

## SSNP170 – Patch test of Taylor

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### Summary:

This problem corresponds to a quasi-static analysis of a problem of mechanics with contact without friction whose analytical solution is known. One is interested particularly here in integration of the terms of contact ( *patch-test* ) by the method *Mortar Room Average Contact* (LAKE). It is a question of studying two identical blocks with a grid differently and subjected to a compression.

This test comprises 25 modelings. The objective is to test all the possible combinations of pairings with incompatible grid for the type of pairing *Mortar* with cutting LAKE in *2D* and *3D* .

Thus this test comprises ten modelings in *2D* :

- modeling a: TRIA3 - TRIA3
- modeling b: TRIA6 - TRIA6
- modeling C: QUAD4 - QUAD4
- modeling D : QUAD8 - QUAD8
- modeling E : TRIA3 - SORTED6
- modeling F : SORTED3 - QUAD4
- modeling G : SORTED3 - QUAD8
- modeling H : SORTED6 - QUAD4
- modeling I : SORTED6 - QUAD8
- modeling J : QUAD4 - QUAD8

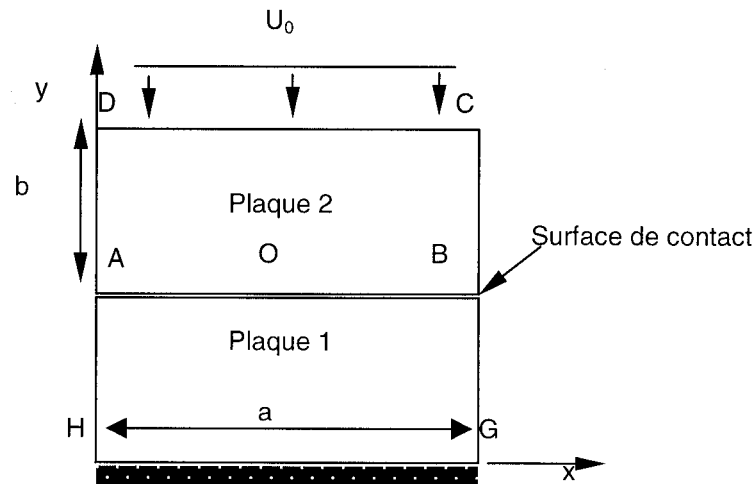
And fifteen modelings in *3D* :

- modeling K: TETRA4 - TETRA4
- modeling L : TETRA10 - TETRA10
- modeling M : HEXA8 - HEXA8
- modeling NR : HEXA20 - HEXA20

- modeling O : HEXA27 - HEXA27
- modeling P : TETRA4 - TETRA10
- modeling Q : TETRA4 - HEXA8
- modeling R : TETRA4 - HEXA20
- modeling S : TETRA4 - HEXA27
- modeling T : TETRA10 - HEXA8
- modeling U : TETRA10 - HEXA20
- modeling V : TETRA10 - HEXA27
- modeling W : HEXA8 - HEXA20
- modeling X : HEXA8 - HEXA27
- modeling Y : HEXA20 - HEXA27
- modeling Z : Cutting PENTA6 , PENTA15, PYRA5, PYRA13

## 1 Problem of reference

### 1.1 Geometry



Length  $a = 100 \text{ mm}$ .

Width  $b = 50 \text{ mm}$ .

$O$  not medium of the segment  $AB$  (origin of the reference mark).

### 1.2 Properties of materials

**Plates 1 and 2:**

Poisson's ratio: 0.3

Young modulus: 2000 MPa

### 1.3 Boundary conditions and loadings

Plate 1 is blocked in  $Y$  :

- On  $HG$   $DY = 0$ .

Plate 2 is subjected to oneE pressure imposedE :

- On  $CD$  :  $PRES = 25 \text{ MPa}$

Conditions of symmetry are imposed in  $X$  in order to model only half of the model

## 2 Reference solution

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### 2.1 Method of calculating used for the reference solution

Without friction, the contact pressure on the level of the interface is equal to the imposed pressure.

### 2.2 Results of reference

The contact pressure is constant and equal to  $25 \text{ MPa}$  on all the surface of contact.

### 2.3 Uncertainty on the solution

Analytical solution.

### 2.4 Bibliographical reference

1. NR. EL-ABBASI and K.J. BATHE: “*Stability and Patch Test Performance of Contact Discretizations and has New Algorithm Solution*“, Computers & Structures, 79,1473-1486, 2001

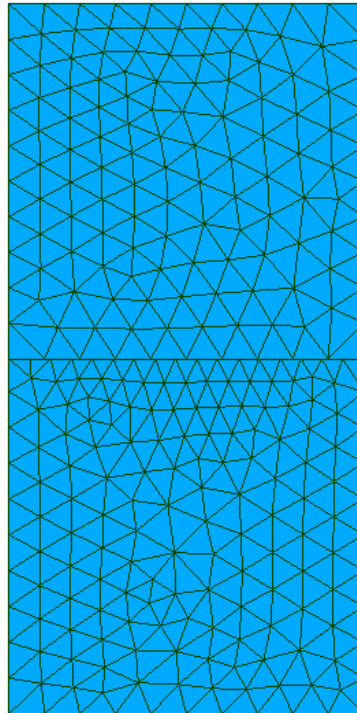
## 3 Modeling A

### 3.1 Characteristics of modeling

A modeling is used `D_PLAN` for the elements solid with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`.

### 3.2 Characteristics of the grid

The grid contains 519 elements of the type `TRIA3`. The grids of 2 surfaces of contact are incompatible.



### 3.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

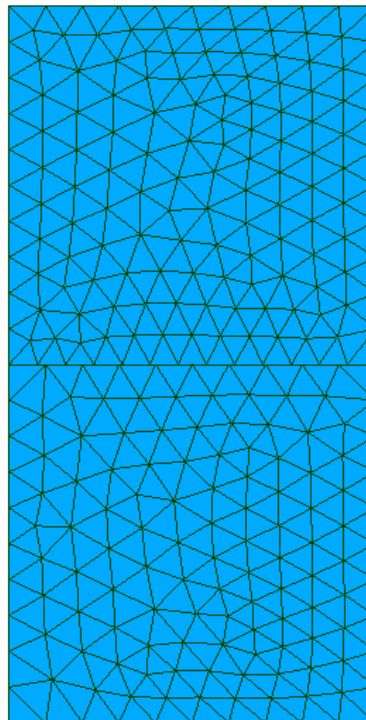
## 4 Modeling B

### 4.1 Characteristics of modeling

A modeling is used `D_PLAN` for the solid elements with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`.

### 4.2 Characteristics of the grid

The grid contains 493 elements of the type `SORTED6`. The grids of 2 surfaces of contact are incompatible.



### 4.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

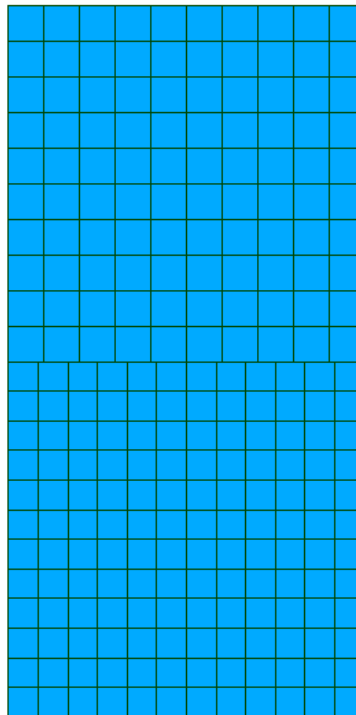
## 5 Modeling C

### 5.1 Characteristics of modeling

A modeling is used `D_PLAN` for the solid elements with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`.

### 5.2 Characteristics of the grid

The grid contains 244 elements of the type `QUAD4`. The grids of 2 surfaces of contact are incompatible.



### 5.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

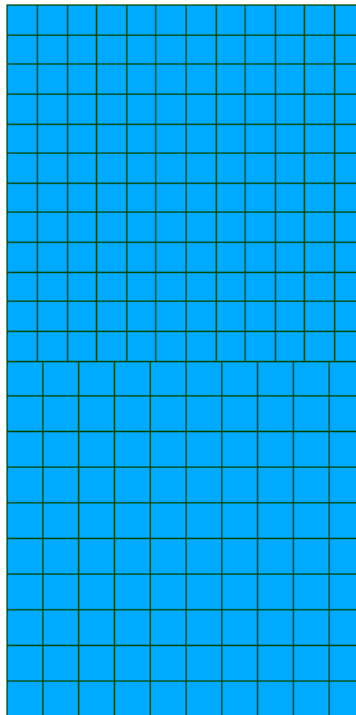
## 6 Modeling D

### 6.1 Characteristics of modeling

A modeling is used `D_PLAN` for the solid elements with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`.

### 6.2 Characteristics of the grid

The grid contains 244 elements of the type `QUAD8`. The grids of 2 surfaces of contact are incompatible.



### 6.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%



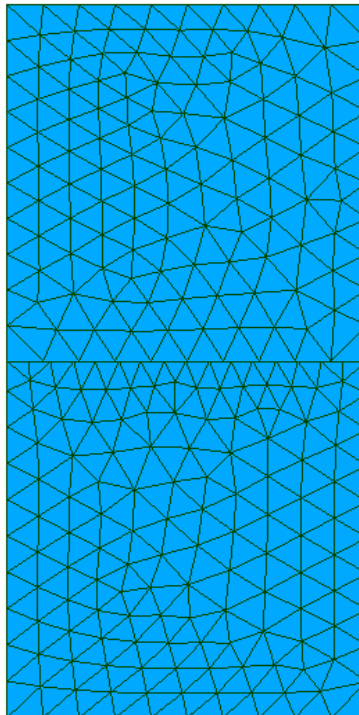
## 7 Modeling E

### 7.1 Characteristics of modeling

A modeling is used `D_PLAN` for the solid elements with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`. Two calculations are carried out by reversing surfaces of main contact and slave.

### 7.2 Characteristics of the grid

The grid contains 230 elements of the type `SORTED3` and 260 elements of the type `SORTED6`. The grids of 2 surfaces of contact are incompatible.



### 7.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

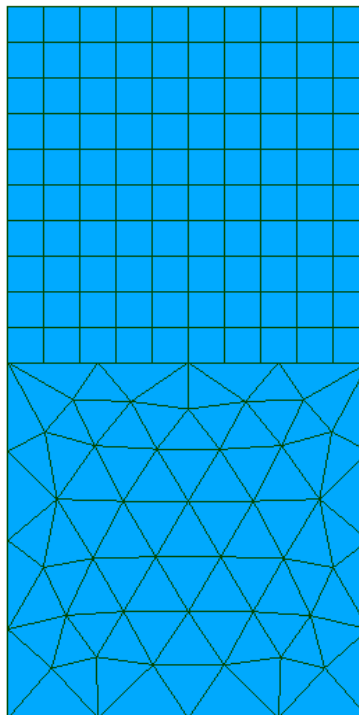
## 8 Modeling F

### 8.1 Characteristics of modeling

A modeling is used `D_PLAN` for the solid elements with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`. Two calculations are carried out by reversing surfaces of main contact and slave.

### 8.2 Characteristics of the grid

Grid contains 80 elements of the type `SORTED3` and 100 elements of the type `QUAD4`. The grids of 2 surfaces of contact are incompatible.



### 8.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

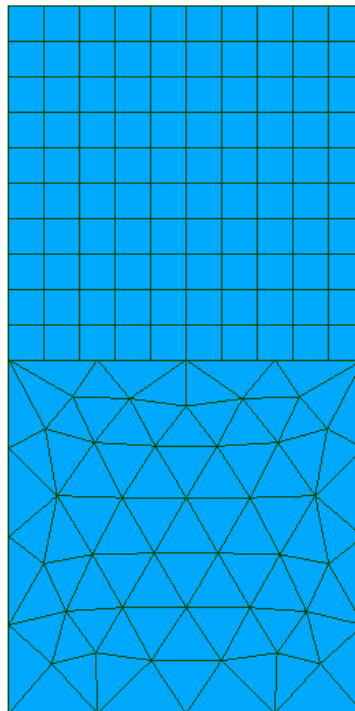
## 9 Modeling G

### 9.1 Characteristics of modeling

A modeling is used `D_PLAN` for the solid elements with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`. Two calculations are carried out by reversing surfaces of main contact and slave.

### 9.2 Characteristics of the grid

The grid contains 80 elements of the type `SORTED3` and 100 elements of the type `QUAD8`. The grids of 2 surfaces of contact are incompatible.



### 9.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

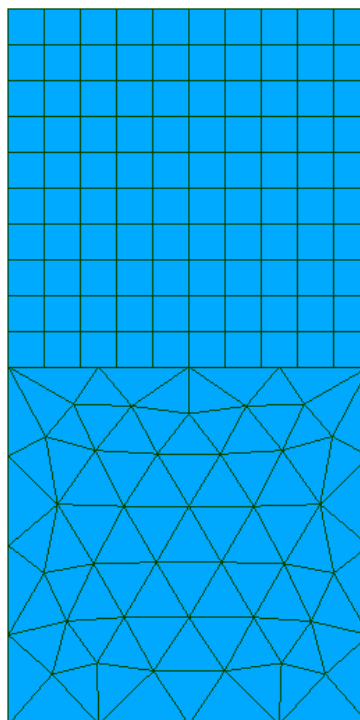
## 10 Modeling H

### 10.1 Characteristics of modeling

A modeling is used `D_PLAN` for the solid elements with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`. Two calculations are carried out by reversing surfaces of main contact and slave.

### 10.2 Characteristics of the grid

The grid contains 80 elements of the type `SORTED6` and 100 elements of the type `QUAD4`. The grids of 2 surfaces of contact are incompatible.



### 10.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

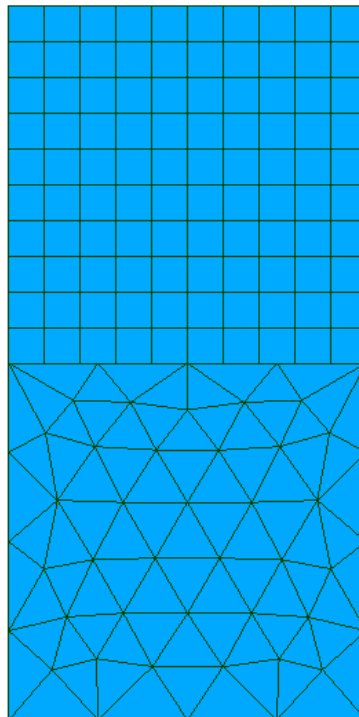
## 11 Modeling I

### 11.1 Characteristics of modeling

A modeling is used `D_PLAN` for the solid elements with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`. Two calculations are carried out by reversing surfaces of main contact and slave.

### 11.2 Characteristics of the grid

The grid contains 80 elements of the type `SORTED6` and 100 elements of the type `QUAD8`. The grids of 2 surfaces of contact are incompatible.



### 11.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

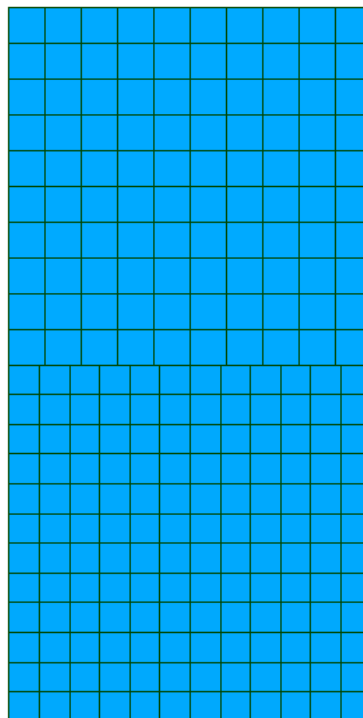
## 12 Modeling J

### 12.1 Characteristics of modeling

A modeling is used `D_PLAN` for the solid elements with the method `CONTINUOUS` for the treatment of `CONTACT` with pairing of the type `MORTAR` and cutting `LAKE`. Two calculations are carried out by reversing surfaces of main contact and slave.

### 12.2 Characteristics of the grid

The grid contains 100 elements of the type `QUAD4` and 144 elements of the type `QUAD8`. The grids of 2 surfaces of contact are incompatible.



### 12.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

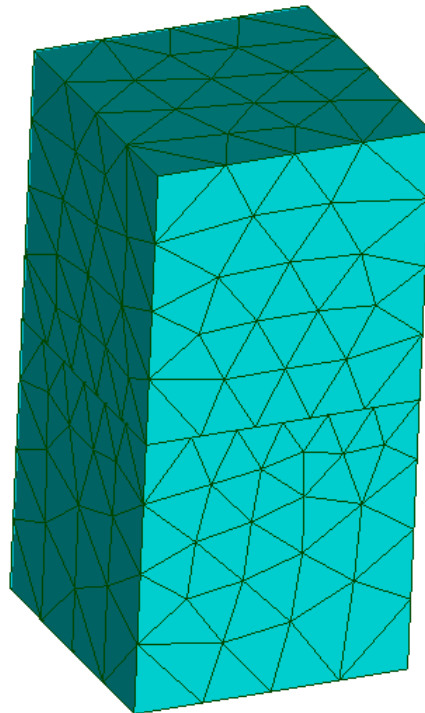
## 13 Modeling K

### 13.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE.

### 13.2 Characteristics of the grid

The grid contains 900 elements of the type TETRA4. The grids of 2 surfaces of contact are incompatible.



### 13.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

The keyword is also tested OBSERVATION at once CONT\_ELEM :

Identification	Type of reference	Value of reference	Precision
CONT_ELEM/X1 on mesh 1Z1527, moment 1.0	'AUTRE_ASTER'	-25	0.1%

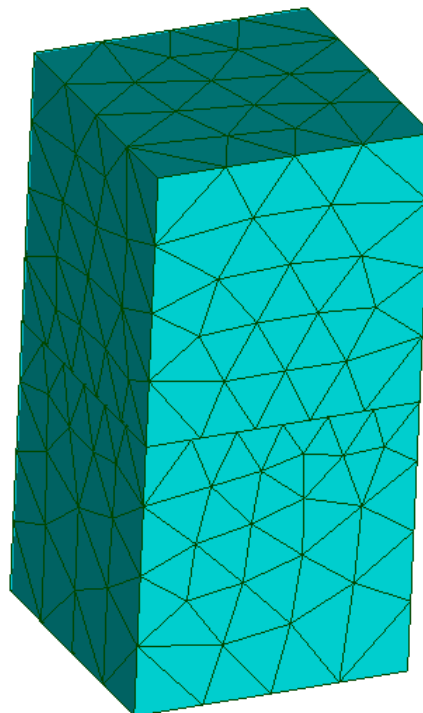
## 14 Modeling L

### 14.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE.

### 14.2 Characteristics of the grid

The grid contains 900 elements of the type TETRA10. The grids of 2 surfaces of contact are incompatible.



### 14.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%



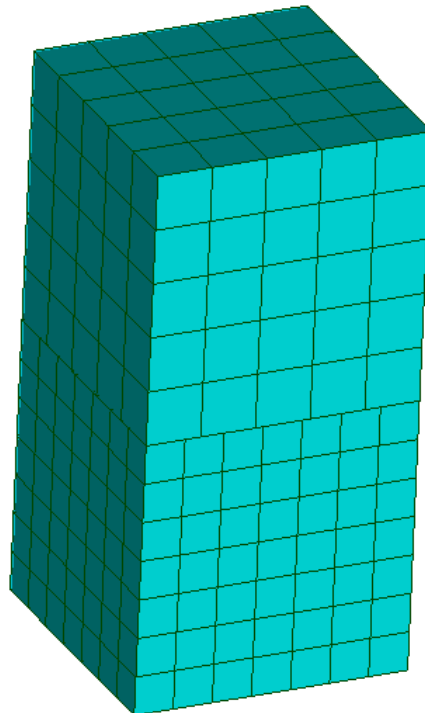
## 15 Modeling M

### 15.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE.

### 15.2 Characteristics of the grid

The grid contains 468 elements of the type HEXA8. The grids of 2 surfaces of contact are incompatible.



### 15.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

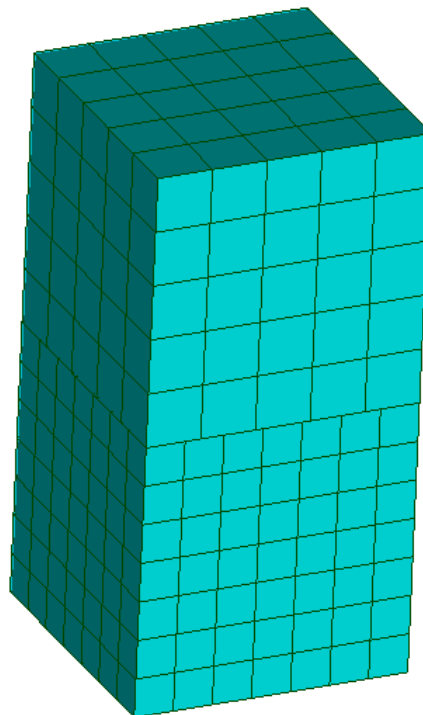
## 16 Modeling NR

### 16.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE.

### 16.2 Characteristics of the grid

The grid contains 468 elements of the type HEXA20. The grids of 2 surfaces of contact are incompatible.



### 16.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

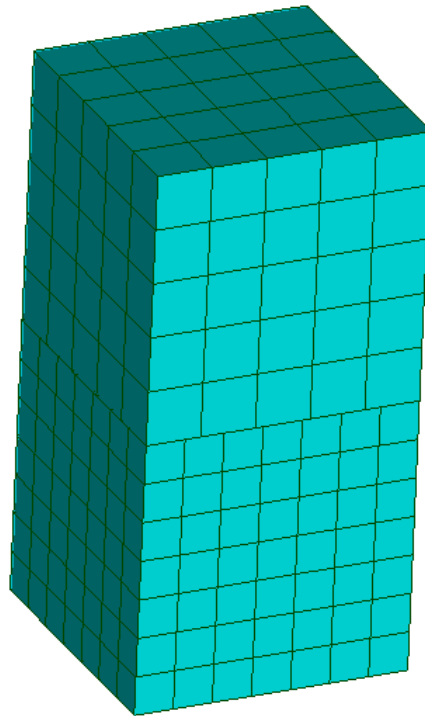
## 17 Modeling O

### 17.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE.

### 17.2 Characteristics of the grid

The grid contains 468 elements of the type HEXA27. The grids of 2 surfaces of contact are incompatible.



### 17.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

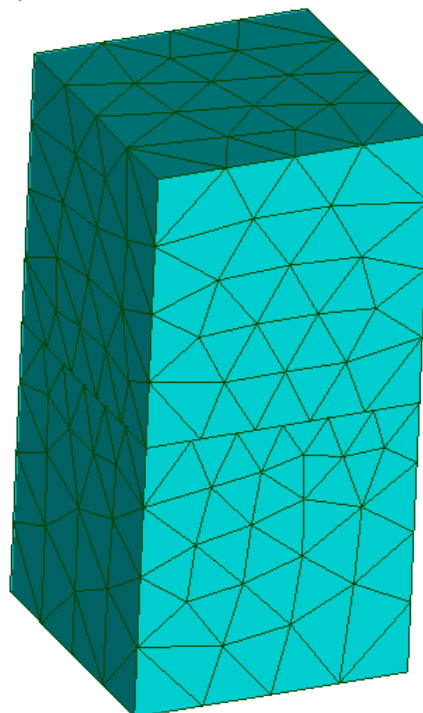
## 18 Modeling P

### 18.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 18.2 Characteristics of the grid

The grid contains 409 elements of the type TETRA4 and 391 elements of the type TETA10. The grids of 2 surfaces of contact are incompatible.



### 18.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

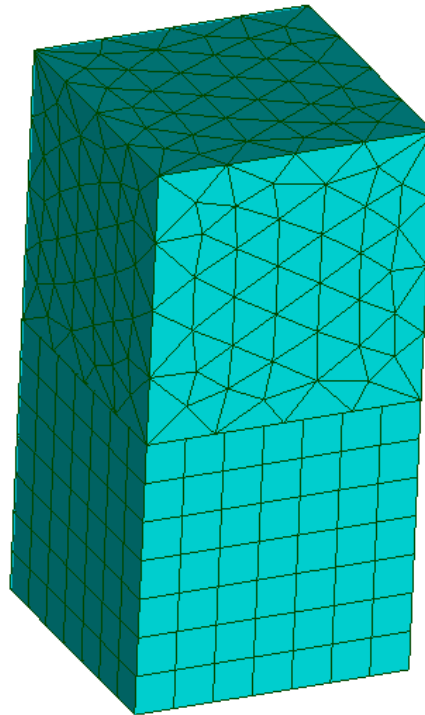
## 19 Modeling Q

### 19.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 19.2 Characteristics of the grid

The grid contains 1374 elements of the type TETRA4 and 343 elements of the type HEXA8. The grids of 2 surfaces of contact are incompatible.



### 19.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

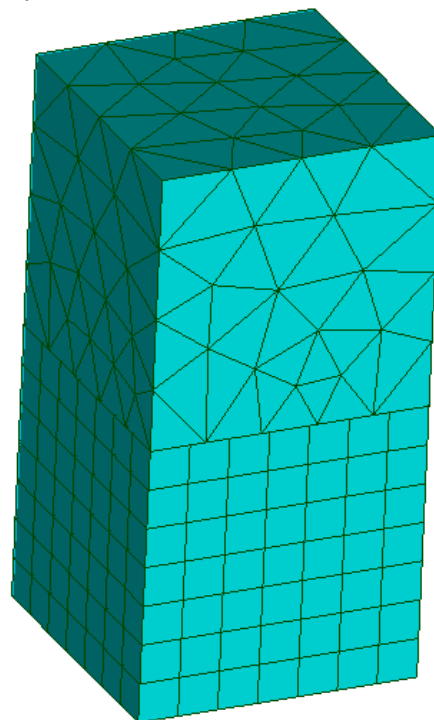
## 20 Modeling R

### 20.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 20.2 Characteristics of the grid

The grid contains 411 elements of the type TETRA4 and 343 elements of the type HEXA20. The grids of 2 surfaces of contact are incompatible.



### 20.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

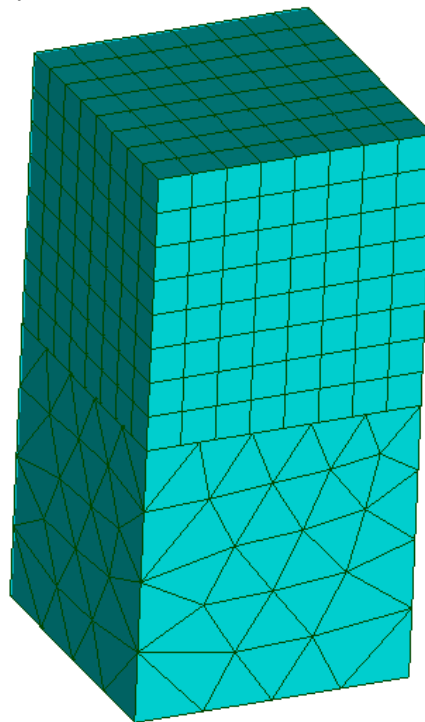
## 21 Modeling S

### 21.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 21.2 Characteristics of the grid

The grid contains 409 elements of the type TETRA4 and 512 elements of the type HEXA27. The grids of 2 surfaces of contact are incompatible.



### 21.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

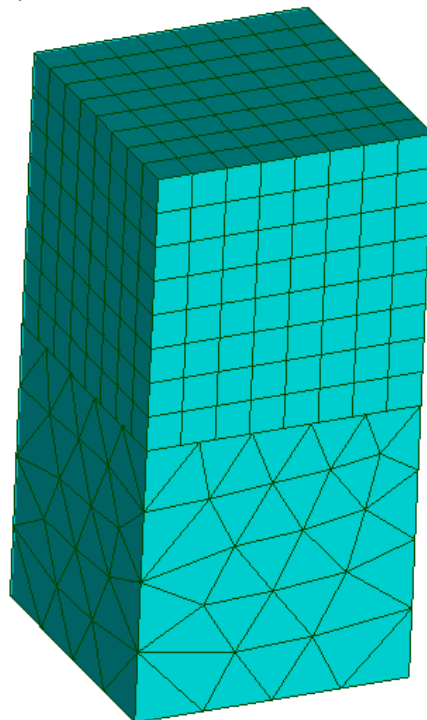
## 22 Modeling T

### 22.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 22.2 Characteristics of the grid

The grid contains 409 elements of the type TETRA10 and 512 elements of the type HEXA8. The grids of 2 surfaces of contact are incompatible.



### 22.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%



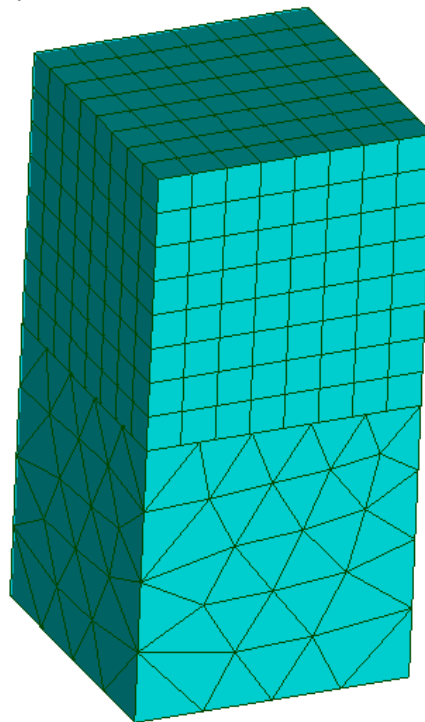
## 23 Modeling U

### 23.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 23.2 Characteristics of the grid

The grid contains 409 elements of the type TETRA10 and 512 elements of the type HEXA20. The grids of 2 surfaces of contact are incompatible.



### 23.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

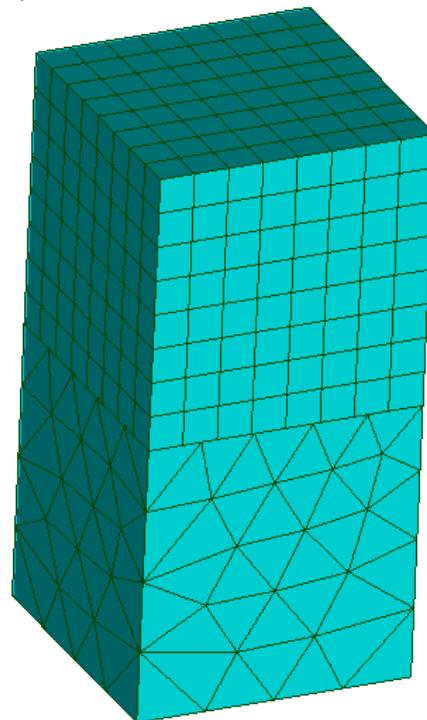
## 24 Modeling V

### 24.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 24.2 Characteristics of the grid

The grid contains 409 elements of the type TETRA10 and 512 elements of the type HEXA27. The grids of 2 surfaces of contact are incompatible.



### 24.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

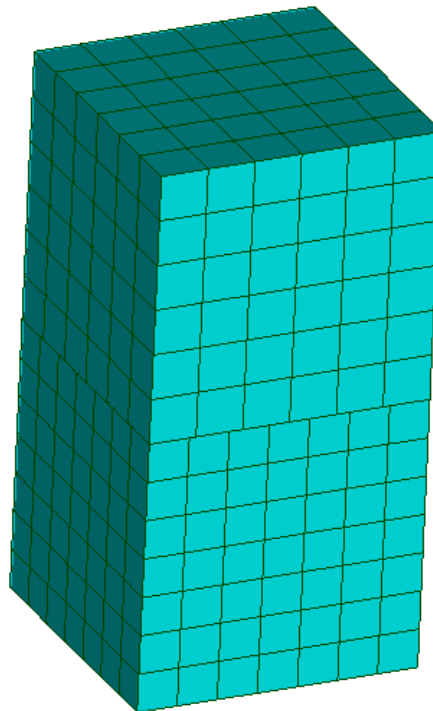
## 25 Modeling W

### 25.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 25.2 Characteristics of the grid

The grid contains 343 elements of the type HEXA8 and 216 elements of the type HEXA20. The grids of 2 surfaces of contact are incompatible.



### 25.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

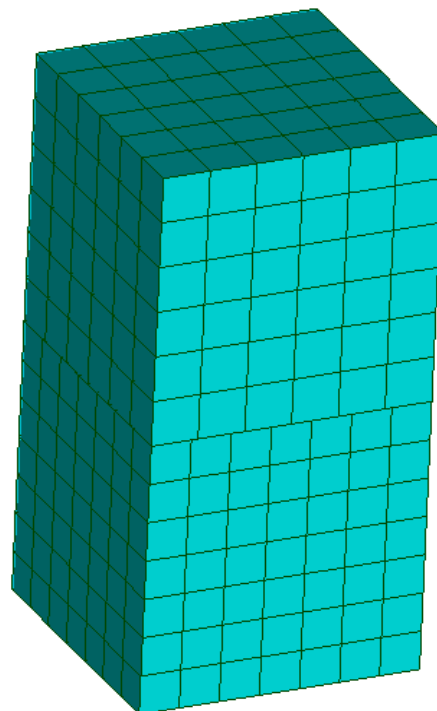
## 26 Modeling X

### 26.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 26.2 Characteristics of the grid

The grid contains 343 elements of the type HEXA8 and 216 elements of the type HEXA27. The grids of 2 surfaces of contact are incompatible.



### 26.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

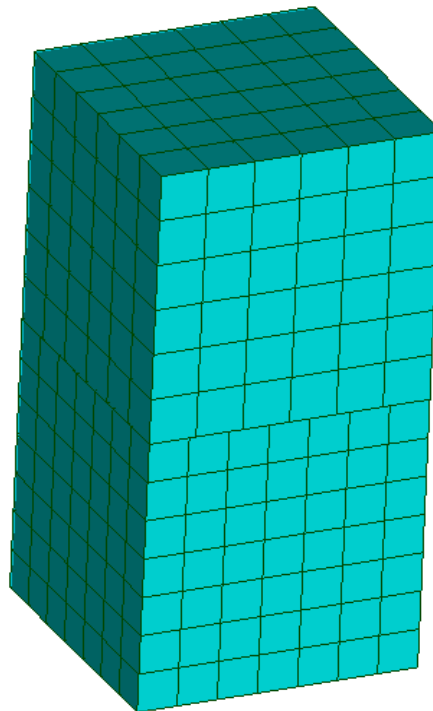
## 27 Modeling Y

### 27.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. Two calculations are carried out by reversing surfaces of main contact and slave.

### 27.2 Characteristics of the grid

The grid contains 343 elements of the type HEXA20 and 216 elements of the type HEXA27. The grids of 2 surfaces of contact are incompatible.



### 27.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

## 28 Modeling Z

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### 28.1 Characteristics of modeling

A modeling is used 3D for the solid elements with the method CONTINUOUS for the treatment of CONTACT with pairing of the type MORTAR and cutting LAKE. This modeling checks the patch test in the event of cutting elements of the type PENTA 6 and 15, PYRA 5 and 13 using 4 grids.

### 28.2 Characteristics of the grid

S 4 grids contain maybe of the elements of type PENTA 6.15 or PYRA 5, 13 in contact with surface slaves. grids of 2 surfaces of contact are incompatible.

### 28.3 Sizes tested and results

It is tested the contact pressure on the entirety of surfaces of main contact and slave.

Identification	Type of reference	Value of reference	Precision
LAGS_C	'ANALYTICAL'	25	0.1%

## 29 Summary of the results

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One seeks on this example very simple to test a novel method of integration of the terms of contact based on the subdivision by subelements. This method is activated when pairing is chosen `MORTAR` for a zone of contact in formulation `CONTINUOUS`. One validates all the possible pairing of `CREA_MALLAGE/DECOUPE_LAC`.

This technique allows to obtain contact pressures very close to the analytical solution. Even on strongly incompatible grids, one obtains residues which are quasi worthless. Here, the pressure is constant on all the surface of contact, contrary to the more classical methods which in general generate oscillations on this kind of case.