SSNS108 – Simulation of test SAFE by the progressive push

Abstract:

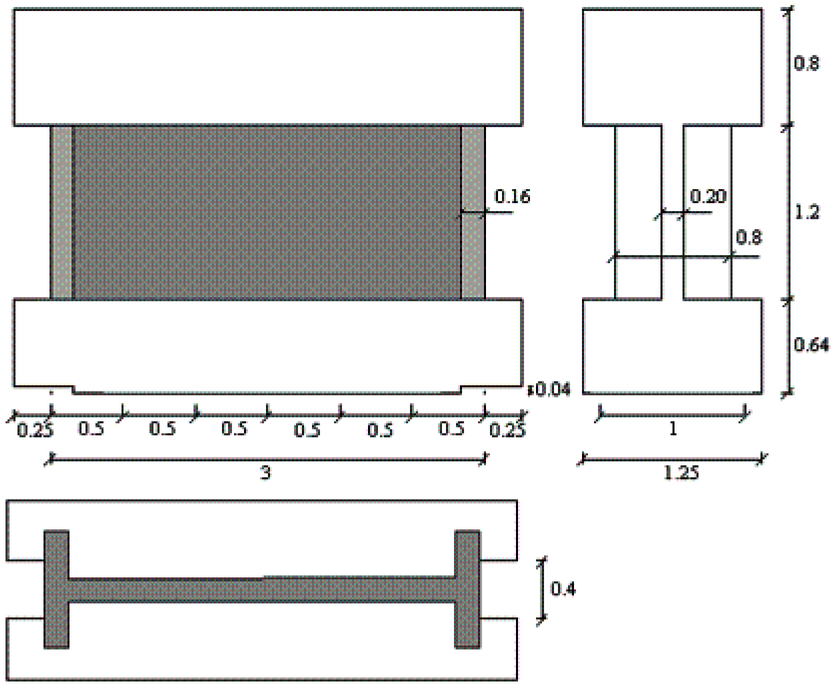
This test represents a simplified modelization of a study SAFE (Structure Armed Slightly Slender) under monotonous static loading of thorough type progressive (“pushover”). It aims to validate computation options DEBORST and TANGENTE_SECANTE under NEWTON.

This test is delicate because he considers a problem badly posed, without unicity of solution, of with softening material related to the damage.

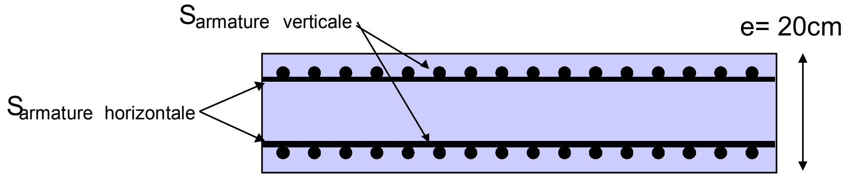
1 Problem of reference

1.1 Geometry

the studied geometry is that of the T5 structure of program SAFE [bib1]. The geometrical characteristics of the parts out of reinforced concrete are illustrated by [Appear 1.1-a]. They are made up of a veil and two walls wing (or partitions). The structure is also equipped with reported metal parts necessary to its setting under loading. These parts will not be modelled in this study.



Appear 1.1-a: Geometry of the model T5



Coupe dans le plan horizontal du mur central
Figure 1.1-b: Illustration of reinforcement

the reinforcement of the model is composed of three-dimensions functions of horizontal and vertical reinforcements placed on each of the two sides of the central wall, like in the returns [Figure 1.1-b]. According to the two horizontal and vertical directions, rates of reinforcement r_h and r_v (quantity of reinforcement per linear meter of the veil) are identical and equal to $0,8\%$, that is to say:

$$\frac{S_{armatures horizontales}}{ml(vertical)}=r_h e=\frac{0,8}{100}.20cm=16\,cm^2/ml$$
$$\frac{S_{armatures verticales}}{ml(horizontale)}=r_v e=\frac{0,8}{100}.20cm=16\,cm^2/ml$$

And this for all two three-dimensions function sides North and South.

Either, $8\,cm^2/ml$ by three-dimensions function and direction (horizontal and vertical, or $2x8=16\,cm^2/ml$).

1.2 Materials properties

the behavior of the concrete is modelled via the elastoplastic behavior endommageable `ENDO_ISOT_BETON` [bib2]. The materials' properties concrete are summarized [Table 1.2-1].

Young modulus	E_b	`E`	$32\,308\,MPa$
Poisson's ratio	ν_b	`NU`	$0{,}2$
Density	ρ_b	`ultimate`	$2\,500\,kg/m^3$
RHO Stress in ultimate	σ_t	`tension`	$3{,}415\,MPa$
SYT Stress in compression	σ_c	`SYC`	$25\,MPa$
Slope of the curved post-peak in tension		`D_SIGM_EPSI`	$-7000\,MPa$

Table 1.2-1: Properties of the model concrete

the parts out of concrete are reinforced by the steel reinforcements modelled by `GRILLE_MEMBRANE` [bib3]. Steel has an elastoplastic behavior with isotropic hardening linear `GRILLE_ISOT_LINE`. The materials' properties steels are recapitulated in the table [Table 1.2-2].

Young modulus	E_a	`E`	200.000 MPa
Poisson's ratio	ν_a	`NU`	0,3
Density	ρ_a	`ultimate`	RHO 7.800
kg/m3 Stress of plasticization	σ_y	`SY`	570 MPa
Slope of hardening		`D_SIGM_EPSI`	300 MPa

Table 1.2-2: Properties of model steel

1.3 Boundary conditions and loadings

Connection at the base:

The connection of the model with the low longitudinal beam was considered to be sufficiently stiff so that one models it by a perfect anchorage. Thus, all the nodes of the base of the model are blocked according to all the degrees of freedom.

Motions of the high longitudinal beam:

The purpose of the presence of the high longitudinal beam is maintaining edge higher of the wall than horizontal by preventing rotations around the axis Y.

Loading:

The loadings taken into account are the inertia loading of structure as well as a displacement imposed at the top of structure.

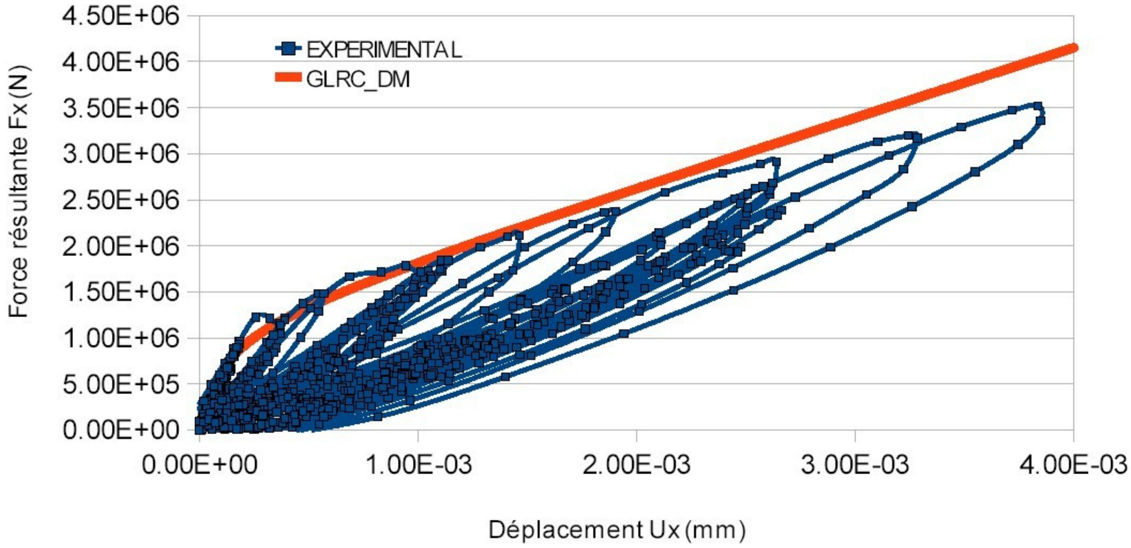
1.4 Initial conditions

Without Reference solution

2 object

2.1 Méthode de calcul

the bench-mark data are recovered of a simulation of the same test with a globalized constitutive law GLRC_DM [bib4]. [Appear 2.1-a] illustrates the results of this simulation compared to the experimental data.



Appear 2.1-a: Comparison of the experimental data for a static loading alternate on the T5 model with a simulation using GLRC_DM

2.2 Quantities and results of reference

the quantities tested are the forces and the displacements at times $t=0{,}03\,s$ and $t=0{,}0495\,s$. The data are recapitulated in [Table 2.2-1].

Time (s)	Forces (MN)
0,03	1,07976
0,0495	1,32921

Table 2.2-1: Quantities tested

2.3 Uncertainty on the solution

numerical Solutions.

2.4 Bibliographical references

[1] P. PEGON, G. MAGONETTE, F.J. MOLINA, G. VERZELETTI, T. DYNGELAND, P. NEGRO, D. TIRELLI, P. TOGNOLI, "Program SAFE: Ratio of the T5 test", Unit Structural mechanics, Institute of the Systems, L `Data-processing and Security, Joint Research Center, European Commission, 21020 Ispra (Varese), Italy

[2] [R7.01.04-C], Constitutive law ENDO_ISOT_BETON

[3] [R3.08.07-A], Elements of grid of reinforcement GRILLE_MEMBRANE

[4] S. GHAVANIAM, S. MILL, "Modelization of the T5 structure of program SAFE using Code_Aster®", EDF R & D, H-T62-2006-04624-FR, 2006.

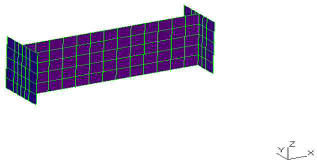
3 Modelization A

3.1 Characteristic of the modelization

the concrete is modelled using elements DKT (multi-layer shell in plane stresses). Reinforcement is simplified by neglecting reinforcements of seam between the various three-dimensions functions. As for the three-dimensions functions of reinforcement of the veils, they are modelled by plane elements of type GRILLE_MEMBRANE (positioned at the exact coast inside the concrete to take account of the concrete of coating). The link between meshes of the central wall and the wing walls is made by the division of the nodes on the level of the median averages.

3.2 Characteristics of the mesh

The mesh used for computation is represented on [Appear 3.2-a].



Appear 3.2-a: Mesh of the model T5

the number of meshes quadrangular linear (QUAD4) is of 625. These meshes are divided into elements:
- DKT with height of 125,
- GRILLE_MEMBRANE to a total value of 500.

3.3 Quantities tested and Time

results (s)	Forces ref. (MN)	Forces num. (MN)	Variation Forces (%)
0,03	1,07976	1,64144	52,1
0,0495	1,32921	1,46471	10,2

4 Summary of the results

Although the results got between the two modelizations can give important variations (more 50%), the case test made it possible to show the possibility of taking into account computation options DEBORST and TANGENTE_SECANTE under NEWTON.