | 10.2%               |
| Vertical stress         | shear<br>$\ \tau_{yz}\ _{L^2}$    | $32.0 \times 10^{-3}$ | $31.3 \times 10^{-3}$ | 11%                 |
| Horizontal stress       | normal<br>$\ \sigma_{zz}\ _{L^2}$ | $48.2 \times 10^{-3}$ | $53.6 \times 10^{-3}$ | 10.2%               |
| Horizontal stress       | shear<br>$\ \tau_{yz}\ _{L^2}$    | $39.0 \times 10^{-3}$ | $36.1 \times 10^{-3}$ | 8.45%               |

### 7.3.b h=5, p=1

| Quantity                |                                   | Measured value         | Reference value        | Relative difference |
|-------------------------|-----------------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                             | $-3.17 \times 10^{-9}$ | $-3.41 \times 10^{-9}$ | 7.06%               |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$           | $15.4 \times 10^{-9}$  | $16.6 \times 10^{-9}$  | 6.99%               |
| Vertical stress         | normal<br>$\ \sigma_{zz}\ _{L^2}$ | 0.434                  | 0.471                  | 7.85%               |
| Vertical stress         | shear<br>$\ \tau_{yz}\ _{L^2}$    | $31.0 \times 10^{-3}$  | $30.6 \times 10^{-3}$  | 3.11%               |
| Horizontal stress       | normal<br>$\ \sigma_{zz}\ _{L^2}$ | $87.2 \times 10^{-3}$  | $94.4 \times 10^{-3}$  | 7.72%               |
| Horizontal stress       | shear<br>$\ \tau_{yz}\ _{L^2}$    | $44.1 \times 10^{-3}$  | $43.9 \times 10^{-3}$  | 1.8%                |

### 7.3.c h=2.5, p=1

| Quantity                |                         | Measured value         | Reference value        | Relative difference |
|-------------------------|-------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                   | $-3.87 \times 10^{-9}$ | $-3.88 \times 10^{-9}$ | 0.293%              |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$ | $18.8 \times 10^{-9}$  | $18.8 \times 10^{-9}$  | 0.291%              |

| Quantity                       |        | Measured value        | Reference value       | Relative difference |
|--------------------------------|--------|-----------------------|-----------------------|---------------------|
| Vertical                       | normal | 0.531                 | 0.533                 | 0.424%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Vertical                       | shear  | $31.8 \times 10^{-3}$ | $31.8 \times 10^{-3}$ | 1.59%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |
| Horizontal                     | normal | 0.108                 | 0.108                 | 0.561%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Horizontal                     | shear  | $46.8 \times 10^{-3}$ | $46.8 \times 10^{-3}$ | 0.401%              |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |

#### 7.3.d h=1.25, p=1

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.97 \times 10^{-9}$ | $-3.97 \times 10^{-9}$ | 0.0566%             |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.3 \times 10^{-9}$  | $19.3 \times 10^{-9}$  | 0.0567%             |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.544                  | 0.544                  | 0.306%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 1.13%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |
| Horizontal                     | normal       | $90.1 \times 10^{-3}$  | $90.1 \times 10^{-3}$  | 0.161%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Horizontal                     | shear        | $46.7 \times 10^{-3}$  | $46.7 \times 10^{-3}$  | 0.101%              |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

#### 7.3.e h=10, p=2

| Quantity                       |              | Measured value         | Reference value        | Relative difference    |
|--------------------------------|--------------|------------------------|------------------------|------------------------|
| Tip                            | displacement | $-3.99 \times 10^{-9}$ | $-3.99 \times 10^{-9}$ | $569 \times 10^{-6}\%$ |
| $u_y$                          |              |                        |                        |                        |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.0039%                |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                        |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.108%                 |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                        |

| Quantity                       |        | Measured value        | Reference value       | Relative difference |
|--------------------------------|--------|-----------------------|-----------------------|---------------------|
| Vertical                       | shear  | $26.7 \times 10^{-3}$ | $26.7 \times 10^{-3}$ | 1.27%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |
| Horizontal                     | normal | $95.3 \times 10^{-3}$ | $95.0 \times 10^{-3}$ | 0.558%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Horizontal                     | shear  | $37.6 \times 10^{-3}$ | $37.5 \times 10^{-3}$ | 0.615%              |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |

### 7.3.f h=5, p=2

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00213%            |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00275%            |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.0171%             |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $30.8 \times 10^{-3}$  | $30.8 \times 10^{-3}$  | 0.782%              |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |
| Horizontal                     | normal       | $95.1 \times 10^{-3}$  | $94.8 \times 10^{-3}$  | 0.422%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Horizontal                     | shear        | $45.2 \times 10^{-3}$  | $45.2 \times 10^{-3}$  | 0.792%              |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

### 7.3.g h=2.5, p=2

| Quantity                       |              | Measured value         | Reference value        | Relative difference    |
|--------------------------------|--------------|------------------------|------------------------|------------------------|
| Tip                            | displacement | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $126 \times 10^{-6}\%$ |
| $u_y$                          |              |                        |                        |                        |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $144 \times 10^{-6}\%$ |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                        |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.016%                 |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                        |
| Vertical                       | shear        | $31.8 \times 10^{-3}$  | $31.8 \times 10^{-3}$  | 0.364%                 |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                        |

| Quantity          |                                | Measured value        | Reference value       | Relative difference |
|-------------------|--------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal stress | normal $\ \sigma_{zz}\ _{L^2}$ | $94.8 \times 10^{-3}$ | $94.8 \times 10^{-3}$ | 0.0359%             |
| Horizontal stress | shear $\ \tau_{yz}\ _{L^2}$    | $46.9 \times 10^{-3}$ | $46.9 \times 10^{-3}$ | 0.281%              |

### 7.3.h h=1.25, p=2

| Quantity                |                                | Measured value         | Reference value        | Relative difference     |
|-------------------------|--------------------------------|------------------------|------------------------|-------------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $87.5 \times 10^{-6}\%$ |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $107 \times 10^{-6}\%$  |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.00561%                |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 0.329%                  |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.0216%                 |
| Horizontal stress       | shear $\ \tau_{yz}\ _{L^2}$    | $46.9 \times 10^{-3}$  | $46.9 \times 10^{-3}$  | 0.0618%                 |

### 7.3.i h=10, p=3

| Quantity                |                                | Measured value         | Reference value        | Relative difference    |
|-------------------------|--------------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00235%               |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $527 \times 10^{-6}\%$ |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.129%                 |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $32.1 \times 10^{-3}$  | $32.0 \times 10^{-3}$  | 4.42%                  |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $94.5 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.898%                 |



| Quantity                                      | Measured value        | Reference value       | Relative difference |
|-----------------------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$ | $46.5 \times 10^{-3}$ | $47.0 \times 10^{-3}$ | 1.79%               |

### 7.3.j h=5, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $554 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $647 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.0285%                |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.112%                 |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $95.0 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.175%                 |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.0 \times 10^{-3}$  | $47.0 \times 10^{-3}$  | 0.183%                 |

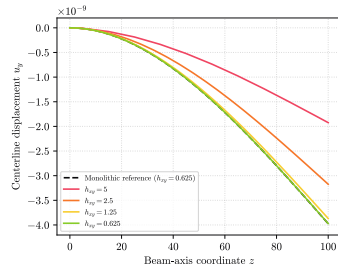
### 7.3.k h=2.5, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $120 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $134 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.0157%                |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.226%                 |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.0879%                |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.0 \times 10^{-3}$  | $47.1 \times 10^{-3}$  | 0.0327%                |

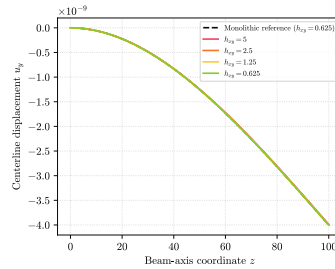
### 7.3.l $h=1.25, p=3$

| Quantity                                         | Measured value         | Reference value        | Relative difference     |
|--------------------------------------------------|------------------------|------------------------|-------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $83.5 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $101 \times 10^{-6}\%$  |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.00336%                |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.0211%                 |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.00912%                |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.1 \times 10^{-3}$  | $47.1 \times 10^{-3}$  | 0.0118%                 |

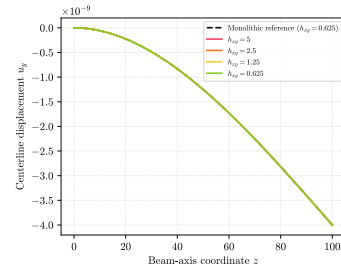
### 7.3.m Centerline displacement profile



(a)  $p = 1$



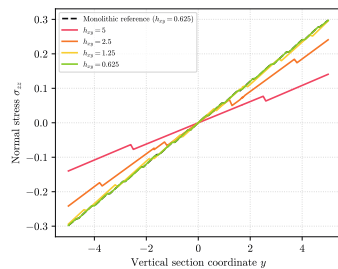
(b)  $p = 2$



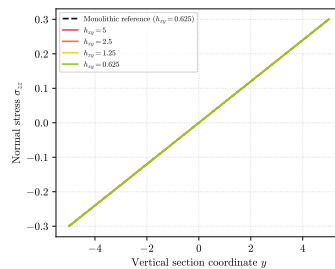
(c)  $p = 3$

Figure 17: Centered one-third square: centerline displacement profiles under mesh refinement.

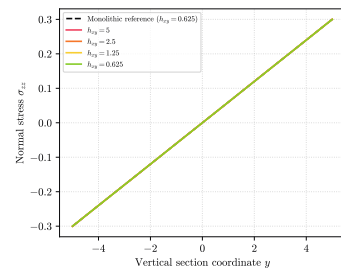
### 7.3.n Transverse normal-stress profile



(a)  $p = 1$



(b)  $p = 2$



(c)  $p = 3$

Figure 18: Centered one-third square: transverse normal-stress profiles under mesh refinement.

### 7.3.o Transverse shear-stress profile

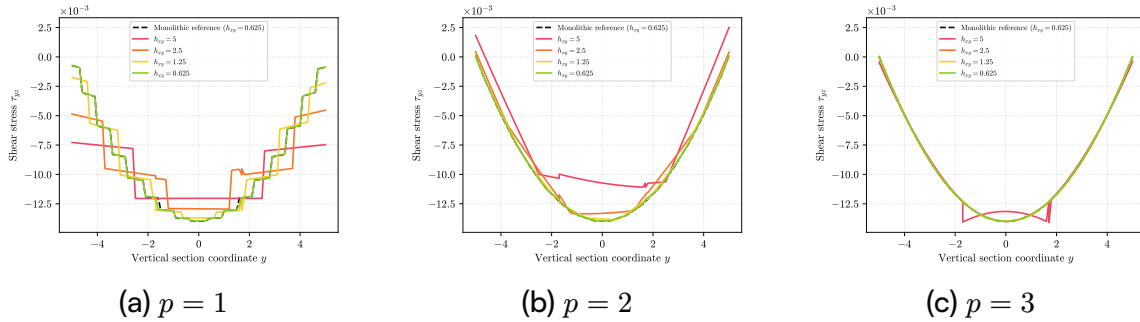


Figure 19: Centered one-third square: transverse shear-stress profiles under mesh refinement.

### 7.3.p Relative differences under refinement

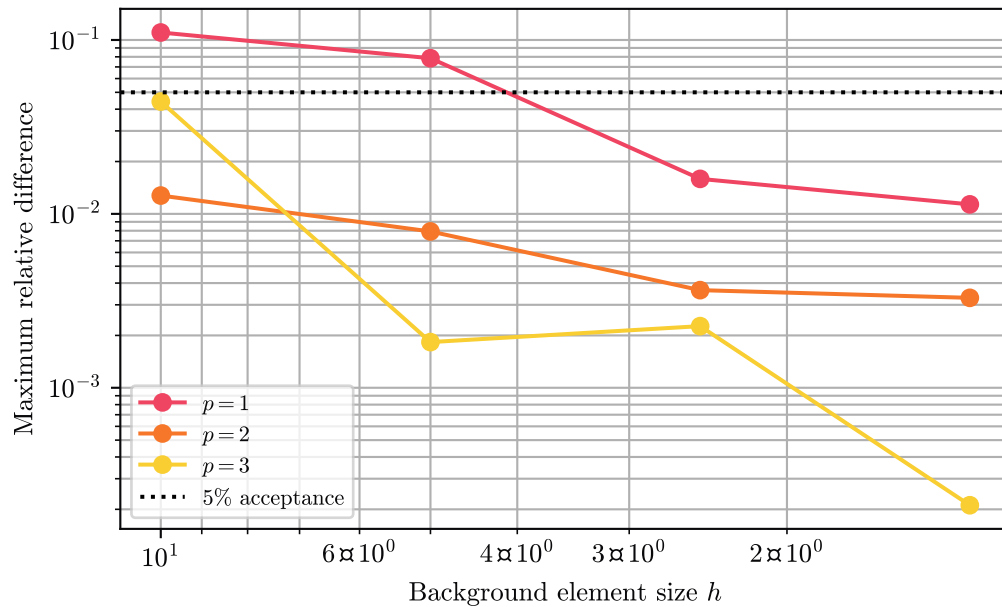


Figure 20: Centered one-third square: maximum homogeneous-response difference under refinement.

## 7.4 Zig-zag interface

### 7.4.a $h=10, p=1$

| Quantity               | Measured value         | Reference value        | Relative difference |
|------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$ | $-1.99 \times 10^{-9}$ | $-2.09 \times 10^{-9}$ | 4.56%               |

| Quantity                |                                   | Measured value        | Reference value       | Relative difference |
|-------------------------|-----------------------------------|-----------------------|-----------------------|---------------------|
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$           | $9.79 \times 10^{-9}$ | $10.2 \times 10^{-9}$ | 4.33%               |
| Vertical stress         | normal<br>$\ \sigma_{zz}\ _{L^2}$ | 0.264                 | 0.279                 | 5.48%               |
| Vertical stress         | shear<br>$\ \tau_{yz}\ _{L^2}$    | $31.6 \times 10^{-3}$ | $31.3 \times 10^{-3}$ | 4.29%               |
| Horizontal stress       | normal<br>$\ \sigma_{zz}\ _{L^2}$ | $50.7 \times 10^{-3}$ | $53.6 \times 10^{-3}$ | 6.81%               |
| Horizontal stress       | shear<br>$\ \tau_{yz}\ _{L^2}$    | $37.2 \times 10^{-3}$ | $36.1 \times 10^{-3}$ | 3.22%               |

#### 7.4.b h=5, p=1

| Quantity                |                                   | Measured value         | Reference value        | Relative difference |
|-------------------------|-----------------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                             | $-3.34 \times 10^{-9}$ | $-3.41 \times 10^{-9}$ | 2.18%               |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$           | $16.2 \times 10^{-9}$  | $16.6 \times 10^{-9}$  | 2.14%               |
| Vertical stress         | normal<br>$\ \sigma_{zz}\ _{L^2}$ | 0.459                  | 0.471                  | 2.75%               |
| Vertical stress         | shear<br>$\ \tau_{yz}\ _{L^2}$    | $30.9 \times 10^{-3}$  | $30.6 \times 10^{-3}$  | 6.14%               |
| Horizontal stress       | normal<br>$\ \sigma_{zz}\ _{L^2}$ | $92.8 \times 10^{-3}$  | $94.4 \times 10^{-3}$  | 3.48%               |
| Horizontal stress       | shear<br>$\ \tau_{yz}\ _{L^2}$    | $44.6 \times 10^{-3}$  | $43.9 \times 10^{-3}$  | 4.02%               |

#### 7.4.c h=2.5, p=1

| Quantity                |                         | Measured value         | Reference value        | Relative difference |
|-------------------------|-------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                   | $-3.87 \times 10^{-9}$ | $-3.88 \times 10^{-9}$ | 0.192%              |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$ | $18.8 \times 10^{-9}$  | $18.8 \times 10^{-9}$  | 0.19%               |

| Quantity                       |        | Measured value        | Reference value       | Relative difference |
|--------------------------------|--------|-----------------------|-----------------------|---------------------|
| Vertical                       | normal | 0.532                 | 0.533                 | 0.295%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Vertical                       | shear  | $31.8 \times 10^{-3}$ | $31.8 \times 10^{-3}$ | 1.13%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |
| Horizontal                     | normal | 0.107                 | 0.108                 | 2.02%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Horizontal                     | shear  | $46.6 \times 10^{-3}$ | $46.8 \times 10^{-3}$ | 0.627%              |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |

#### 7.4.d h=1.25, p=1

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.97 \times 10^{-9}$ | $-3.97 \times 10^{-9}$ | 0.0271%             |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.3 \times 10^{-9}$  | $19.3 \times 10^{-9}$  | 0.0269%             |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.544                  | 0.544                  | 0.133%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 1.16%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |
| Horizontal                     | normal       | $90.1 \times 10^{-3}$  | $90.1 \times 10^{-3}$  | 0.838%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Horizontal                     | shear        | $46.6 \times 10^{-3}$  | $46.7 \times 10^{-3}$  | 0.499%              |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

#### 7.4.e h=10, p=2

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.99 \times 10^{-9}$ | $-3.99 \times 10^{-9}$ | 0.0283%             |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.0335%             |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.0635%             |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |

| Quantity                       |        | Measured value        | Reference value       | Relative difference |
|--------------------------------|--------|-----------------------|-----------------------|---------------------|
| Vertical                       | shear  | $26.2 \times 10^{-3}$ | $26.7 \times 10^{-3}$ | 7.17%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |
| Horizontal                     | normal | $95.3 \times 10^{-3}$ | $95.0 \times 10^{-3}$ | 1.14%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Horizontal                     | shear  | $37.3 \times 10^{-3}$ | $37.5 \times 10^{-3}$ | 2.15%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |

#### 7.4.f h=5, p=2

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00223%            |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00296%            |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.00625%            |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $30.8 \times 10^{-3}$  | $30.8 \times 10^{-3}$  | 1.22%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |
| Horizontal                     | normal       | $95.0 \times 10^{-3}$  | $94.8 \times 10^{-3}$  | 0.294%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Horizontal                     | shear        | $45.0 \times 10^{-3}$  | $45.2 \times 10^{-3}$  | 0.807%              |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

#### 7.4.g h=2.5, p=2

| Quantity                       |              | Measured value         | Reference value        | Relative difference    |
|--------------------------------|--------------|------------------------|------------------------|------------------------|
| Tip                            | displacement | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $645 \times 10^{-6}\%$ |
| $u_y$                          |              |                        |                        |                        |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $751 \times 10^{-6}\%$ |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                        |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.0114%                |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                        |
| Vertical                       | shear        | $31.8 \times 10^{-3}$  | $31.8 \times 10^{-3}$  | 0.139%                 |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                        |

| Quantity          |                                | Measured value        | Reference value       | Relative difference |
|-------------------|--------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal stress | normal $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$ | $94.8 \times 10^{-3}$ | 0.0528%             |
| Horizontal stress | shear $\ \tau_{yz}\ _{L^2}$    | $46.8 \times 10^{-3}$ | $46.9 \times 10^{-3}$ | 0.561%              |

#### 7.4.h h=1.25, p=2

| Quantity                |                                | Measured value         | Reference value        | Relative difference    |
|-------------------------|--------------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $456 \times 10^{-6}\%$ |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $543 \times 10^{-6}\%$ |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.00128%               |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 0.142%                 |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.044%                 |
| Horizontal stress       | shear $\ \tau_{yz}\ _{L^2}$    | $46.9 \times 10^{-3}$  | $46.9 \times 10^{-3}$  | 0.0546%                |

#### 7.4.i h=10, p=3

| Quantity                |                                | Measured value         | Reference value        | Relative difference |
|-------------------------|--------------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00743%            |
| Centerline displacement | $\ u_y\ _{L^2}$                | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00885%            |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.0519%             |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $32.1 \times 10^{-3}$  | $32.0 \times 10^{-3}$  | 1.15%               |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $95.0 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.254%              |

| Quantity                                      | Measured value        | Reference value       | Relative difference |
|-----------------------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$ | $47.2 \times 10^{-3}$ | $47.0 \times 10^{-3}$ | 1.44%               |

#### 7.4.j h=5, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference |
|--------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00261%            |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00306%            |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.0168%             |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.415%              |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.8 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.147%              |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.0 \times 10^{-3}$  | $47.0 \times 10^{-3}$  | 0.459%              |

#### 7.4.k h=2.5, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $422 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $506 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.0063%                |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.193%                 |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.058%                 |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.0 \times 10^{-3}$  | $47.1 \times 10^{-3}$  | 0.269%                 |



#### 7.4.l $h=1.25, p=3$

| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $217 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $256 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | $620 \times 10^{-6}\%$ |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.46%                  |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.00508%               |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.1 \times 10^{-3}$  | $47.1 \times 10^{-3}$  | 0.265%                 |

#### 7.4.m Centerline displacement profile

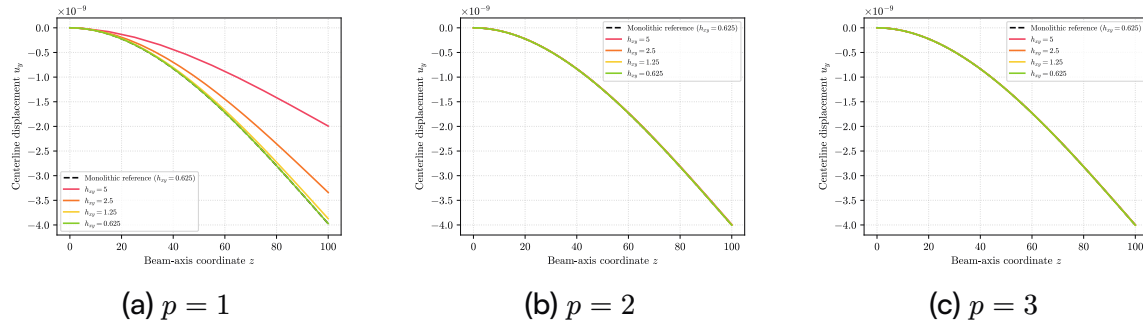


Figure 21: Zig-zag interface: centerline displacement profiles under mesh refinement.

#### 7.4.n Transverse normal-stress profile

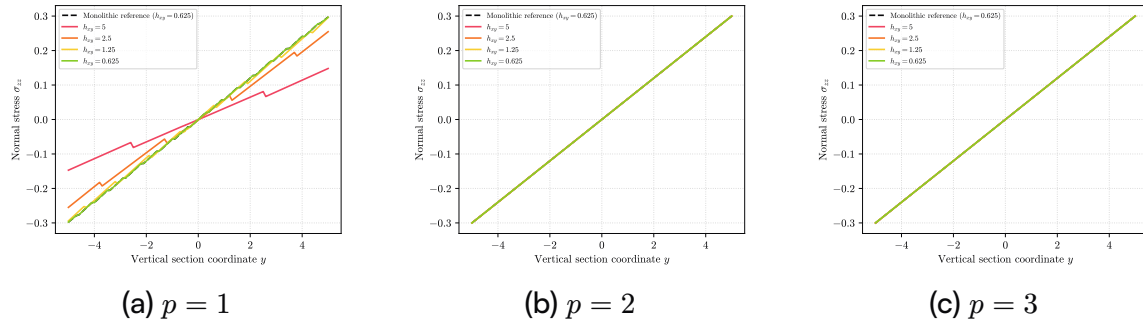


Figure 22: Zig-zag interface: transverse normal-stress profiles under mesh refinement.

#### 7.4.o Transverse shear-stress profile

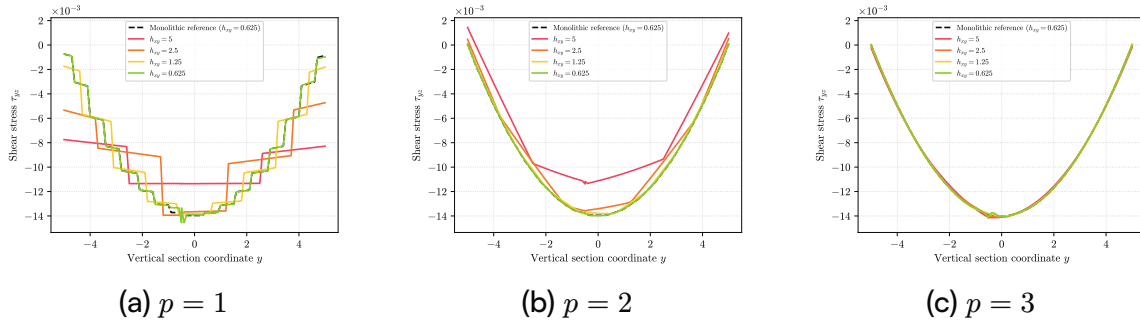


Figure 23: Zig-zag interface: transverse shear-stress profiles under mesh refinement.

#### 7.4.p Relative differences under refinement

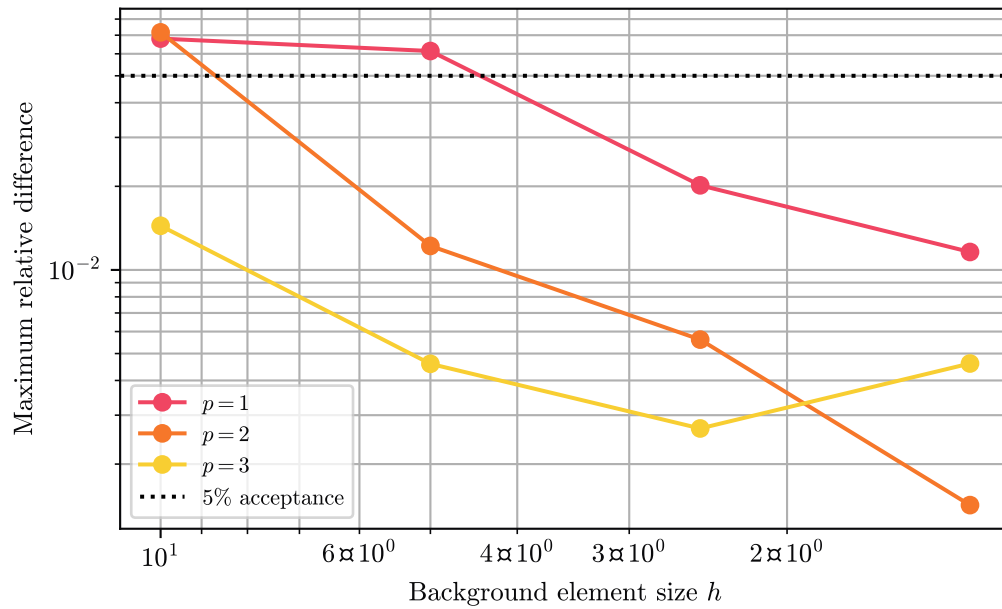


Figure 24: Zig-zag interface: maximum homogeneous-response difference under refinement.

### 7.5 Nested L interface

#### 7.5.a $h=10, p=1$

| Quantity   |                              | Measured value         | Reference value        | Relative difference |
|------------|------------------------------|------------------------|------------------------|---------------------|
| Tip        | displacement $u_y$           | $-1.97 \times 10^{-9}$ | $-2.09 \times 10^{-9}$ | 5.7%                |
| Centerline | displacement $\ u_y\ _{L^2}$ | $9.67 \times 10^{-9}$  | $10.2 \times 10^{-9}$  | 5.46%               |

| Quantity                       |        | Measured value        | Reference value       | Relative difference |
|--------------------------------|--------|-----------------------|-----------------------|---------------------|
| Vertical                       | normal | 0.259                 | 0.279                 | 7.17%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Vertical                       | shear  | $31.7 \times 10^{-3}$ | $31.3 \times 10^{-3}$ | 6.61%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |
| Horizontal                     | normal | $49.8 \times 10^{-3}$ | $53.6 \times 10^{-3}$ | 8.16%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Horizontal                     | shear  | $37.9 \times 10^{-3}$ | $36.1 \times 10^{-3}$ | 5.33%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |

#### 7.5.b h=5, p=1

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.27 \times 10^{-9}$ | $-3.41 \times 10^{-9}$ | 4.25%               |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $15.9 \times 10^{-9}$  | $16.6 \times 10^{-9}$  | 4.2%                |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.451                  | 0.471                  | 4.5%                |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $31.1 \times 10^{-3}$  | $30.6 \times 10^{-3}$  | 2.72%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |
| Horizontal                     | normal       | $91.7 \times 10^{-3}$  | $94.4 \times 10^{-3}$  | 5.81%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Horizontal                     | shear        | $44.2 \times 10^{-3}$  | $43.9 \times 10^{-3}$  | 3.01%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

#### 7.5.c h=2.5, p=1

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.87 \times 10^{-9}$ | $-3.88 \times 10^{-9}$ | 0.236%              |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $18.8 \times 10^{-9}$  | $18.8 \times 10^{-9}$  | 0.235%              |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.531                  | 0.533                  | 0.268%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |

| Quantity                       |        | Measured value        | Reference value       | Relative difference |
|--------------------------------|--------|-----------------------|-----------------------|---------------------|
| Vertical                       | shear  | $31.8 \times 10^{-3}$ | $31.8 \times 10^{-3}$ | 2.08%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |
| Horizontal                     | normal | 0.108                 | 0.108                 | 1.21%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Horizontal                     | shear  | $46.6 \times 10^{-3}$ | $46.8 \times 10^{-3}$ | 0.705%              |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |

#### 7.5.d h=1.25, p=1

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.97 \times 10^{-9}$ | $-3.97 \times 10^{-9}$ | 0.042%              |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.3 \times 10^{-9}$  | $19.3 \times 10^{-9}$  | 0.0421%             |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.544                  | 0.544                  | 0.153%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 0.394%              |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |
| Horizontal                     | normal       | $90.1 \times 10^{-3}$  | $90.1 \times 10^{-3}$  | 0.22%               |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Horizontal                     | shear        | $46.7 \times 10^{-3}$  | $46.7 \times 10^{-3}$  | 0.145%              |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

#### 7.5.e h=10, p=2

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.99 \times 10^{-9}$ | $-3.99 \times 10^{-9}$ | 0.0061%             |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00721%            |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.106%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $26.4 \times 10^{-3}$  | $26.7 \times 10^{-3}$  | 5.02%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

| Quantity          |                                | Measured value        | Reference value       | Relative difference |
|-------------------|--------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal stress | normal $\ \sigma_{zz}\ _{L^2}$ | $95.4 \times 10^{-3}$ | $95.0 \times 10^{-3}$ | 0.896%              |
| Horizontal stress | shear $\ \tau_{yz}\ _{L^2}$    | $39.1 \times 10^{-3}$ | $37.5 \times 10^{-3}$ | 8.02%               |

#### 7.5.f h=5, p=2

| Quantity                |                                | Measured value         | Reference value        | Relative difference |
|-------------------------|--------------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00741%            |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$        | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00917%            |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.11%               |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $30.8 \times 10^{-3}$  | $30.8 \times 10^{-3}$  | 3.45%               |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $95.1 \times 10^{-3}$  | $94.8 \times 10^{-3}$  | 0.459%              |
| Horizontal stress       | shear $\ \tau_{yz}\ _{L^2}$    | $45.2 \times 10^{-3}$  | $45.2 \times 10^{-3}$  | 0.832%              |

#### 7.5.g h=2.5, p=2

| Quantity                |                                | Measured value         | Reference value        | Relative difference    |
|-------------------------|--------------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $348 \times 10^{-6}\%$ |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$        | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $361 \times 10^{-6}\%$ |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.0146%                |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $31.8 \times 10^{-3}$  | $31.8 \times 10^{-3}$  | 1.01%                  |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.8 \times 10^{-3}$  | 0.0821%                |

| Quantity                                      | Measured value        | Reference value       | Relative difference |
|-----------------------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$ | $46.8 \times 10^{-3}$ | $46.9 \times 10^{-3}$ | 0.546%              |

#### 7.5.h h=1.25, p=2

| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $174 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $198 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.00781%               |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 0.147%                 |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.0388%                |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $46.9 \times 10^{-3}$  | $46.9 \times 10^{-3}$  | 0.0578%                |

#### 7.5.i h=10, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference |
|--------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00109%            |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00126%            |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.0291%             |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.1 \times 10^{-3}$  | $32.0 \times 10^{-3}$  | 0.992%              |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $95.0 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.433%              |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $46.9 \times 10^{-3}$  | $47.0 \times 10^{-3}$  | 1.38%               |

### 7.5.j h=5, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference |
|--------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00197%            |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00234%            |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.0299%             |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.229%              |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.8 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.191%              |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.0 \times 10^{-3}$  | $47.0 \times 10^{-3}$  | 0.392%              |

### 7.5.k h=2.5, p=3

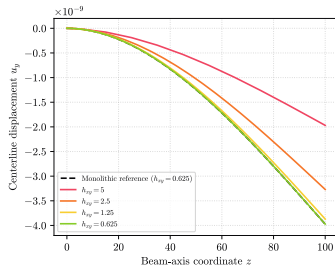
| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $499 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $597 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.00985%               |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.0595%                |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.1%                   |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.1 \times 10^{-3}$  | $47.1 \times 10^{-3}$  | 0.0749%                |

### 7.5.l h=1.25, p=3

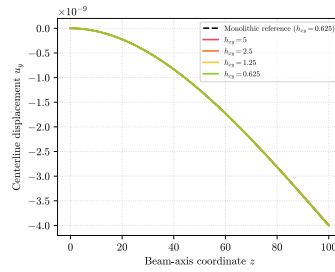
| Quantity               | Measured value         | Reference value        | Relative difference    |
|------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$ | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $230 \times 10^{-6}\%$ |

| Quantity                                  |        | Measured value        | Reference value       | Relative difference    |
|-------------------------------------------|--------|-----------------------|-----------------------|------------------------|
| Centerline displacement $\ u_y\ _{L^2}$   | dis-   | $19.4 \times 10^{-9}$ | $19.4 \times 10^{-9}$ | $271 \times 10^{-6}\%$ |
| Vertical stress $\ \sigma_{zz}\ _{L^2}$   | normal | 0.548                 | 0.548                 | 0.00192%               |
| Vertical stress $\ \tau_{yz}\ _{L^2}$     | shear  | $32.2 \times 10^{-3}$ | $32.2 \times 10^{-3}$ | 0.0289%                |
| Horizontal stress $\ \sigma_{zz}\ _{L^2}$ | normal | $94.9 \times 10^{-3}$ | $94.9 \times 10^{-3}$ | 0.0136%                |
| Horizontal stress $\ \tau_{yz}\ _{L^2}$   | shear  | $47.1 \times 10^{-3}$ | $47.1 \times 10^{-3}$ | 0.0194%                |

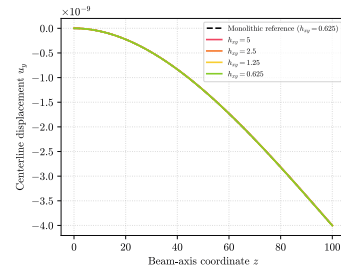
### 7.5.m Centerline displacement profile



(a)  $p = 1$



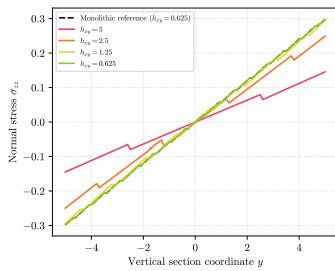
(b)  $p = 2$



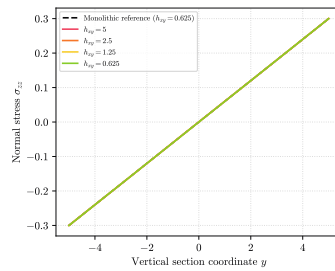
(c)  $p = 3$

Figure 25: Nested L interface: centerline displacement profiles under mesh refinement.

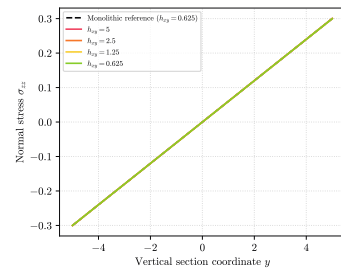
### 7.5.n Transverse normal-stress profile



(a)  $p = 1$



(b)  $p = 2$

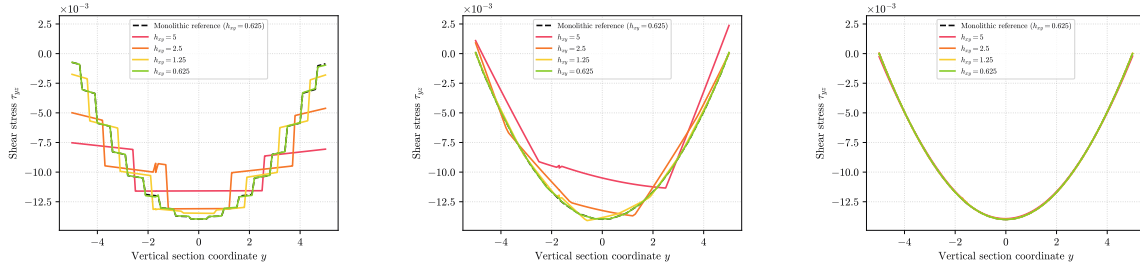


(c)  $p = 3$

Figure 26: Nested L interface: transverse normal-stress profiles under mesh refinement.



### 7.5.o Transverse shear-stress profile



a(a)  $p = 1$

a(b)  $p = 2$

a(c)  $p = 3$

Figure 27: Nested L interface: transverse shear-stress profiles under mesh refinement.

### 7.5.p Relative differences under refinement

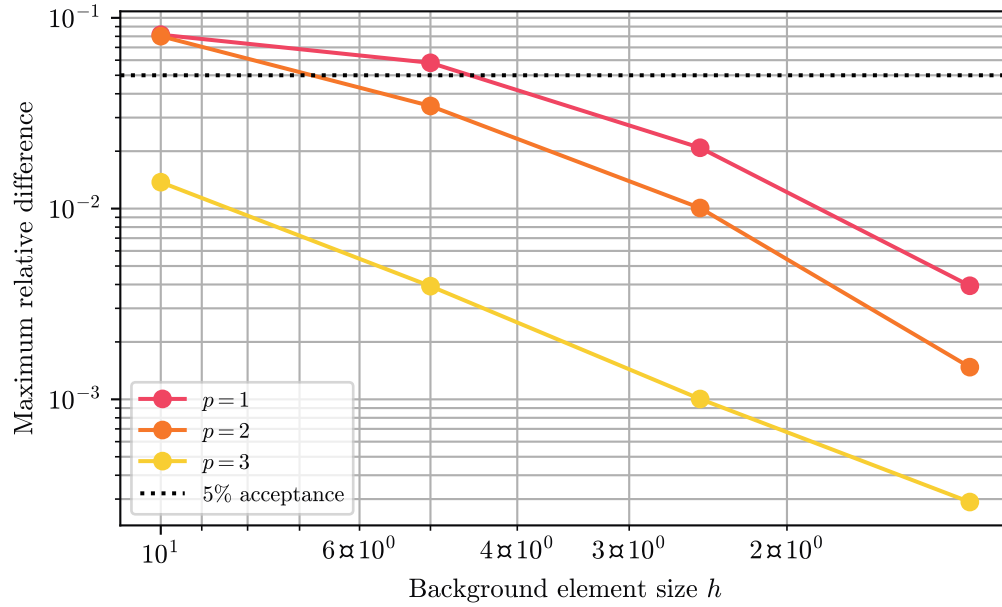


Figure 28: Nested L interface: maximum homogeneous-response difference under refinement.

## 7.6 Tetris partition

### 7.6.a $h=10, p=1$

| Quantity   |                 | Measured value         | Reference value        | Relative difference |
|------------|-----------------|------------------------|------------------------|---------------------|
| Tip        | displacement    | $-1.93 \times 10^{-9}$ | $-2.09 \times 10^{-9}$ | 7.82%               |
| $u_y$      |                 |                        |                        |                     |
| Centerline | dis-            | $9.46 \times 10^{-9}$  | $10.2 \times 10^{-9}$  | 7.6%                |
| placement  | $\ u_y\ _{L^2}$ |                        |                        |                     |

| Quantity   |                         | Measured value        | Reference value       | Relative difference |
|------------|-------------------------|-----------------------|-----------------------|---------------------|
| Vertical   | normal                  | 0.254                 | 0.279                 | 9.19%               |
| stress     | $\ \sigma_{zz}\ _{L^2}$ |                       |                       |                     |
| Vertical   | shear                   | $31.7 \times 10^{-3}$ | $31.3 \times 10^{-3}$ | 12.3%               |
| stress     | $\ \tau_{yz}\ _{L^2}$   |                       |                       |                     |
| Horizontal | normal                  | $48.7 \times 10^{-3}$ | $53.6 \times 10^{-3}$ | 9.33%               |
| stress     | $\ \sigma_{zz}\ _{L^2}$ |                       |                       |                     |
| Horizontal | shear                   | $39.0 \times 10^{-3}$ | $36.1 \times 10^{-3}$ | 8.45%               |
| stress     | $\ \tau_{yz}\ _{L^2}$   |                       |                       |                     |

#### 7.6.b h=5, p=1

| Quantity   |                         | Measured value         | Reference value        | Relative difference |
|------------|-------------------------|------------------------|------------------------|---------------------|
| Tip        | displacement            | $-3.17 \times 10^{-9}$ | $-3.41 \times 10^{-9}$ | 7.15%               |
| $u_y$      |                         |                        |                        |                     |
| Centerline | dis-                    | $15.4 \times 10^{-9}$  | $16.6 \times 10^{-9}$  | 7.08%               |
| placement  | $\ u_y\ _{L^2}$         |                        |                        |                     |
| Vertical   | normal                  | 0.435                  | 0.471                  | 7.83%               |
| stress     | $\ \sigma_{zz}\ _{L^2}$ |                        |                        |                     |
| Vertical   | shear                   | $31.2 \times 10^{-3}$  | $30.6 \times 10^{-3}$  | 4.9%                |
| stress     | $\ \tau_{yz}\ _{L^2}$   |                        |                        |                     |
| Horizontal | normal                  | $87.0 \times 10^{-3}$  | $94.4 \times 10^{-3}$  | 8.27%               |
| stress     | $\ \sigma_{zz}\ _{L^2}$ |                        |                        |                     |
| Horizontal | shear                   | $43.8 \times 10^{-3}$  | $43.9 \times 10^{-3}$  | 1.5%                |
| stress     | $\ \tau_{yz}\ _{L^2}$   |                        |                        |                     |

#### 7.6.c h=2.5, p=1

| Quantity   |                         | Measured value         | Reference value        | Relative difference |
|------------|-------------------------|------------------------|------------------------|---------------------|
| Tip        | displacement            | $-3.86 \times 10^{-9}$ | $-3.88 \times 10^{-9}$ | 0.394%              |
| $u_y$      |                         |                        |                        |                     |
| Centerline | dis-                    | $18.8 \times 10^{-9}$  | $18.8 \times 10^{-9}$  | 0.392%              |
| placement  | $\ u_y\ _{L^2}$         |                        |                        |                     |
| Vertical   | normal                  | 0.531                  | 0.533                  | 0.616%              |
| stress     | $\ \sigma_{zz}\ _{L^2}$ |                        |                        |                     |

| Quantity                       |        | Measured value        | Reference value       | Relative difference |
|--------------------------------|--------|-----------------------|-----------------------|---------------------|
| Vertical                       | shear  | $31.8 \times 10^{-3}$ | $31.8 \times 10^{-3}$ | 1.35%               |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |
| Horizontal                     | normal | 0.107                 | 0.108                 | 1.1%                |
| stress $\ \sigma_{zz}\ _{L^2}$ |        |                       |                       |                     |
| Horizontal                     | shear  | $46.8 \times 10^{-3}$ | $46.8 \times 10^{-3}$ | 0.0943%             |
| stress $\ \tau_{yz}\ _{L^2}$   |        |                       |                       |                     |

#### 7.6.d h=1.25, p=1

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.97 \times 10^{-9}$ | $-3.97 \times 10^{-9}$ | 0.0768%             |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.3 \times 10^{-9}$  | $19.3 \times 10^{-9}$  | 0.077%              |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.544                  | 0.544                  | 0.311%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 1.13%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |
| Horizontal                     | normal       | $90.1 \times 10^{-3}$  | $90.1 \times 10^{-3}$  | 0.223%              |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Horizontal                     | shear        | $46.7 \times 10^{-3}$  | $46.7 \times 10^{-3}$  | 0.107%              |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

#### 7.6.e h=10, p=2

| Quantity                       |              | Measured value         | Reference value        | Relative difference |
|--------------------------------|--------------|------------------------|------------------------|---------------------|
| Tip                            | displacement | $-3.99 \times 10^{-9}$ | $-3.99 \times 10^{-9}$ | 0.0152%             |
| $u_y$                          |              |                        |                        |                     |
| Centerline                     | dis-         | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.0173%             |
| placement $\ u_y\ _{L^2}$      |              |                        |                        |                     |
| Vertical                       | normal       | 0.548                  | 0.548                  | 0.0549%             |
| stress $\ \sigma_{zz}\ _{L^2}$ |              |                        |                        |                     |
| Vertical                       | shear        | $26.6 \times 10^{-3}$  | $26.7 \times 10^{-3}$  | 4.89%               |
| stress $\ \tau_{yz}\ _{L^2}$   |              |                        |                        |                     |

| Quantity          |                                | Measured value        | Reference value       | Relative difference |
|-------------------|--------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal stress | normal $\ \sigma_{zz}\ _{L^2}$ | $95.0 \times 10^{-3}$ | $95.0 \times 10^{-3}$ | 0.585%              |
| Horizontal stress | shear $\ \tau_{yz}\ _{L^2}$    | $36.8 \times 10^{-3}$ | $37.5 \times 10^{-3}$ | 2.69%               |

#### 7.6.f h=5, p=2

| Quantity                |                                | Measured value         | Reference value        | Relative difference |
|-------------------------|--------------------------------|------------------------|------------------------|---------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00511%            |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$        | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00635%            |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.0158%             |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $30.8 \times 10^{-3}$  | $30.8 \times 10^{-3}$  | 0.922%              |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $94.6 \times 10^{-3}$  | $94.8 \times 10^{-3}$  | 0.348%              |
| Horizontal stress       | shear $\ \tau_{yz}\ _{L^2}$    | $45.4 \times 10^{-3}$  | $45.2 \times 10^{-3}$  | 0.666%              |

#### 7.6.g h=2.5, p=2

| Quantity                |                                | Measured value         | Reference value        | Relative difference    |
|-------------------------|--------------------------------|------------------------|------------------------|------------------------|
| Tip displacement        | $u_y$                          | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $139 \times 10^{-6}\%$ |
| Centerline displacement | dis-<br>$\ u_y\ _{L^2}$        | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $194 \times 10^{-6}\%$ |
| Vertical stress         | normal $\ \sigma_{zz}\ _{L^2}$ | 0.548                  | 0.548                  | 0.0138%                |
| Vertical stress         | shear $\ \tau_{yz}\ _{L^2}$    | $31.8 \times 10^{-3}$  | $31.8 \times 10^{-3}$  | 0.349%                 |
| Horizontal stress       | normal $\ \sigma_{zz}\ _{L^2}$ | $94.8 \times 10^{-3}$  | $94.8 \times 10^{-3}$  | 0.0555%                |

| Quantity                                      | Measured value        | Reference value       | Relative difference |
|-----------------------------------------------|-----------------------|-----------------------|---------------------|
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$ | $46.9 \times 10^{-3}$ | $46.9 \times 10^{-3}$ | 0.155%              |

#### 7.6.h h=1.25, p=2

| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $447 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $538 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.00531%               |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.1 \times 10^{-3}$  | $32.1 \times 10^{-3}$  | 0.335%                 |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.0253%                |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $46.9 \times 10^{-3}$  | $46.9 \times 10^{-3}$  | 0.0473%                |

#### 7.6.i h=10, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference |
|--------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00862%            |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.0102%             |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.13%               |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.1 \times 10^{-3}$  | $32.0 \times 10^{-3}$  | 1.6%                |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.8 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.468%              |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.1 \times 10^{-3}$  | $47.0 \times 10^{-3}$  | 0.799%              |

### 7.6.j h=5, p=3

| Quantity                                         | Measured value         | Reference value        | Relative difference |
|--------------------------------------------------|------------------------|------------------------|---------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | 0.00187%            |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | 0.00225%            |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.0112%             |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.175%              |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.102%              |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.0 \times 10^{-3}$  | $47.0 \times 10^{-3}$  | 0.0945%             |

### 7.6.k h=2.5, p=3

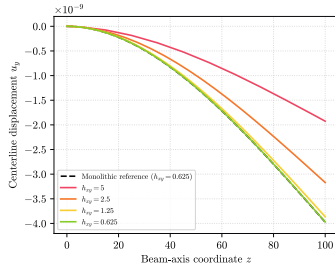
| Quantity                                         | Measured value         | Reference value        | Relative difference    |
|--------------------------------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$                           | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $788 \times 10^{-6}\%$ |
| Centerline displacement $\ u_y\ _{L^2}$          | $19.4 \times 10^{-9}$  | $19.4 \times 10^{-9}$  | $936 \times 10^{-6}\%$ |
| Vertical normal stress $\ \sigma_{zz}\ _{L^2}$   | 0.548                  | 0.548                  | 0.0184%                |
| Vertical shear stress $\ \tau_{yz}\ _{L^2}$      | $32.2 \times 10^{-3}$  | $32.2 \times 10^{-3}$  | 0.366%                 |
| Horizontal normal stress $\ \sigma_{zz}\ _{L^2}$ | $94.9 \times 10^{-3}$  | $94.9 \times 10^{-3}$  | 0.0806%                |
| Horizontal shear stress $\ \tau_{yz}\ _{L^2}$    | $47.1 \times 10^{-3}$  | $47.1 \times 10^{-3}$  | 0.017%                 |

### 7.6.l h=1.25, p=3

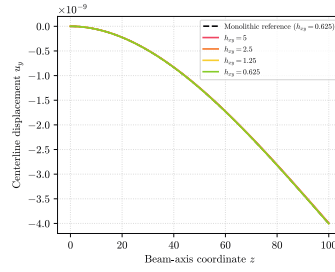
| Quantity               | Measured value         | Reference value        | Relative difference    |
|------------------------|------------------------|------------------------|------------------------|
| Tip displacement $u_y$ | $-4.00 \times 10^{-9}$ | $-4.00 \times 10^{-9}$ | $267 \times 10^{-6}\%$ |

| Quantity                                  |        | Measured value        | Reference value       | Relative difference    |
|-------------------------------------------|--------|-----------------------|-----------------------|------------------------|
| Centerline displacement $\ u_y\ _{L^2}$   | dis-   | $19.4 \times 10^{-9}$ | $19.4 \times 10^{-9}$ | $320 \times 10^{-6}\%$ |
| Vertical stress $\ \sigma_{zz}\ _{L^2}$   | normal | 0.548                 | 0.548                 | 0.0033%                |
| Vertical stress $\ \tau_{yz}\ _{L^2}$     | shear  | $32.2 \times 10^{-3}$ | $32.2 \times 10^{-3}$ | 0.0264%                |
| Horizontal stress $\ \sigma_{zz}\ _{L^2}$ | normal | $94.9 \times 10^{-3}$ | $94.9 \times 10^{-3}$ | 0.011%                 |
| Horizontal stress $\ \tau_{yz}\ _{L^2}$   | shear  | $47.1 \times 10^{-3}$ | $47.1 \times 10^{-3}$ | 0.0148%                |

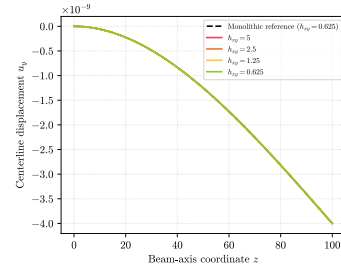
### 7.6.m Centerline displacement profile



c(a)  $p = 1$



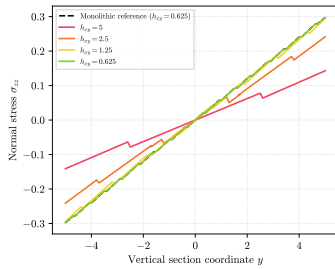
c(b)  $p = 2$



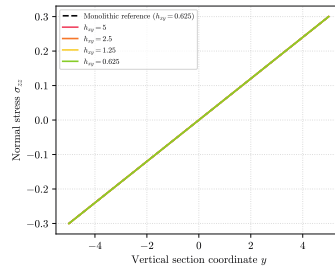
c(c)  $p = 3$

Figure 29: Tetris partition: centerline displacement profiles under mesh refinement.

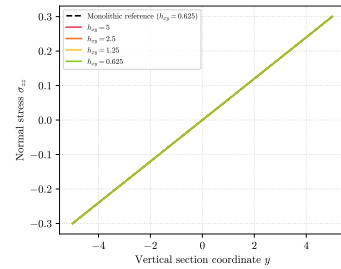
### 7.6.n Transverse normal-stress profile



d(a)  $p = 1$



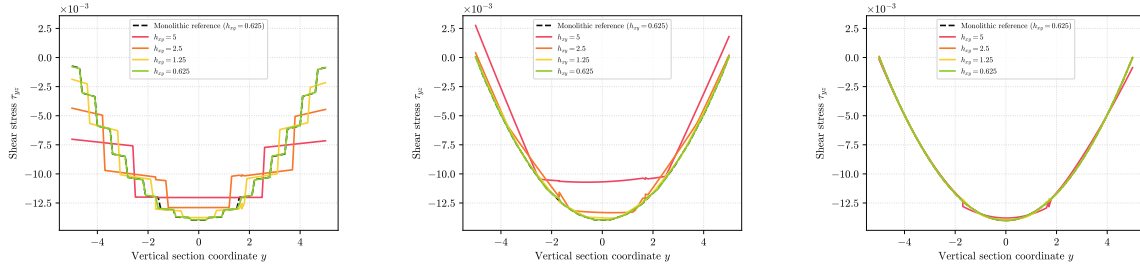
d(b)  $p = 2$



d(c)  $p = 3$

Figure 30: Tetris partition: transverse normal-stress profiles under mesh refinement.

### 7.6.o Transverse shear-stress profile



e(a)  $p = 1$

e(b)  $p = 2$

e(c)  $p = 3$

Figure 31: Tetris partition: transverse shear-stress profiles under mesh refinement.

### 7.6.p Relative differences under refinement

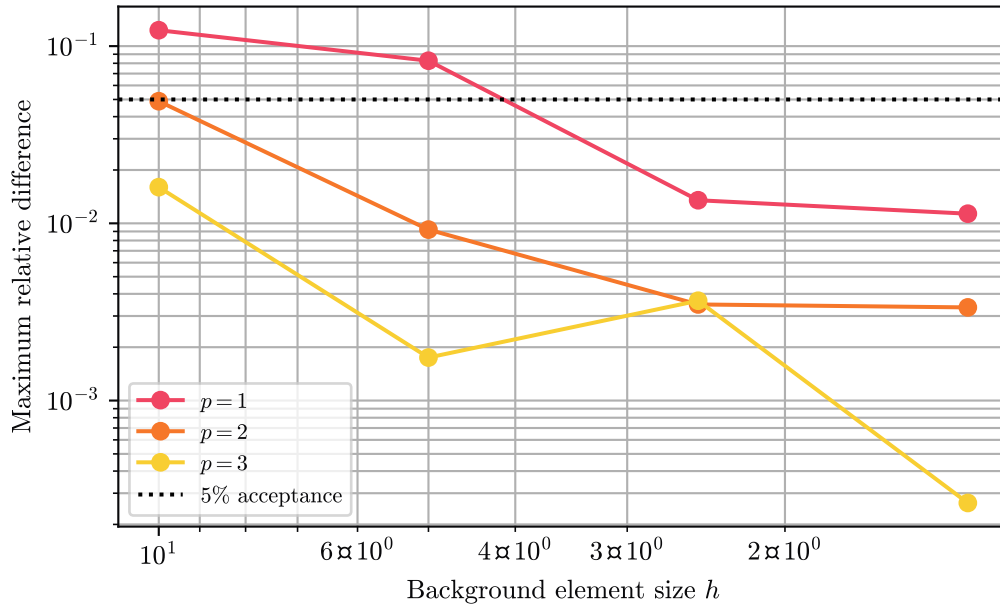


Figure 32: Tetris partition: maximum homogeneous-response difference under refinement.

## 8 Performance

Trimming and Abaqus solve statistics are reported for every mesh level and degree, grouped by geometry. Abaqus problem size, timing, completion, and actual thread topology come from a sanitized JSON record generated from `abaqus summarize -detail advanced` and the solver message file. The raw summary files can contain host, user, and absolute-path data, so they are not published.

### 8.1 Monolithic reference

Coreform IGA Mesh



### 8.1.a $p = 1$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 325        | 99     | 90      | 1    | 4.0           |
| 5     | 1,127      | 525    | 354     | 2    | 9.8           |
| 2.5   | 5,203      | 3,321  | 1,410   | 4    | 33.0          |
| 1.25  | 29,963     | 23,409 | 5,634   | 8    | 152.5         |

### 8.1.b $p = 2$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 735        | 99     | 90      | 1    | 4.2           |
| 5     | 2,025      | 525    | 354     | 2    | 10.3          |
| 2.5   | 7,605      | 3,321  | 1,410   | 4    | 37.2          |
| 1.25  | 37,485     | 23,409 | 5,634   | 8    | 164.4         |

### 8.1.c $p = 3$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 1,377      | 99     | 90      | 1    | 6.6           |
| 5     | 3,267      | 525    | 354     | 2    | 11.8          |
| 2.5   | 10,575     | 3,321  | 1,410   | 4    | 41.3          |
| 1.25  | 46,023     | 23,409 | 5,634   | 8    | 170.7         |

## Coreform IGA for Abaqus solve

### 8.1.d $p = 1$

| $h_z$ | Elements | Nodes  | DOFs   | Threads | Wall-time [s] |
|-------|----------|--------|--------|---------|---------------|
| 10    | 579      | 482    | 1,446  | 1       | 1.0           |
| 5     | 1,137    | 1,152  | 3,456  | 2       | 1.0           |
| 2.5   | 4,345    | 4,778  | 14,334 | 4       | 1.0           |
| 1.25  | 26,605   | 28,296 | 84,888 | 8       | 6.0           |

### 8.1.e $p = 2$

| $h_z$ | Elements | Nodes | DOFs  | Threads | Wall-time [s] |
|-------|----------|-------|-------|---------|---------------|
| 10    | 575      | 613   | 1,839 | 1       | 1.0           |

| $h_z$ | Elements | Nodes  | DOFs   | Threads | Wall-time [s] |
|-------|----------|--------|--------|---------|---------------|
| 5     | 1,137    | 1,487  | 4,461  | 2       | 1.0           |
| 2.5   | 4,345    | 5,781  | 17,343 | 4       | 3.0           |
| 1.25  | 27,055   | 31,916 | 95,748 | 8       | 19.0          |

### 8.1.f $p = 3$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 571      | 786    | 2,358   | 1       | 2.0           |
| 5     | 1,137    | 1,896  | 5,688   | 2       | 5.0           |
| 2.5   | 4,993    | 7,274  | 21,822  | 4       | 18.0          |
| 1.25  | 29,817   | 37,002 | 111,006 | 8       | 82.0          |

## 8.2 Bottom-centered one-third square

Coreform IGA Mesh

### 8.2.a $p = 1$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 325        | 132    | 110     | 1    | 5.4           |
| 5     | 1,127      | 630    | 390     | 2    | 14.2          |
| 2.5   | 5,203      | 3,690  | 1,638   | 4    | 46.1          |
| 1.25  | 29,963     | 24,786 | 6,374   | 8    | 214.9         |

### 8.2.b $p = 2$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 735        | 132    | 110     | 1    | 5.9           |
| 5     | 2,025      | 630    | 390     | 2    | 15.2          |
| 2.5   | 7,605      | 3,690  | 1,638   | 4    | 51.6          |
| 1.25  | 37,485     | 24,786 | 6,374   | 8    | 236.1         |

### 8.2.c $p = 3$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 1,377      | 132    | 110     | 1    | 9.4           |
| 5     | 3,267      | 630    | 390     | 2    | 16.8          |

| $h_z$ | Background | Active | Trimmed | CPU's | Wall-time [s] |
|-------|------------|--------|---------|-------|---------------|
| 2.5   | 10,575     | 3,690  | 1,638   | 4     | 57.4          |
| 1.25  | 46,023     | 24,786 | 6,374   | 8     | 252.8         |

Coreform IGA for Abaqus solve

#### 8.2.d $p = 1$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 5,556    | 3,696  | 11,088  | 1       | 2.0           |
| 5     | 7,062    | 4,974  | 14,922  | 2       | 2.0           |
| 2.5   | 12,406   | 10,172 | 30,516  | 4       | 3.0           |
| 1.25  | 48,538   | 42,586 | 127,758 | 8       | 8.0           |

#### 8.2.e $p = 2$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 5,648    | 3,982  | 11,946  | 1       | 4.0           |
| 5     | 7,302    | 5,654  | 16,962  | 2       | 4.0           |
| 2.5   | 12,406   | 11,750 | 35,250  | 4       | 6.0           |
| 1.25  | 50,212   | 48,647 | 145,941 | 8       | 21.0          |

#### 8.2.f $p = 3$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 5,644    | 4,299  | 12,897  | 1       | 5.0           |
| 5     | 7,366    | 6,380  | 19,140  | 2       | 9.0           |
| 2.5   | 15,158   | 15,020 | 45,060  | 4       | 22.0          |
| 1.25  | 64,942   | 62,052 | 186,156 | 8       | 107.0         |

### 8.3 Bottom-left one-half square

Coreform IGA Mesh

#### 8.3.a $p = 1$

| $h_z$ | Background | Active | Trimmed | CPU's | Wall-time [s] |
|-------|------------|--------|---------|-------|---------------|
| 10    | 325        | 132    | 88      | 1     | 5.6           |
| 5     | 1,127      | 630    | 346     | 2     | 14.2          |

| $h_z$ | Background | Active | Trimmed | CPU's | Wall-time [s] |
|-------|------------|--------|---------|-------|---------------|
| 2.5   | 5,203      | 3,690  | 1,378   | 4     | 45.0          |
| 1.25  | 29,963     | 24,786 | 5,506   | 8     | 219.5         |

### 8.3.b $p = 2$

| $h_z$ | Background | Active | Trimmed | CPU's | Wall-time [s] |
|-------|------------|--------|---------|-------|---------------|
| 10    | 735        | 132    | 88      | 1     | 6.0           |
| 5     | 2,025      | 630    | 346     | 2     | 14.8          |
| 2.5   | 7,605      | 3,690  | 1,378   | 4     | 54.5          |
| 1.25  | 37,485     | 24,786 | 5,506   | 8     | 223.6         |

### 8.3.c $p = 3$

| $h_z$ | Background | Active | Trimmed | CPU's | Wall-time [s] |
|-------|------------|--------|---------|-------|---------------|
| 10    | 1,377      | 132    | 88      | 1     | 8.8           |
| 5     | 3,267      | 630    | 346     | 2     | 15.9          |
| 2.5   | 10,575     | 3,690  | 1,378   | 4     | 56.6          |
| 1.25  | 46,023     | 24,786 | 5,506   | 8     | 244.4         |

## Coreform IGA for Abaqus solve

### 8.3.d $p = 1$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 5,534    | 3,505  | 10,515  | 1       | 1.0           |
| 5     | 6,918    | 4,738  | 14,214  | 2       | 3.0           |
| 2.5   | 11,522   | 9,576  | 28,728  | 4       | 4.0           |
| 1.25  | 47,298   | 41,780 | 125,340 | 8       | 8.0           |

### 8.3.e $p = 2$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 5,634    | 3,795  | 11,385  | 1       | 2.0           |
| 5     | 7,078    | 5,380  | 16,140  | 2       | 4.0           |
| 2.5   | 11,522   | 11,158 | 33,474  | 4       | 6.0           |
| 1.25  | 48,870   | 47,776 | 143,328 | 8       | 21.0          |

### 8.3.f $p = 3$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 5,580    | 4,090  | 12,270  | 1       | 5.0           |
| 5     | 7,158    | 6,118  | 18,354  | 2       | 8.0           |
| 2.5   | 14,494   | 14,548 | 43,644  | 4       | 22.0          |
| 1.25  | 63,590   | 61,092 | 183,276 | 8       | 126.0         |

## 8.4 Centered one-third square

### Coreform IGA Mesh

#### 8.4.a $p = 1$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 325        | 110    | 99      | 1    | 5.2           |
| 5     | 1,127      | 693    | 504     | 2    | 18.7          |
| 2.5   | 5,203      | 3,649  | 1,720   | 4    | 48.2          |
| 1.25  | 29,963     | 25,353 | 7,480   | 8    | 245.4         |

#### 8.4.b $p = 2$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 735        | 110    | 99      | 1    | 5.6           |
| 5     | 2,025      | 693    | 504     | 2    | 19.3          |
| 2.5   | 7,605      | 3,649  | 1,720   | 4    | 49.4          |
| 1.25  | 37,485     | 25,353 | 7,480   | 8    | 261.7         |

#### 8.4.c $p = 3$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 1,377      | 110    | 99      | 1    | 8.2           |
| 5     | 3,267      | 693    | 504     | 2    | 22.1          |
| 2.5   | 10,575     | 3,649  | 1,720   | 4    | 59.8          |
| 1.25  | 46,023     | 25,353 | 7,480   | 8    | 291.2         |

### Coreform IGA for Abaqus solve

#### 8.4.d $p = 1$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 6,518    | 4,334  | 13,002  | 1       | 4.0           |
| 5     | 9,993    | 6,672  | 20,016  | 2       | 3.0           |
| 2.5   | 14,513   | 11,442 | 34,326  | 4       | 2.0           |
| 1.25  | 57,941   | 48,232 | 144,696 | 8       | 12.0          |

#### 8.4.e $p = 2$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 6,642    | 4,614  | 13,842  | 1       | 3.0           |
| 5     | 10,249   | 7,362  | 22,086  | 2       | 3.0           |
| 2.5   | 14,513   | 12,848 | 38,544  | 4       | 6.0           |
| 1.25  | 60,119   | 54,816 | 164,448 | 8       | 27.0          |

#### 8.4.f $p = 3$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 6,344    | 4,743  | 14,229  | 1       | 7.0           |
| 5     | 10,377   | 8,120  | 24,360  | 2       | 13.0          |
| 2.5   | 17,609   | 16,122 | 48,366  | 4       | 23.0          |
| 1.25  | 78,465   | 70,226 | 210,678 | 8       | 166.0         |

### 8.5 Zig-zag interface

#### Coreform IGA Mesh

#### 8.5.a $p = 1$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 325        | 132    | 66      | 1    | 5.8           |
| 5     | 1,127      | 630    | 258     | 2    | 14.4          |
| 2.5   | 5,203      | 3,690  | 1,026   | 4    | 48.4          |
| 1.25  | 29,963     | 24,786 | 4,098   | 8    | 211.0         |

### 8.5.b $p = 2$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 735        | 132    | 66      | 1    | 6.0           |
| 5     | 2,025      | 630    | 258     | 2    | 15.2          |
| 2.5   | 7,605      | 3,690  | 1,026   | 4    | 49.8          |
| 1.25  | 37,485     | 24,786 | 4,098   | 8    | 223.7         |

### 8.5.c $p = 3$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 1,377      | 132    | 66      | 1    | 9.3           |
| 5     | 3,267      | 630    | 258     | 2    | 16.0          |
| 2.5   | 10,575     | 3,690  | 1,026   | 4    | 57.2          |
| 1.25  | 46,023     | 24,786 | 4,098   | 8    | 257.8         |

## Coreform IGA for Abaqus solve

### 8.5.d $p = 1$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 6,200    | 4,026  | 12,078  | 1       | 3.0           |
| 5     | 7,442    | 5,212  | 15,636  | 2       | 1.0           |
| 2.5   | 13,514   | 10,830 | 32,490  | 4       | 4.0           |
| 1.25  | 51,154   | 44,414 | 133,242 | 8       | 10.0          |

### 8.5.e $p = 2$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 6,310    | 4,323  | 12,969  | 1       | 2.0           |
| 5     | 7,610    | 5,904  | 17,712  | 2       | 4.0           |
| 2.5   | 13,514   | 12,498 | 37,494  | 4       | 5.0           |
| 1.25  | 53,138   | 51,132 | 153,396 | 8       | 29.0          |

### 8.5.f $p = 3$

| $h_z$ | Elements | Nodes | DOFs   | Threads | Wall-time [s] |
|-------|----------|-------|--------|---------|---------------|
| 10    | 6,278    | 4,629 | 13,887 | 1       | 5.0           |

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 5     | 8,038    | 6,868  | 20,604  | 2       | 10.0          |
| 2.5   | 16,002   | 15,734 | 47,202  | 4       | 25.0          |
| 1.25  | 69,778   | 66,026 | 198,078 | 8       | 150.0         |

## 8.6 Nested L interface

### Coreform IGA Mesh

#### 8.6.a $p = 1$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 325        | 132    | 66      | 1    | 5.4           |
| 5     | 1,127      | 672    | 298     | 2    | 16.8          |
| 2.5   | 5,203      | 3,772  | 1,106   | 4    | 49.9          |
| 1.25  | 29,963     | 25,272 | 4,578   | 8    | 247.6         |

#### 8.6.b $p = 2$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 735        | 132    | 66      | 1    | 5.8           |
| 5     | 2,025      | 672    | 298     | 2    | 17.3          |
| 2.5   | 7,605      | 3,772  | 1,106   | 4    | 55.1          |
| 1.25  | 37,485     | 25,272 | 4,578   | 8    | 259.4         |

#### 8.6.c $p = 3$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 1,377      | 132    | 66      | 1    | 8.8           |
| 5     | 3,267      | 672    | 298     | 2    | 18.7          |
| 2.5   | 10,575     | 3,772  | 1,106   | 4    | 62.8          |
| 1.25  | 46,023     | 25,272 | 4,578   | 8    | 282.4         |

### Coreform IGA for Abaqus solve

#### 8.6.d $p = 1$

| $h_z$ | Elements | Nodes | DOFs   | Threads | Wall-time [s] |
|-------|----------|-------|--------|---------|---------------|
| 10    | 7,202    | 4,539 | 13,617 | 1       | 4.0           |



| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 5     | 9,148    | 6,056  | 18,168  | 2       | 3.0           |
| 2.5   | 14,108   | 11,170 | 33,510  | 4       | 3.0           |
| 1.25  | 55,176   | 46,522 | 139,566 | 8       | 11.0          |

#### 8.6.e $p = 2$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 7,336    | 4,848  | 14,544  | 1       | 3.0           |
| 5     | 9,372    | 6,776  | 20,328  | 2       | 3.0           |
| 2.5   | 14,108   | 12,840 | 38,520  | 4       | 7.0           |
| 1.25  | 57,200   | 53,264 | 159,792 | 8       | 34.0          |

#### 8.6.f $p = 3$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 7,204    | 5,104  | 15,312  | 1       | 6.0           |
| 5     | 9,484    | 7,578  | 22,734  | 2       | 11.0          |
| 2.5   | 17,944   | 16,764 | 50,292  | 4       | 25.0          |
| 1.25  | 75,792   | 69,142 | 207,426 | 8       | 137.0         |

### 8.7 Tetris partition

Coreform IGA Mesh

#### 8.7.a $p = 1$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 325        | 143    | 66      | 1    | 5.9           |
| 5     | 1,127      | 777    | 294     | 2    | 20.4          |
| 2.5   | 5,203      | 3,977  | 1,102   | 4    | 59.1          |
| 1.25  | 29,963     | 26,325 | 4,542   | 8    | 297.7         |

#### 8.7.b $p = 2$

| $h_z$ | Background | Active | Trimmed | CPUs | Wall-time [s] |
|-------|------------|--------|---------|------|---------------|
| 10    | 735        | 143    | 66      | 1    | 6.3           |
| 5     | 2,025      | 777    | 294     | 2    | 21.6          |

| $h_z$ | Background | Active | Trimmed | CPU's | Wall-time [s] |
|-------|------------|--------|---------|-------|---------------|
| 2.5   | 7,605      | 3,977  | 1,102   | 4     | 62.6          |
| 1.25  | 37,485     | 26,325 | 4,542   | 8     | 347.4         |

#### 8.7.c $p = 3$

| $h_z$ | Background | Active | Trimmed | CPU's | Wall-time [s] |
|-------|------------|--------|---------|-------|---------------|
| 10    | 1,377      | 143    | 66      | 1     | 9.6           |
| 5     | 3,267      | 777    | 294     | 2     | 23.4          |
| 2.5   | 10,575     | 3,977  | 1,102   | 4     | 68.8          |
| 1.25  | 46,023     | 26,325 | 4,542   | 8     | 413.7         |

### Coreform IGA for Abaqus solve

#### 8.7.d $p = 1$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 10,513   | 6,895  | 20,685  | 1       | 3.0           |
| 5     | 13,721   | 9,176  | 27,528  | 2       | 2.0           |
| 2.5   | 20,069   | 15,330 | 45,990  | 4       | 4.0           |
| 1.25  | 72,117   | 57,780 | 173,340 | 8       | 17.0          |

#### 8.7.e $p = 2$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 10,707   | 7,315  | 21,945  | 1       | 5.0           |
| 5     | 14,113   | 10,201 | 30,603  | 2       | 4.0           |
| 2.5   | 20,069   | 17,399 | 52,197  | 4       | 7.0           |
| 1.25  | 75,087   | 66,478 | 199,434 | 8       | 37.0          |

#### 8.7.f $p = 3$

| $h_z$ | Elements | Nodes  | DOFs    | Threads | Wall-time [s] |
|-------|----------|--------|---------|---------|---------------|
| 10    | 10,483   | 7,638  | 22,914  | 1       | 9.0           |
| 5     | 14,285   | 11,314 | 33,942  | 2       | 17.0          |
| 2.5   | 24,797   | 22,294 | 66,882  | 4       | 28.0          |
| 1.25  | 101,505  | 88,218 | 264,654 | 8       | 118.0         |

## 9 Discussion

Because all material definitions are identical, the exact continuum response is independent of the internal cell decomposition. Differences from the monolithic result therefore measure numerical sensitivity to retained interfaces, including closed inclusions, re-entrant partition corners, diagonal interfaces, and three-material junctions. The full refinement history is retained so that a passing finest-level result can be distinguished from a coarse-grid coincidence and so regressions at individual interface topologies remain visible.

## References

[1] J. M. Gere and S. P. Timoshenko, *Mechanics of materials*, 4th ed. Boston: PWS Publishing Company, 1997.

## Appendix

### 9.1 Capabilities exercised

The table is generated from current passing simulation and study artifacts. Each row must satisfy the linked capability card's evidence contract; declaring a capability in a test does not, by itself, create evidence.

Table 4: Capabilities exercised by the current verification artifacts.

| Capability                             | Evidence level            | Official verification test                               |
|----------------------------------------|---------------------------|----------------------------------------------------------|
| Linear static analysis                 | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Pinned boundary condition              | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Threaded Abaqus/Standard execution     | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Parallel Coreform IGA mesh generation  | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Surface traction loading               | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Cell-based material section assignment | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Multi-cell material interfaces         | Numerically validated     | verification_study_multiplanar_material_interfaces_neste |
| Linear elastic material behavior       | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Linear C0 spline basis                 | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Quadratic C1 spline basis              | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Cubic C2 spline basis                  | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Immersed rectilinear meshes            | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Explicit field-output selection        | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Stress field output (S)                | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Displacement field output (U)          | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Line probes                            | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Boolean merge with retained boundaries | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |
| Dependent part instances               | Test <del>Exercised</del> | verification_multiplanar_material_interfaces_nested_l    |

## 9.2 Download artifacts

Download artifacts are available from the HTML version of this page.

### 9.2.a Geometry CAD files

No separate CAD file is required for this problem; the geometry is fully defined in the Abaqus/CAE journal files.

### 9.2.b Abaqus/CAE journal files

*Individual journal downloads are available from the HTML version of this page.*

## 9.3 Supported Abaqus keywords

The deck below is reproduced from the monolithic  $h_0p_2$  test with comments stripped and instance-specific names redacted.

### **i** multiplanar\_material\_interfaces\_monolithic\_h0.inp - outline

```
*Heading
*Preprint, echo=NO, model=NO, history=NO, contact=NO
*Include, input=<iga-mesh-inp>
*System
*Material, name=<material>
*Elastic
  1e+11, 0.3
*User Output Variables
  1,
*Boundary
<node-set>, PINNED
*Step, name=<step>, nlgeom=NO
*Static
  1., 1., 1e-05, 1.
*Restart, write, frequency=0
*Output, field
*Node Output
  U,
*Element Output, position=AVERAGED AT NODES, directions=YES
  S,
*Output, history, variable=PRESELECT
*End Step
```

## 9.4 Provenance

The records below identify the execution environment and verification basis for every simulation and study CTest reported on this page.

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_hOp1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:31:14                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_h1p1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:36:20                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_h2p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:41:37                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_h3p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:55:11                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_hOp2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:31:29                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_h1p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:36:25                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |



**i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_h2p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:42:13                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_h3p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:57:00                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_hOp3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:31:42                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_h1p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:36:36                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_h2p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:43:04                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_center\_third\_h3p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:58:57                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_hOp1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:31:35                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h1p1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:36:25                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h2p1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:42:39                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h3p1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:56:28                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h0p2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:31:37                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h1p2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:36:43                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h2p2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:43:10                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h3p2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:57:18                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h0p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:31:50                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h1p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:37:19                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |



**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h2p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:43:33                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_bottom\_left\_half\_h3p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:59:52                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_hOp1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:32:18                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_h1p1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:37:14                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_h2p1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:43:05                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_h3p1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:57:33                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_hOp2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:32:32                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_h1p2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:37:22                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_h2p2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:43:19                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_h3p2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:58:16                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_hOp3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:32:40                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_h1p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:37:57                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_h2p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:44:20                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_centered\_third\_h3p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 21:01:42                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_hOp1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:30:19                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_h1p1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:35:42                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |



### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_h2p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:41:05                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_h3p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:53:03                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_hOp2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:31:02                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_h1p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:35:44                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_h2p2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:41:14                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_h3p2**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:53:48                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_hOp3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:31:14                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_h1p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:36:07                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_h2p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:41:37                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_monolithic\_h3p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:55:23                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_hOp1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:33:00                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_h1p1**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:38:09                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_h2p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:43:41                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_h3p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:58:52                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_hOp2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:33:09                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_h1p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:38:14                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |



### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_h2p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:45:22                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_h3p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 21:00:37                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_hOp3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:33:44                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_h1p3**

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:38:58                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_h2p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:45:53                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_nested\_l\_h3p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 21:03:44                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_hOp1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:33:50                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_h1p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:38:51                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_h2p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:45:22                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_h3p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 21:00:59                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_hOp2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:34:00                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_h1p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:38:59                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_h2p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:45:41                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_h3p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 21:02:56                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_hOp3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:34:16                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_h1p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:39:40                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |



### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_h2p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:46:31                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_tetris\_h3p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 21:06:21                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_hOp1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:32:46                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_h1p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (0 positive) |
| Test date            | 27-Jul-2026 20:37:45                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_h2p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:43:37                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_h3p1

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:57:27                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_hOp2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:32:54                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_hlp2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:37:59                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_h2p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:43:44                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_h3p2

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:58:27                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_hOp3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:33:03                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### i Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_h1p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:38:06                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_h2p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 20:44:51                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

### **i** Test\_abaqus\_verification\_multiplanar\_material\_interfaces\_zig\_zag\_h3p3

| Parameter            | Value                                           |
|----------------------|-------------------------------------------------|
| Evidence type        | Record-only diagnostic                          |
| CTest result         | Passed (Release)                                |
| Verification result  | Not asserted — 1 record-only check (1 positive) |
| Test date            | 27-Jul-2026 21:02:24                            |
| Operating system     | Ubuntu Linux 24.04.2 LTS (Noble Numbat)         |
| Coreform IGA version | 2026.7-dev+gvernon2_1785204663                  |
| Source revision      | db258ffe9358                                    |
| Abaqus version       | 2026_06_24-12.44.52 DEVr428 214170              |

**i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_bottom\_center\_third\_p1

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_bottom\_center\_third\_p2

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |



**i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_bottom\_center\_third\_p3

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_bottom\_left\_half\_p1

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_bottom\_left\_half\_p2

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_bottom\_left\_half\_p3

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i**

Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_centered\_third\_p1

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i**

Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_centered\_third\_p2

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

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Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_centered\_third\_p3

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

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Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_nested\_l\_p1

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_nested\_l\_p2**

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_nested\_l\_p3**

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

### **i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_tetris\_p1

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

### **i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_tetris\_p2

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

### **i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_tetris\_p3

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

### **i** Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_zig\_zag\_p1

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_zig\_zag\_p2**

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |

**i Test\_abaqus\_verification\_study\_multiplanar\_material\_interfaces\_zig\_zag\_p3**

| Parameter            | Value                                      |
|----------------------|--------------------------------------------|
| Evidence type        | Numerical verification                     |
| CTest result         | Passed (Release)                           |
| Verification result  | Passed — 1/1 enforced criterion passed     |
| Test date            | 28-Jul-2026 03:09:22 UTC                   |
| Operating system     | —                                          |
| Coreform IGA version | Not applicable — postprocessing-only CTest |
| Source revision      | <a href="#">db258ffe9358</a>               |
| Abaqus version       | Not applicable — postprocessing-only CTest |