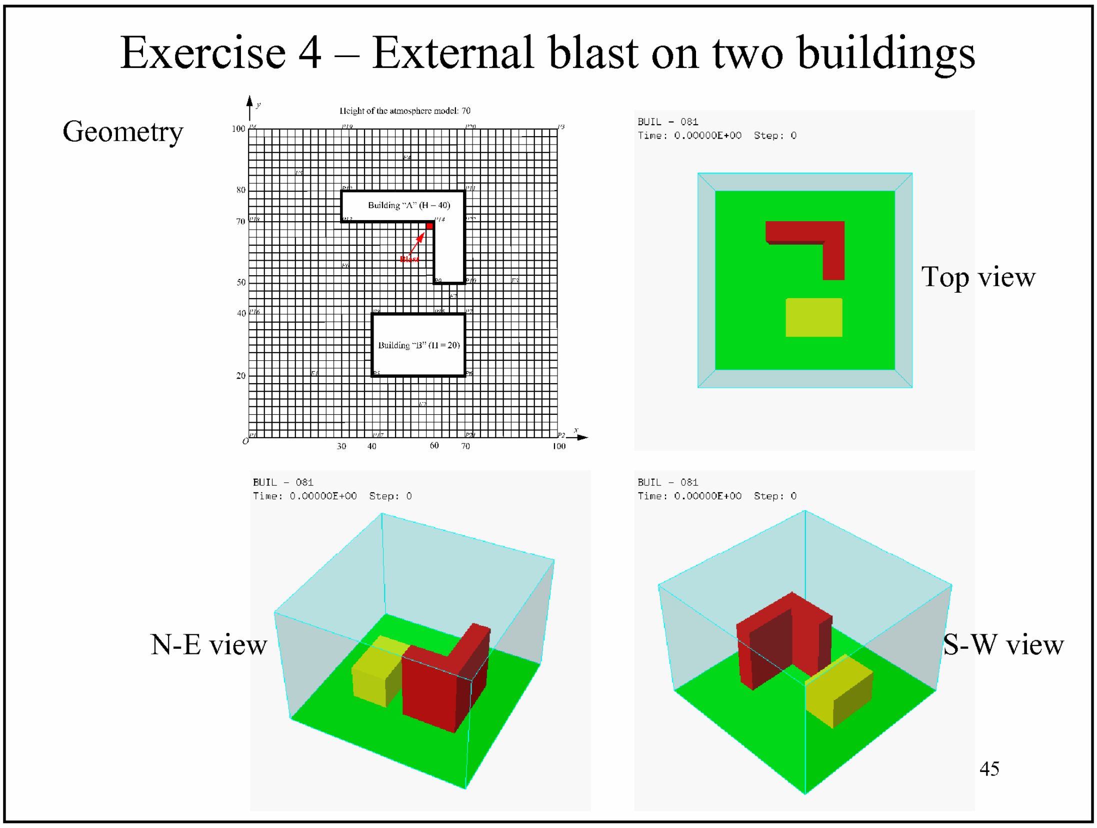


Geometric data:
External blast in an urban area with two buildings. The model size is 100 x 100 m and the atmosphere is modelled up to a height of 70 m. The two buildings are 40 and 20 m high, respectively. A regular mesh of 40 x 40 x 28 elements is used.

Boundary conditions:
Buildings are treated as rigid in this analysis. Non-reflecting conditions (absorbing boundaries) are prescribed on the external surface of the atmosphere model to prevent non-realistic pressure wave reflections. FSR (fluid-structure rigid) conditions (see Part 3) are adopted at the interface between the atmosphere and the buildings or the ground.

Materials
The explosive bubble is a perfect gas with $\gamma = 1.4$, initial density 1000 and initial pressure 100000 bar. The surrounding atmosphere is also a perfect gas, with a density of 1 and a pressure of 1 bar.
We want to study the effects of the explosion up to 100 ms of physical time.

BUIL08

Eulerian solution: the whole mesh is Eulerian. The mesh generation file is:

```
opti echo 1;
opti trac psc;
opti dime 3 elem cub8;
p1 = 0 0 0;
p2 = 100 0 0;
p3 = 100 100 0;
p4 = 0 100 0;
p5 = 40 20 0;
```

```
p6 = 70 20 0;
p7 = 70 40 0;
p8 = 40 40 0;
p9 = 60 50 0;
p10 = 70 50 0;
p11 = 70 80 0;
p12 = 30 80 0;
p13 = 30 70 0;
p14 = 60 70 0;
p15 = 60 40 0;
p16 = 0 40 0;
p17 = 40 0 0;
p18 = 0 70 0;
p19 = 30 100 0;
p20 = 70 100 0;
p21 = 70 0 0;
p22 = 70 70 0;
tol = 0.01;
f1 = dall (p1 d 16 p17) (p17 d 8 p5 d 8 p8) (p8 d 16 p16)
          (p16 d 16 p1) plan;
f2 = dall (p17 d 12 p21) (p21 d 8 p6) (p6 d 12 p5)
          (p5 d 8 p17) plan;
f3 = dall (p21 d 12 p2) (p2 d 40 p3) (p3 d 12 p20)
          (p20 d 8 p11 d 4 p22 d 8 p10 d 4 p7 d 8 p6 d 8 p21) plan;
f4 = dall (p12 d 16 p11) (p11 d 8 p20) (p20 d 16 p19)
          (p19 d 8 p12) plan;
f5 = dall (p18 d 12 p13) (p13 d 4 p12 d 8 p19) (p19 d 12 p4)
          (p4 d 12 p18) plan;
f6 = dall (p16 d 16 p8 d 8 p15) (p15 d 4 p9 d 8 p14)
          (p14 d 12 p13 d 12 p18) (p18 d 12 p16) plan;
f7 = dall (p15 d 4 p7) (p7 d 4 p10) (p10 d 4 p9) (p9 d 4 p15) plan;
trac qual (f1 et f2 et f3 et f4 et f5 et f6 et f7);
z1 = 0 0 70;
v1 = f1 volu tran 28 z1;
v2 = f2 volu tran 28 z1;
v3 = f3 volu tran 28 z1;
v4 = f4 volu tran 28 z1;
v5 = f5 volu tran 28 z1;
v6 = f6 volu tran 28 z1;
v7 = f7 volu tran 28 z1;
z8 = 0 0 20;
p5u = p5 plus z8;
p6u = p6 plus z8;
p7u = p7 plus z8;
p8u = p8 plus z8;
f8 = dall (p5u d 12 p6u) (p6u d 8 p7u) (p7u d 12 p8u)
          (p8u d 8 p5u) plan;
v8 = f8 volu tran 20 (0 0 50);
z910 = 0 0 40;
p9u = p9 plus z910;
p10u = p10 plus z910;
p11u = p11 plus z910;
p12u = p12 plus z910;
p13u = p13 plus z910;
p14u = p14 plus z910;
p22u = p22 plus z910;
f9 = dall (p9u d 4 p10u) (p10u d 8 p22u) (p22u d 4 p14u)
          (p14u d 8 p9u) plan;
f10= dall (p13u d 16 p22u) (p22u d 4 p11u) (p11u d 16 p12u)
          (p12u d 4 p13u) plan;
trac qual (f1 et f2 et f3 et f4 et f5 et f6 et f7 et f8 et
           f9 et f10);
v9 = f9 volu tran 12 (0 0 30);
v10 = f10 volu tran 12 (0 0 30);
fluid = v1 et v2 et v3 et v4 et v5 et v6 et v7 et v8 et v9 et v10;
elim tol (fluid et p5u et p6u et p7u et p8u et p9u et p10u
          et p11u et p12u et p13u et p14u et p22u);
p1u = p1 plus z1;
p2u = p2 plus z1;
p3u = p3 plus z1;
p4u = p4 plus z1;
abs1 = dall (p1 d 28 p1u) (p1u d 40 p4u) (p4u d 28 p4)
            (p4 d 40 p1) plan;
abs2 = dall (p2 d 28 p2u) (p2u d 40 p1u) (p1u d 28 p1)
            (p1 d 40 p2) plan;
abs3 = dall (p3 d 28 p3u) (p3u d 40 p2u) (p2u d 28 p2)
            (p2 d 40 p3) plan;
```

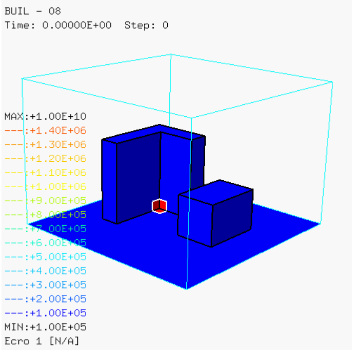
```
abs4 = dall (p4 d 28 p4u) (p4u d 40 p3u) (p3u d 28 p3)
            (p3 d 40 p4) plan;
abs5 = dall (p1u d 40 p2u) (p2u d 40 p3u) (p3u d 40 p4u)
            (p4u d 40 p1u) plan;
absor = abs1 et abs2 et abs3 et abs4 et abs5;
elim tol (fluid et absor);

pexp = p14 plus (-2.5 -2.5 2.5);
*explo = fluid elem appu larg pexp;
explo = fluid elem appu larg p14;
list (nbel explo);
air = diff fluid explo;
list (nbel air);

fsrn = enve fluid;
list (nbno fsrn);
fsrn = diff fsrn absor;
list (nbno fsrn);
bloz = p1 d 40 p2 d 40 p3 d 40 p4 d 40 p1;
elim tol (bloz et fluid);
list (nbno bloz);
fsrn = chan poi1 fsrn;
bloz = chan poi1 bloz;
fsrn = diff fsrn bloz;
list (nbno fsrn);

**explo = (fluid elem appu larg pexp) coul roug;
* explo = fluid elem appu larg pexp;
**air = (diff fluid explo) coul turq;
* air = diff fluid explo;
**fluid = (explo et air) coul jaun;
**fluid = explo et air;
mesh = fluid et absor et fsrn et bloz;
tass mesh;
opti sauv form 'buil08.msh';
sauv form mesh;
list (nbel fluid);
list (nbno fluid);
*list (nbel explo);
*list (nbel air);
list (nbel absor);
list (nbel mesh);
list (nbno mesh);
**trac cach face fluid;
**trac cach face (floor et explo);
**trac cach face absor;
 trac cach fluid;
* trac cach (floor et explo);
 trac cach absor;
```

The input file is:

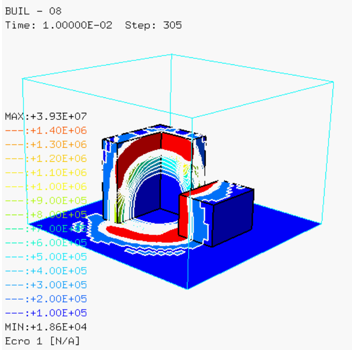
```
BUIL - 08
$
 ECHO
$VERI
!CONV win
CAST MESH
TRID NONL EULE
$
DIME
 PT3L 47029
 CUBE 42496 CL3D 6080 ZONE 2
 BLOQ 10000
TERM
$
GEOM
  CUBE fluid
  CL3D absor
TERM
*
COMP COUL roug LECT explo TERM
          turq LECT air   TERM
          rose LECT absor TERM
*
MATE
```

```
$ high-pressure perfect gas (explosive bubble)
     GAZP RO 1000 GAMM 1.4 PINI 100000.E5
          PREF 1.E5 LECT explo TERM
$ air
     GAZP RO 1 GAMM 1.4 PINI 1.E5
          PREF 1.E5 LECT air TERM
$ absorbing
     IMPE ABSO RO 0 C 0
          LECT absor TERM
$
LIAI FREQ 1
     BLOQ 3 LECT bloz TERM
     FSR LECT fsrn TERM
$
ECRI VITE ECRO TFRE 100.E-3
     FICH ALIC TFRE 1.E-3
$
OPTI NOTEST
 csta 0.5e0
 log 1
CALCUL TINI 0 TEND 0.1E0
*==================================================================
FIN
```

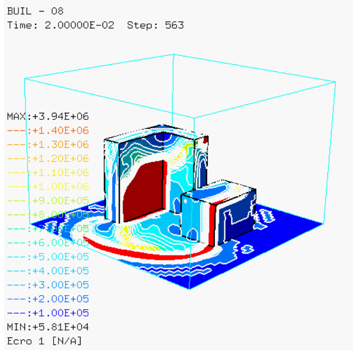
The fluid pressures on the building and on the ground at some selected instants are shown below:



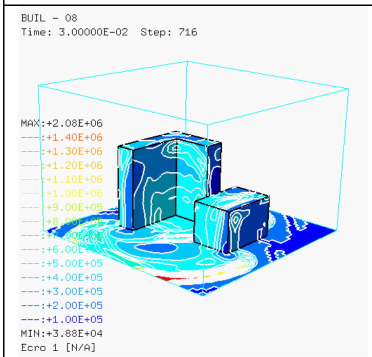
Pressure at t = 0



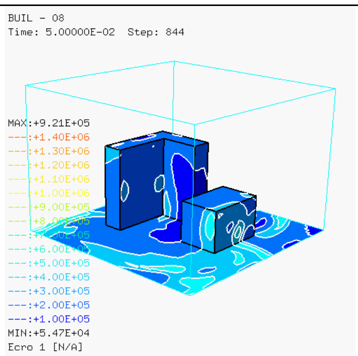
Pressure at t = 10 ms



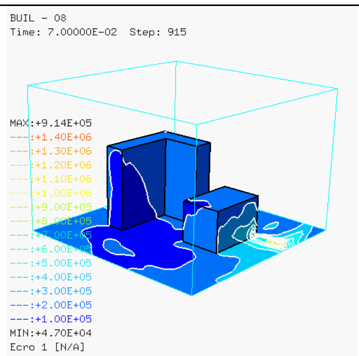
Pressure at t = 20 ms



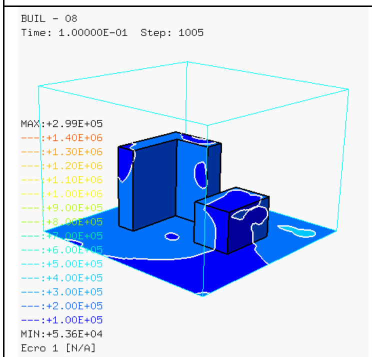
Pressure at t = 30 ms



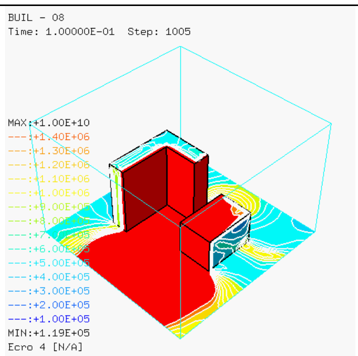
Pressure at t = 50 ms



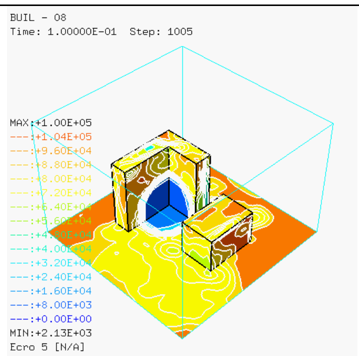
Pressure at t = 70 ms



Pressure at t = 100 ms



Max pressure map



Min pressure map