Zencrack 7.9 - Crack-block Library

Issue 7.9

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Software – versions are identified by version number and build date

Version	Build date	Description
7.9-a	27 November 2013	Zencrack GUI
7.9-1	19 November 2013	Zencrack analysis program

Version Status for this manual:

This version of the manual is to be used with Zencrack program version 7.9-1 and Zencrack GUI version 7.9-a. The program version and build date are shown in the banner at the start of every Zencrack output file (i.e. the .rep file). The GUI version is shown in the program Help > About menu. All pages are at "Issue 7.9, Revision 0".

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1. Introduction

Crack-blocks are groups of elements arranged in such a way that they contain a section of crack front. Each crack-block is stored in a unit cube form in a data file that is held in the "crack" directory of the Zencrack installation. Crack-blocks are mapped into element space in the user's uncracked mesh in order to introduce cracks into an uncracked mesh. Complete crack fronts in a mesh may be defined by one crack-block or a series of connected crack-blocks depending upon the modelling requirements.

The crack-block library contains two types of crack-blocks:

- "Standard" crack-blocks
- "Large" crack-blocks

The standard crack-blocks reduce to a single element on their back faces and merge with the rest of the mesh via shared nodal numbers. The large crack-blocks contain multiple nodes on their back faces and are used with surface-based tying to connect them to the surrounding (dis-similar) mesh. The standard and large crack-blocks contain two topologically different crack-block types:

- Quarter circular crack-blocks
- Through crack-blocks

The quarter circular crack-blocks contain a corner crack in their unit-cube form. The through crack-blocks contain a straight section of crack front in their unit cube form. During the mapping process to place crack-blocks into the user's mesh, the required crack front can be specified by the user.

Crack-blocks can be connected to one another in a variety of face-to-face or side-to-side orientations. A crack-block can make a face-to-face match with itself if it contains symmetry in its crack plane. This is the case for the majority of crack-blocks. Exceptions to the face-to-face matching exist as pairs of crack-blocks with a and b appended to their names, e.g. s01_q178x8a and s01_q178x8b. These crack-blocks have refinement at opposite ends of their crack fronts giving a lack of symmetry in the crack plane.

1.1 Crack-block families

The crack-blocks are grouped into "families". All crack-blocks within each family are compatible with all other family members for side-to-side combinations. The naming convention of the crack- blocks is based on a family reference, the topological type, the number of elements in the crack- block and the number of elements along the crack front section. For example:

l01_q496x8	l01	Large crack-block family 1
	q	Quarter circular crack-block
	496	Total of 496 elements
	x8	8 elements along the crack front
s02_t19x1	s02	Standard crack-block family 2
	t	Through crack-block
	19	Total of 19 elements
	x1	1 element along the crack front

Crack-blocks are referenced on the CRACK FRONT keyword using the crack-block name, e.g. l01_q496x8, s02_t19x1.

1.2 Updates on crack-blocks faces

During mesh generation Zencrack produces reports in the .rep output file for all crack-block faces that have had boundary conditions, loads or surface definitions updated, e.g.:

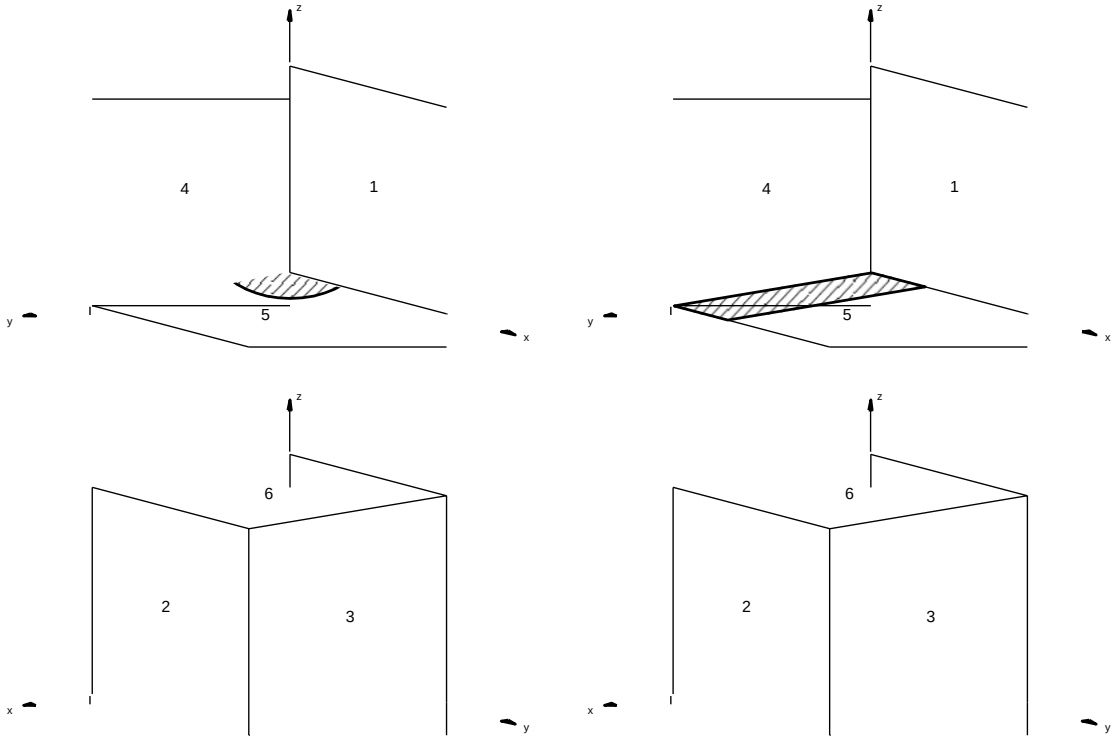
```
***INFORMATION : BOUNDARY CONDITION UPDATE FOR CRACK-BLOCK    1, FACE
1, DOF 2
Fixed displacements of equal magnitude on all four corner nodes
will be updated onto all nodes on the face in the cracked mesh.

***INFORMATION : CRACK-BLOCK LOADING
LOAD ON FACE 5 OF CRACK-BLOCK   1 HAS BEEN UPDATED
(THIS IS THE CRACK FACE)

***INFORMATION : CRACK-BLOCK SURFACE
SURFACE ON FACE 6 OF CRACK-BLOCK    1 HAS BEEN UPDATED
```

1.3 Standardised face numbering for crack-blocks

The standard numbering for faces 1 to 6 as referenced in the messages above is shown in Figure 1-1. The crack front is always on face 5. Node and element sets for the outer faces of the crack-blocks can be created using the **BLOCK FACES** parameter on the NODE SETS and ELEMENT SETS respectively. For the purposes of set generation, face 5 is split into two parts – one for the open crack face and one for the closed ligament.



quarter circular crack-block through crack-block

Figure 1-1 – Schematic showing Zencrack face number conventions for crack-blocks

1.4 Restrictions

The following additional points are noted with regard to the crack-blocks:

- Some of the standard crack-blocks, (e.g. s02_q38x2) have a node at the centre of their upper back face (at the midside of the diagonal edge across the face). This upper face is allowed to connect with a standard element face. Zencrack adds a tying constraint for the centre node to ensure compatibility is maintained.
- Some crack-blocks cannot be used with Ansys version 13 (or earlier) due to a collapsed internal element that is not permitted in these versions of Ansys: s02_q38x2, s03_q46x2, s04_q70x2, s05_q24x2. All crack-blocks can be used with Ansys 14.0 (or later) due to a change in Ansys.
- If a model contains only large crack-blocks then the following options will have no effect:
  - Boundary shifting
  - Mesh relaxation
- The split set capability requires that the elements connected to the split sets are replaced by standard crack-blocks – the split set capability does not apply for crack fronts consisting of large crack-blocks.
- Crack fronts that are required to take advantage of the BOUNDARY SHIFT, TYPE=TRANSFER option to allow the crack front to move through the mesh should contain only standard through crack-blocks selected from families s02, s03, s04 or s05.

2. Crack-block Family Overview

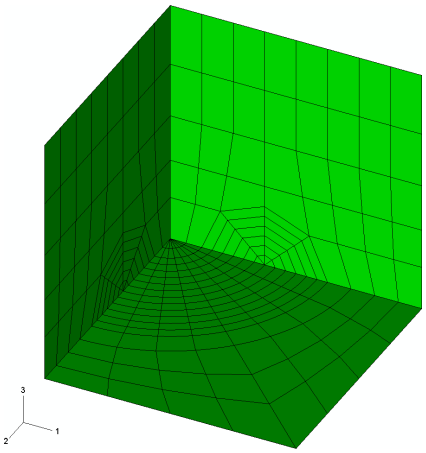
This section presents an overview of all the crack-block families with all family members pictured on a single page. Section 3 provides larger images of the individual crack-blocks and additional details for each.

2.1 Large crack-blocks

There are six large crack-block families available, named l01 to l06, described on the following pages.

Different families are provided to suit different applications. For example, the highly refined l02 and l06 families would be appropriate if very detailed stresses were required from an analysis.

l01



l01_q496x8

Notes for l01 family:

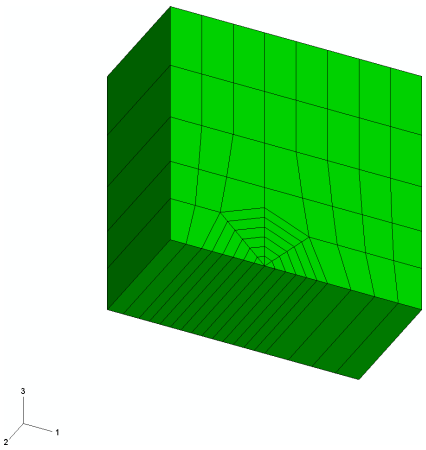
The ideal edge ratio for this family is 0.375.

6 element rings are controlled for mapping purposes.

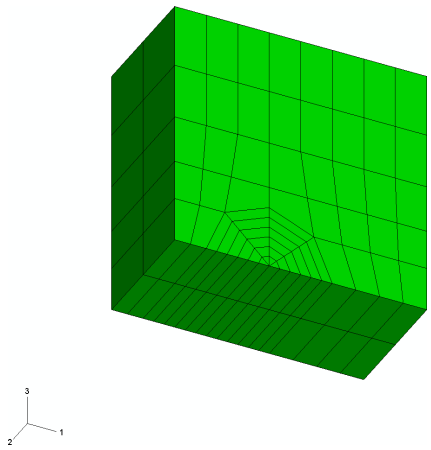
Contour evaluations are possible for up to 6 contours for Abaqus and Ansys.

When using the "enhanced ring control" mapping method (see MAPPING keyword), families l05 and l06 should be used rather than l01 and l02 due to the improved element distribution on the back faces of the crack-blocks.

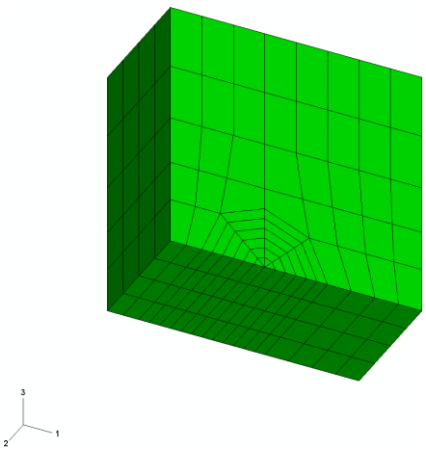
A 2x2x2 refined version of the l01 family is contained in the l02 family, e.g. l02_q3968x16 is the 2x2x2 refined version of l01_q496x8.



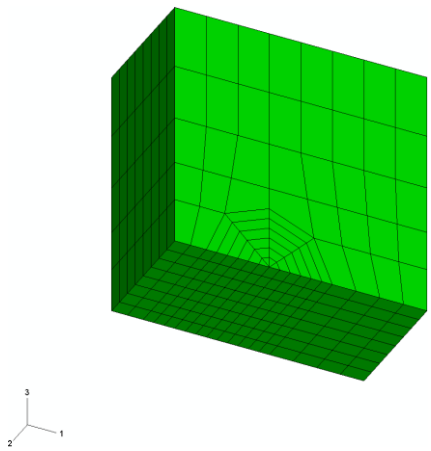
l01_t062x1



l01_t124x2



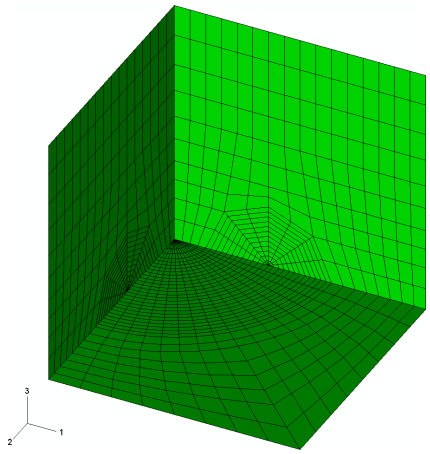
l01_t248x4



l01_t496x8

Figure 2-1 – Crack-block family l01

l02



l02_q3968x16

Notes for l02 family:

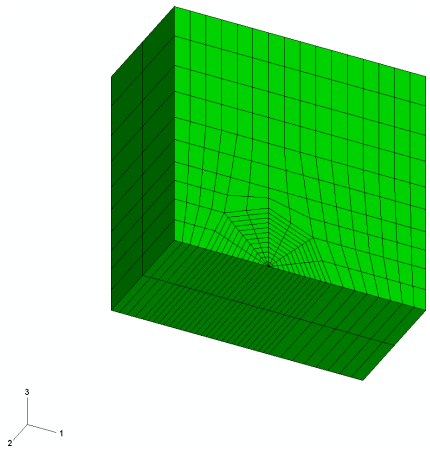
The ideal edge ratio for this family is 0.375.

12 element rings are controlled for mapping purposes.

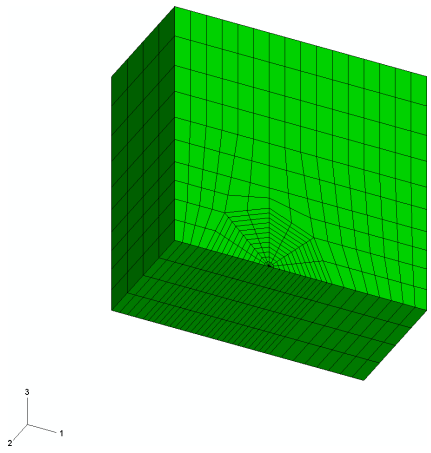
Contour evaluations are possible for up to 12 contours for Abaqus and Ansys.

When using the "enhanced ring control" mapping method (see MAPPING keyword), families l05 and l06 should be used rather than l01 and l02 due to the improved element distribution on the back faces of the crack-blocks.

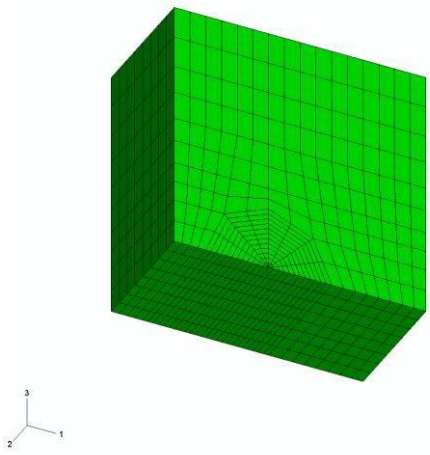
A coarser version of the l02 family is the l01 family, e.g. l02_q3968x16 is the refined version of l01_q496x8.



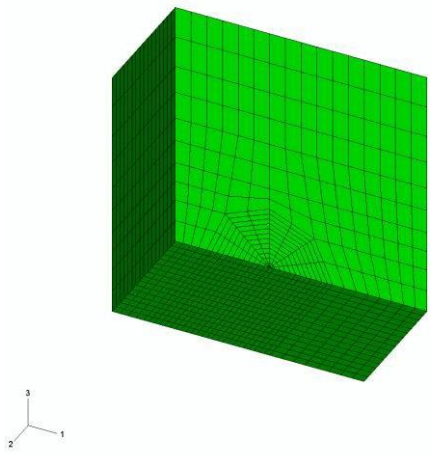
l02_t0496x2



l02_t0992x4



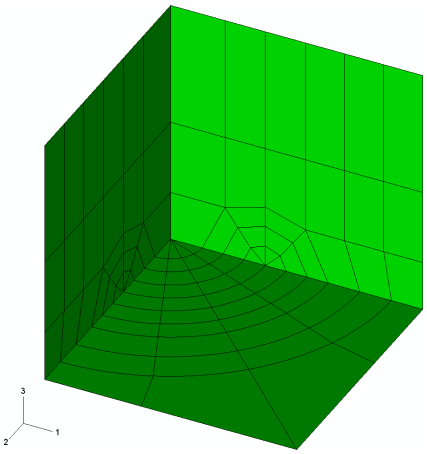
l02_t1984x8



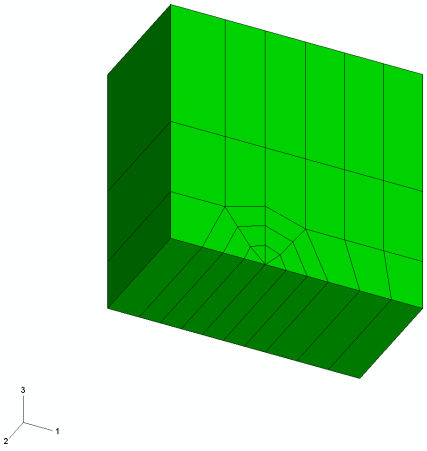
l02_t3968x16

Figure 2-2 – Crack-block family l02

l03



l03_q112x4



l03_t28x1

Notes for l03 family:

The ideal edge ratio for this family is 0.375.

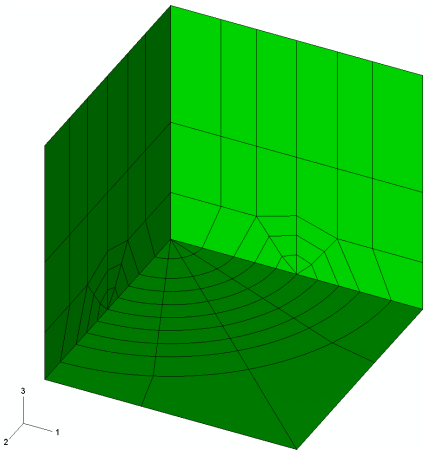
3 element rings are controlled for mapping purposes.

Contour evaluations are possible for up to 3 contours for Abaqus and Ansys.

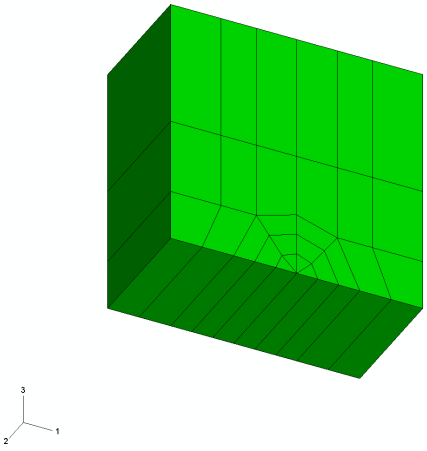
Family l04 is similar to l03 but has a larger ideal edge ratio of 0.5.

Figure 2-3 – Crack-block family l03

l04



l04_q112x4



l04_t28x1

Notes for l04 family:

The ideal edge ratio for this family is 0.5.

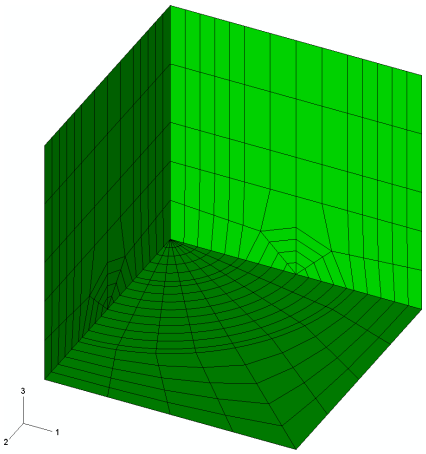
3 element rings are controlled for mapping purposes.

Contour evaluations are possible for up to 3 contours for Abaqus and Ansys.

Family l03 is similar but has a smaller ideal edge ratio of 0.375.

Figure 2-4 – Crack-block family l04

l05



l05_q672x8

Notes for l05 family:

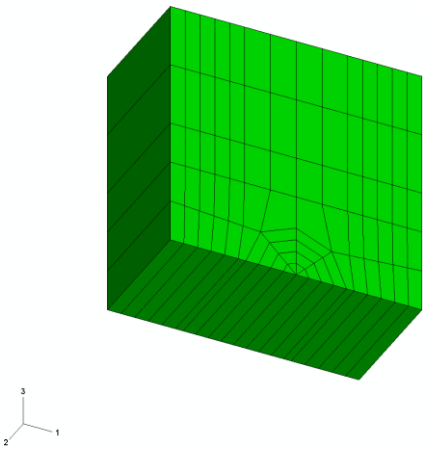
The ideal edge ratio for this family is 0.5.

4 element rings are controlled for mapping purposes.

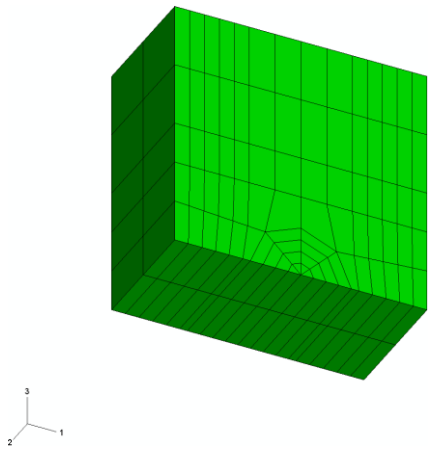
Contour evaluations are possible for up to 6 contours for Abaqus and Ansys.

When using the "enhanced ring control" mapping method (see MAPPING keyword), families l05 and l06 should be used rather than l01 and l02 due to the improved element distribution on the back faces of the crack-blocks.

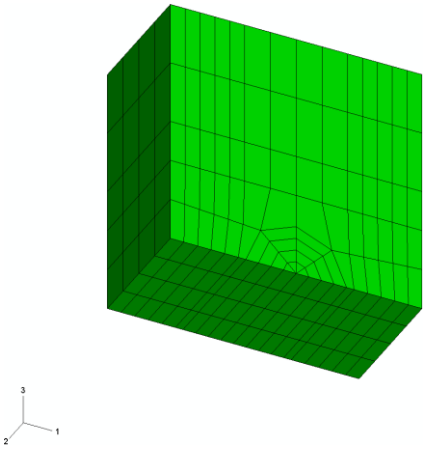
A 2x2x2 refined version of the l05 family is contained in the l06 family, e.g. l06_q5376x16 is the refined version of l05_q672x8.



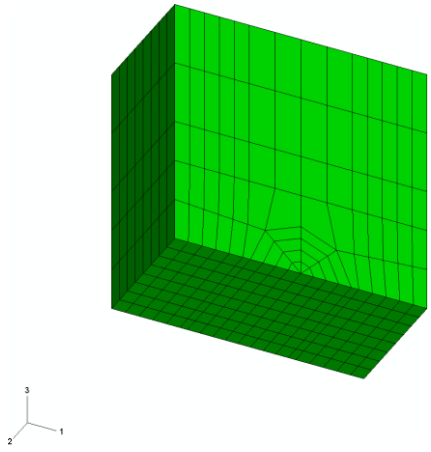
l05_t084x1



l05_t168x2



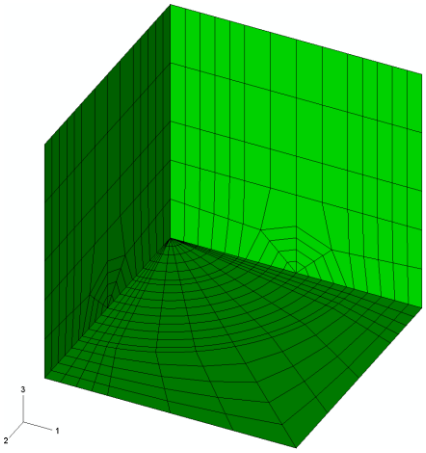
l05_t336x4



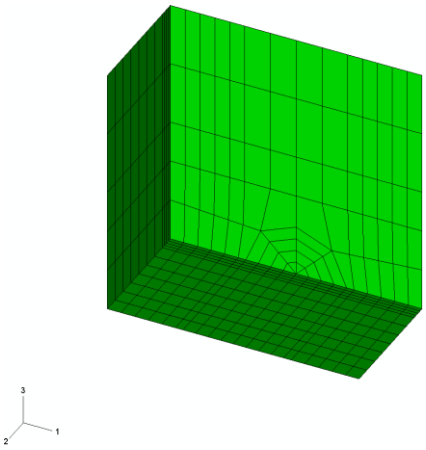
l05_t672x8

Figure 2-5 – Crack-block family l05

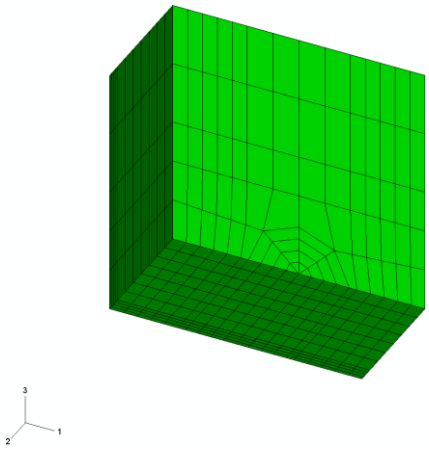
These crack-blocks are extensions to the l05 family with additional sub-divisions along part of the crack front.



l05_q1176x14



l05_t924x11a



l05_t924x11b

Figure 2-6 – Crack-block family l05 (extensions)