SSNS108 – Simulation of test SAFE by the progressive push

Summary:

This test represents a simplified modeling of a study SAFE (Structure Armed Slightly Slim) under monotonous static loading of thorough type progressive (“pushover”). It aims to validate the option of calculation DEBORST 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 Problème 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 [Figure 1.1-a]. They are made up of a veil and two wing walls (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.

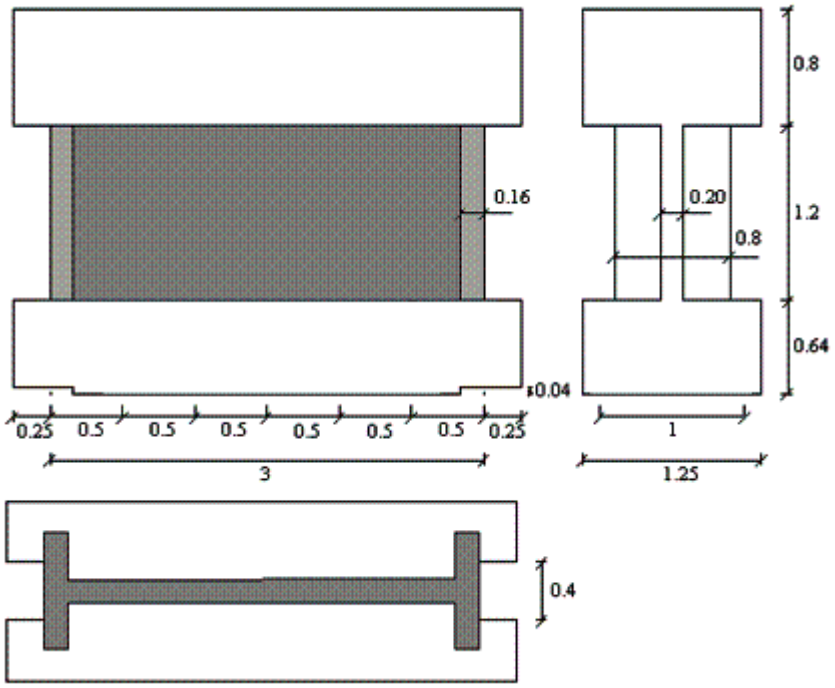
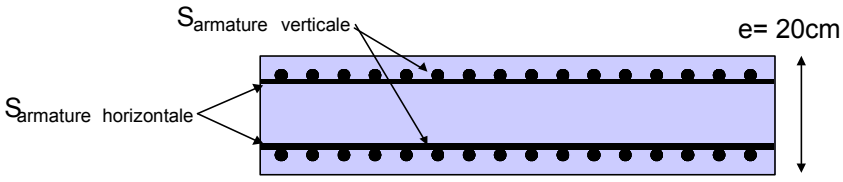


Figure 1.1-a: Geometry of the T5 model



Coupe dans le plan horizontal du mur central

Figure 1.1-b: Illustration of reinforcement

The reinforcement of the model is composed of tablecloths of horizontal and vertical reinforcements placed on each of the two faces of the central wall, like in the returns [Figure 1.1-b]. According to the two horizontal and vertical directions, the 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 tablecloth faces North and South.

Maybe, $8\,cm²/ml$ by tablecloth and direction (horizontal and vertical, that is to say $2\text{x}8=16\,cm²/ml$).

1.2 Properties materials

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

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

Table 1.2-1: Properties of the model concrete

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

Young modulus	E_a	E	200,000 MPa
Poisson's ratio	ν_a	NAKED	0.3
Density	ρ_a	RHO	7,800 kg/m^3
Ultimate stress of plasticization	σ_y	SY	570 MPa
Slope of work 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 anchoring. Thus, all the nodes of the base of the model are blocked according to all the degrees of freedom.

Movements of the high longitudinal beam:

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

Loading:

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

1.4 Initial conditions

Without object

2 Reference solution

2.1 Method of calculating

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

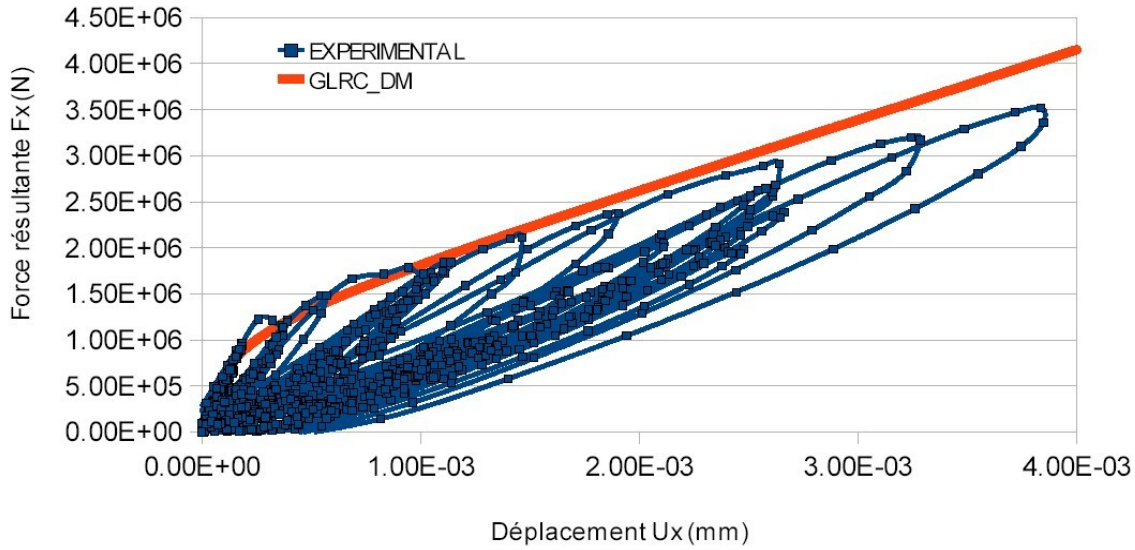


Figure 2.1-a: Comparison of the experimental data for a static loading alternate on the T5 model with a simulation using GLRC_DM

2.2 Sizes and results of reference

The sizes tested are the efforts and displacements at the moments $t=0,03\,s$ and $t=0,0495\,s$. The data are recapitulated in [Table 2.2-1].

Moment (s)	Force (MN)
0.03	1.07976
0.0495	1.32921

Table 2.2-1: Sizes tested

2.3 Uncertainty on the solution

Digital 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: Report of the T5 test”, Mechanical Unit of the Structures, Institute of the Systems, Data processing and Security, Joint Research Centre, European Commission, 21020 Ispra (Varese), Italy

[2] [R7.01.04-C], Law of behavior ENDO_ISOT_BETON

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

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

3 Modeling A

3.1 Characteristics of modeling

The concrete is modelled using elements DKT (multi-layer hull in plane constraints). Reinforcement is simplified by neglecting the reinforcements of seam between the various tablecloths. As for the tablecloths of reinforcement of the veils, they are modelled by elements plans of the type GRILLE_MEMBRANE (positioned at the exact coast inside the concrete to take account of the concrete of coating). The link between the meshs of the central wall and the wing walls is made by the division of Nœuds on the level of the median layers.

3.2 Characteristics of the grid

The grid used for calculation is represented on [Figure 3.2-a].

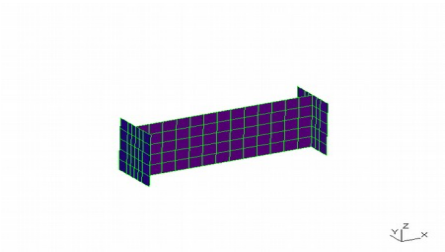


Figure 3.2-a: Grid of the T5 model

The number of linear quadrangular meshs (QUAD4) is of 625. These meshs are divided into elements:

- DKT to a total value of 125,
- GRILLE_MEMBRANE to a total value of 500.

3.3 Sizes tested and results

Moment (s)	Force ref. (MN)	Force num. (MN)	Variation Forces (%)
0.03	1.07976	1.64144	52.1
0.0495	1.32921	1.46471	13.1

4 Summary of the results

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