SSNL124 - Axial creep of an element HEXA8 with a behavior of LEMAITRE_IRRA

Summary:

This CAS-test makes it possible to implement a phenomenon of axial creep on a cube. This test is carried out by applying a field of fluence to a modeling 3D, realized with a mesh HEXA8. The properties of the cube are defined by the law of Lemaitre irradiation.

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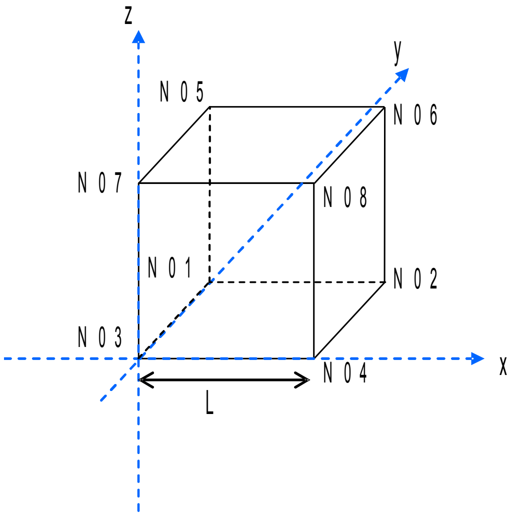
1 Problem of reference

1.1 Geometry



Geometry of the cube (m) : $L=1$

Coordinates of the points (m) :

$NO1:(0.0, 1.0, 0.0)$
$NO2:(1.0, 1.0, 0.0)$
$NO3:(0.0, 0.0, 0.0)$
$NO4:(1.0, 0.0, 0.0)$
$NO5:(0.0, 1.0, 1.0)$
$NO6:(1.0, 1.0, 1.0)$
$NO7:(0.0, 0.0, 1.0)$
$NO8:(1.0, 0.0, 1.0)$

Mesh:

$MA1$: together cube

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1.2 Properties of material

- Rubber band
  - $E=10^5 Pa$ Young modulus
  - $\nu=0.3$ Poisson's ratio
  - $\alpha=0.\ /^{\circ}C$ Dilation coefficient

- Lemaitre
  - $\frac{1}{K}=10^{-6}$
  - $\frac{1}{m}=0.207060772$
  - $n=2.3364$
  - $L=0.$
  - $\phi_0=4.240281\times 10^{21}$
  - $\beta=1.2$
  - $QSR\_K=3321.093$
  - $a=-1.51\times 10^{-16}$
  - $b=1.542\times 10^{-13}$
  - $S=0.396$

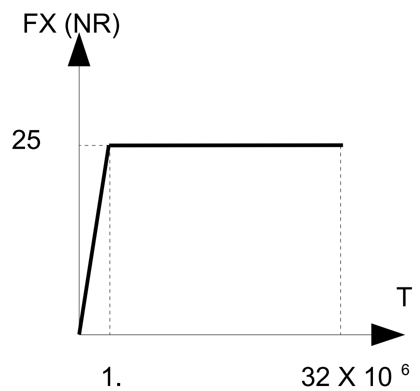
1.3 Boundary conditions and loadings

- Imposed displacement (m) :

  - $N01: DX=DZ=0$
  - $N03: DX=DY=DZ=0$
  - $N05: DX=0$
  - $N07: DX=0$

- Loading

  The loading, is imposed on the nodes $N02, N04, N06, N08,$ vary gradually on the interval $t\in[0,1.]$ and remains constant on the interval $t\in]1.,32.\ 10^6]$ as on the figure below.



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- Fluence imposed on nodes.

Moment (s)	Fluence $(n.m^{-2})$
0.0	0.
1.0	7.20000×10^{21}
8.64990×10^{2}	6.22793×10^{24}
1.72898×10^{3}	1.24487×10^{25}
2.16097×10^{3}	1.24487×10^{25}
2.59297×10^{3}	1.86694×10^{25}
3.45696×10^{3}	2.48901×10^{25}

- Temperature imposed on nodes.

$T=299.85\,°C$ with a temperature of reference of $T_{ref}=299.85\,°C$

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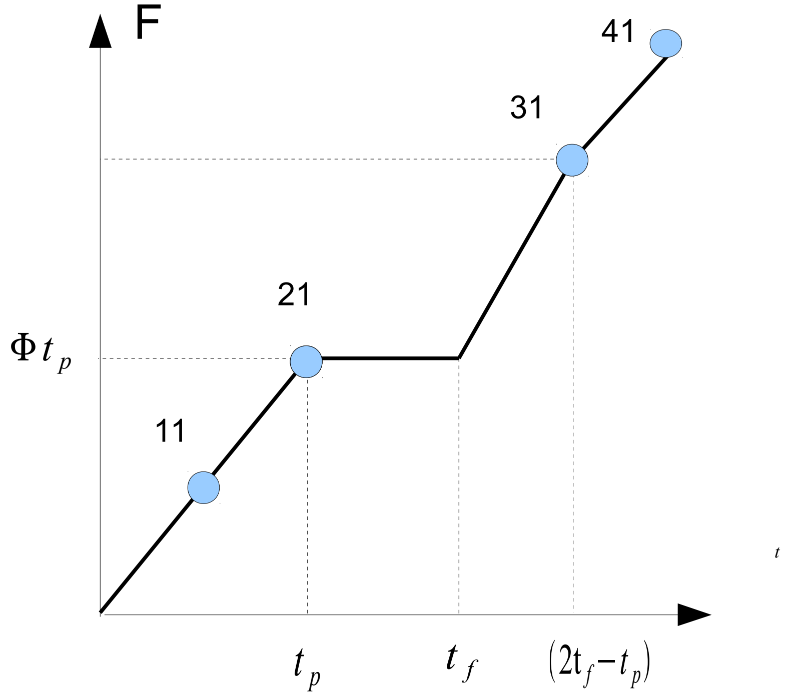
2 Reference solution

2.1 Method of calculating used for the reference solution

$K=10^6$, $\frac{\Phi}{\Phi_0}=1.698$



$F=\Phi_1 t$ $\quad\Phi_1=7.2\times10^{21}$ if $t\in[0,t_p=1728.98]=I_1$ $\Rightarrow\Phi=\Phi_1$

$F=\Phi_1 t_p$ $\quad\Phi_1=7.2\times10^{21}$ if $t\in[t_p,t_f=2160.975]=I_2$ $\Rightarrow\Phi=0$

$F=\Phi_1 t_p+2\Phi_1(t-t_f)$ $\quad\Phi_1=7.2\times10^{21}$ if $t\in[t_f,2t_f-t_p]=I_3$ $\Rightarrow\Phi=2\Phi_1$

$F=\Phi_1 t$ $\quad\Phi_1=7.2\times10^{21}$ if $t>(2t_f-t_p)=I_4$ $\Rightarrow\Phi=\Phi_1$

$$p=\left[\frac{n+m}{m}\sigma^n\left(\frac{1}{K}\frac{\Phi}{\Phi_0}+L\right)^{\beta} t\, e^{-\frac{Q}{R(T+T_0)}}\right]^{\frac{m}{n+m}} \text{ if } t\in I_1$$

$$p=\left[\frac{n+m}{m}\sigma^n\left(\frac{1}{K}\frac{\Phi}{\Phi_0}+L\right)^{\beta} t_p\, e^{-\frac{Q}{R(T+T_0)}}\right]^{\frac{m}{n+m}}=p_f \text{ if } t\in I_2$$

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$p=p_f$ with $t=t_f$ $\boxed{L=0}$

$$\dot{p}=\left[\frac{\sigma}{p^{\frac{1}{m}}}\right]^n\left(\frac{1}{K}\frac{2\Phi}{\Phi_0}+L\right)^\beta e^{\frac{-Q}{R(T+T_0)}}$$

$$\dot{p}\,p^{\frac{n}{m}}=\sigma^n\left(\frac{1}{K}\frac{2\Phi}{\Phi_0}+L\right)^\beta e^{\frac{-Q}{R(T+T_0)}}$$

$$\dot{p}^{\frac{m+n}{m}}=\frac{m+n}{m}\sigma^n\left(\frac{1}{K}\frac{2\Phi}{\Phi_0}+L\right)^\beta e^{\frac{-Q}{R(T+T_0)}}$$

$$p=\left[\frac{m+n}{m}\sigma^n\left(\frac{1}{K}\frac{2\Phi}{\Phi_0}+L\right)^\beta e^{\frac{-Q}{R(T+T_0)}}((t-t_f)2\beta+t_p)\right]^{\frac{m}{m+n}}\quad \text{if}\quad t\in I_3$$

$$p=\left[\frac{m+n}{m}\sigma^n\left(\frac{1}{K}\frac{2\Phi}{\Phi_0}+L\right)^\beta e^{\frac{-Q}{R(T+T_0)}}(t+(t_f-t_p(2\beta-2)))\right]^{\frac{m}{m+n}}\quad \text{if}\quad t\in I_4$$

Digital application

$$\frac{1}{K}=10^{-6}\ ;\ \frac{\Phi}{\Phi_0}=1.698\ ;\ \sigma=100\ ;\ \beta=1.2$$

with $t=3456.96$

$$p=(0.09067259953)^{\left(\frac{m}{(n+m)}\right)}=0.198332841$$
$$\varepsilon=0.200569905$$

with $t=2592.97$

$$p=(0.06882302104)^{\left(\frac{m}{(n+m)}\right)}=0.164696317$$
$$\varepsilon=0.166804179$$

2.2 Reference variables

- Displacement DX with the node $N02$
- Constraint $SIXX$ in the mesh $MA1$
- Cumulated plastic deformation $V1$ in the mesh $MA1$

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2.3 Result of reference

Size	Node or Mesh	moment	Reference
$V1$	$MA1$	2.59297×10^3	0.164696
$DX(m)$	$N02$	2.59297×10^3	0.166804
$V1$	$MA1$	3.45696×10^3	0.119833
$DX(m)$	$N02$	3.45696×10^3	0.20057
$SIYY\ (Pa)$	$MA1$	3.45696×10^3	100

2.4 Uncertainty on the solution

Analytical solution

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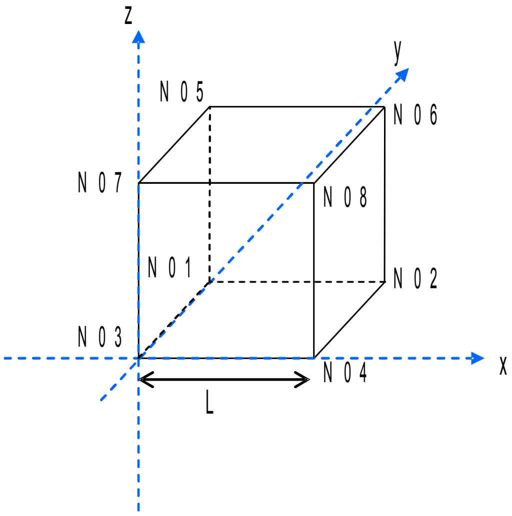
3 Modeling A

3.1 Characteristics of modeling A



Modeling 3D,
Relation of behavior of LEMAITRE_IRRA:

Many nodes 8
Many meshs 1
That is to say:HEXA8 1

3.2 Sizes tested and results

Size	Node or Mesh	moment	Reference	Aster	Variation (%)
$V1$	$MA1$	2.59297×10^{3}	0.164696	0.164464	-0,141
$DX(m)$	$N02$	2.59297×10^{3}	0.166804	0.166572	-0,139
$V1$	$MA1$	3.45696×10^{3}	0.198330	0.198116	-0,108
$DX(m)$	$N02$	3.45696×10^{3}	0.20057	0.20035	-0,106
$SIYY\ (Pa)$	$MA1$	3.45696×10^{3}	100	100	-7.5E-5

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4 Summary of the results

The comparison between the got results and the analytical solution is very satisfactory.

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