SDNV114 – Simulation of benchmark SAFE - T5 veil out of reinforced concrete

Summary:

This test represents a simplified modeling of a test SAFE (Structure Armed Slightly Slim) of reinforced concrete veils under cyclic static loading. One is interested in the T5 veil. This test makes it possible to compare the answer of the structure modelled with the law GLRC_DM then with the law DHRC with the experimental results.

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 [Figure 1.1-a]. They are made up of a veil and two wing walls (or partitions). The structure is also equipped with metal parts (longitudinal beams) reported necessary to its setting under loading. These parts will not be modelled in this study.

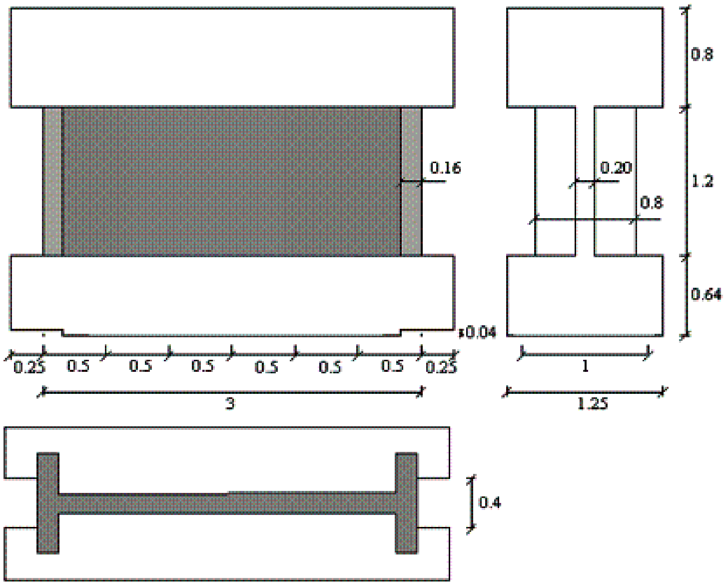
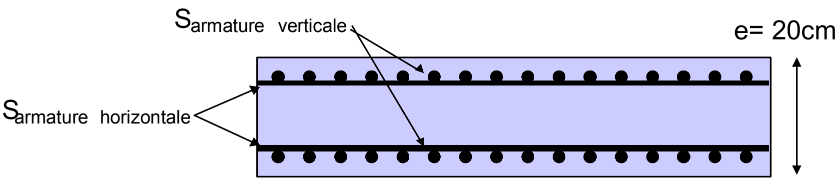


Figure 1.1-a: Geometry of the T5 model



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 [feeding-bottle 1]. 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:

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

And this for all two tablecloth faces North and South.

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

1.2 Properties of material

- Law of behavior GLRC_DM

For modeling A, the behavior of the reinforced concrete is modelled via the law GLRC_DM. The parameters of law of behavior were readjusted to obtain an answer close to experimental measurements. The parameters materials of the law are given, cf [feeding-bottle 1] and [feeding-bottle 2] for the principal veil and the two secondary veils (edges).

Effective Young modulus out of membrane	E_M	$27\,160\,MPa$
Effective Poisson's ratio out of membrane	NU_M	$0{,}19$
Effective Young modulus out of membrane	E_F	$29\,091\,MPa$
Effective Poisson's ratio out of membrane	NU_F	$0{,}18$
Thrust load of yield stress in traction	NYT	$353\,kN/m$
Moment limits inflection	MYF	$13\,kN.m/m$
Thrust load limits in compression	NYC	$1\,976\,kN.m/m$
Parameter of damage in traction	GAMMA_T	$0{,}013$
Parameter of damage in inflection	GAMMA_F	$0{,}18$
Parameter of damage in compression	GAMMA_C	$0{,}9$
Parameter of damage of coupling	ALPHA_C	$1{,}1$

Table 1.2-1: Parameters of the model concrete for the principal veil

Effective Young modulus out of membrane	E_M	$27\,574\,MPa$
Effective Poisson's ratio out of membrane	NU_M	$0{,}19$
Effective Young modulus out of membrane	E_F	$29\,598\,MPa$
Effective Poisson's ratio out of membrane	NU_F	$0{,}18$
Thrust load of yield stress in traction	NYT	$286\,kN/m$
Moment limits inflection	MYF	$8\,kN.m/m$
Thrust load limits in compression	NYC	$1\,627\,kN.m/m$
Parameter of damage in traction	GAMMA_T	$0{,}015$
Parameter of damage in inflection	GAMMA_F	$0{,}209$
Parameter of damage in compression	GAMMA_C	$0{,}9$
Parameter of damage of coupling	ALPHA_C	$1{,}1$

Table 1.2-2: Parameters of the model concrete for the secondary veils

- Law of behavior DHRC

For modeling B, the behavior of the reinforced concrete is modelled via the law DHRC. The parameters of law of behavior were obtained thanks to plug-in Salomé. The data materials come from the experimental data [1] or assumptions resulting from Eurocode 2.

Young modulus of the concrete (Eurocode)	E_C	$34\,150\,MPa$
Poisson's ratio of the concrete (Experiment)	NU_C	$0{,}2$
Constraint with the peak in compression (Experiment)	SYC	$43{,}3\,MPa$
Constraint with the peak in traction (Experiment)	SYT	$3{,}32$
Deformation with the peak of compression (Eurocode)	EPSC	$2{,}25$ ‰
Young modulus of steel (Experiment)	E_A	$200\,000\,MPa$
Poisson's ratio of steel (Experiment)	NU_A	$0{,}3$
Elastic limit of steel (Experiment)	SYA	$570\,MPa$

Table 1.2-3: Parameters of the model concrete for the principal veil

One uses the following options for the determination of the microscopic parameters: Automatic 4R RIGI_ACIER and Orthotropic TCD.
For the veil, the distribution of the reinforcements is identical in the horizontal and vertical directions (either $8\,cm^2/ml$). For the edges, the density of reinforcements is different for the horizontal reinforcements (either $8{,}5\,cm^2/ml$) and verticals (either $19{,}2\,cm^2/ml$).

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. The way of loading is given

1.4 Initial conditions

Nothing

2 Reference solution

2.1 Method of calculating

The reference solution corresponds to experimental measurements of forces according to imposed displacement.

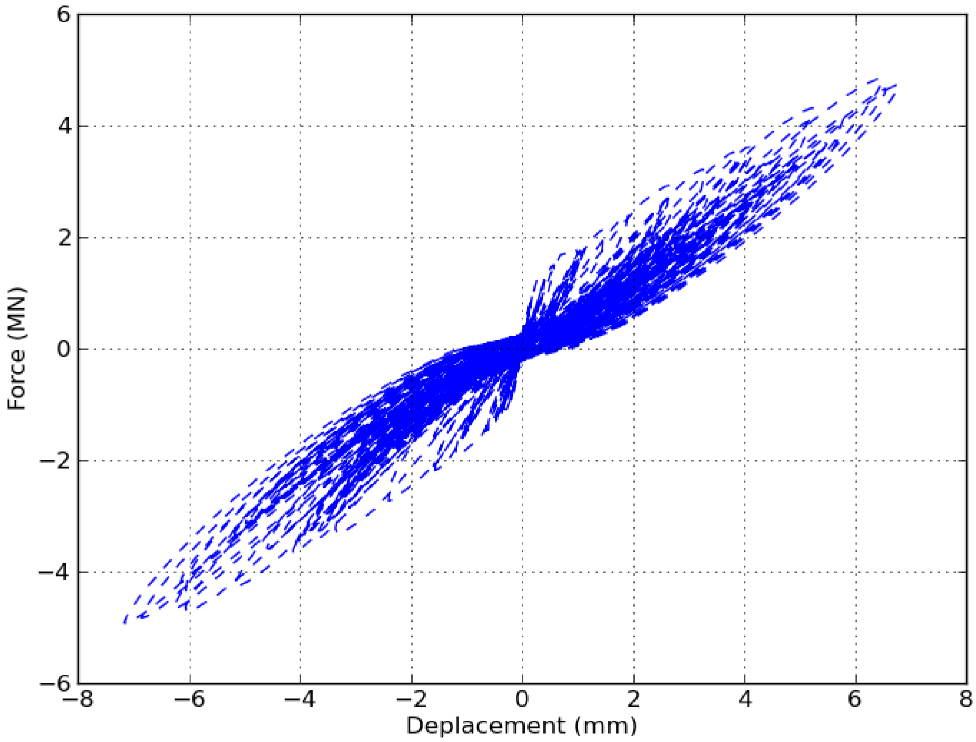


Figure 2.1-1: Experimental answer of veil SAFE T5.

2.2 Sizes and results of reference

The sizes tested are the horizontal force of reaction of the wall at various moments. The data are recapitulated in [Table 2.2-1].

Moment (s **)**	**Force (** MN **)**
11.07	2.9087
11.96	-3.2389
12.13	2.6812
13.09	-2,873
13.3	3.1698
13.47	-3.4344
14.03	2.3883
16.34	-3.1527
16.53	3.3595
16.72	-3.0954

Table 2.2-1: Sizes tested

2.3 Uncertainties on the solution

Experimental 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, 1998.

[2] 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 various veils are modelled by elements DKTG. 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 contains 308 elements of the type QUAD4 and is represented on [Figure 3.2-1].

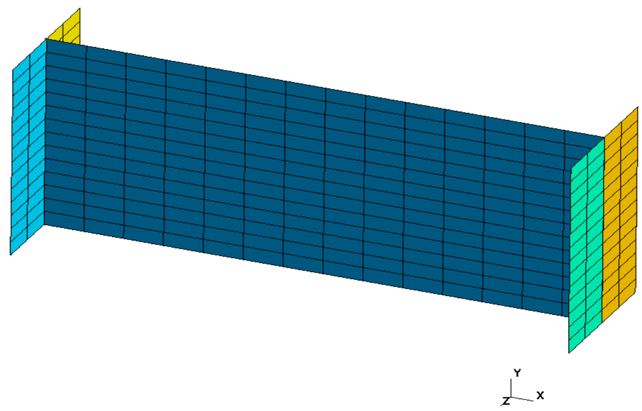


Figure 3.2-1: Grid of the T5 model

3.3 Sizes tested and results

One tests the horizontal force of reaction of the wall calculated on the higher edge of the veil.

Identification	Type of reference	Value of reference	Tolerance
Moment 11.07s	'SOURCE_EXTERNE'	2.9087E+06	2,00%
Moment 11.96s	'SOURCE_EXTERNE'	-3.2389E+06	6,00%
Moment 12.13s	'SOURCE_EXTERNE'	2.6812E+06	2,00%
Moment 13.09s	'SOURCE_EXTERNE'	-2.873E+06	10,50%
Moment 13.3s	'SOURCE_EXTERNE'	3.1698E+06	4,00%
Moment 13.47s	'SOURCE_EXTERNE'	-3.4344E+06	5,50%
Moment 14.03s	'SOURCE_EXTERNE'	2.3883E+06	10,00%
Moment 16.34s	'SOURCE_EXTERNE'	-3.1527E+06	9,00%
Moment 16.53s	'SOURCE_EXTERNE'	3.3595E+06	10,00%
Moment 16.72s	'SOURCE_EXTERNE'	-3.0954E+06	9,00%

3.4 Remarks

The modeling of wall SAFE thanks to the law of behavior GLRC_DM whose parameters were readjusted very satisfactory results in comparison with the experimental answer in term of effort and displacement give. However as one can see it on Figure 3.4-1, the loops of hysteresis are not sufficiently important what makes it possible to propose not taken it in account of certain dissipative phenomena (friction of the lips of cracks of the concrete, steel-concrete connection,…).

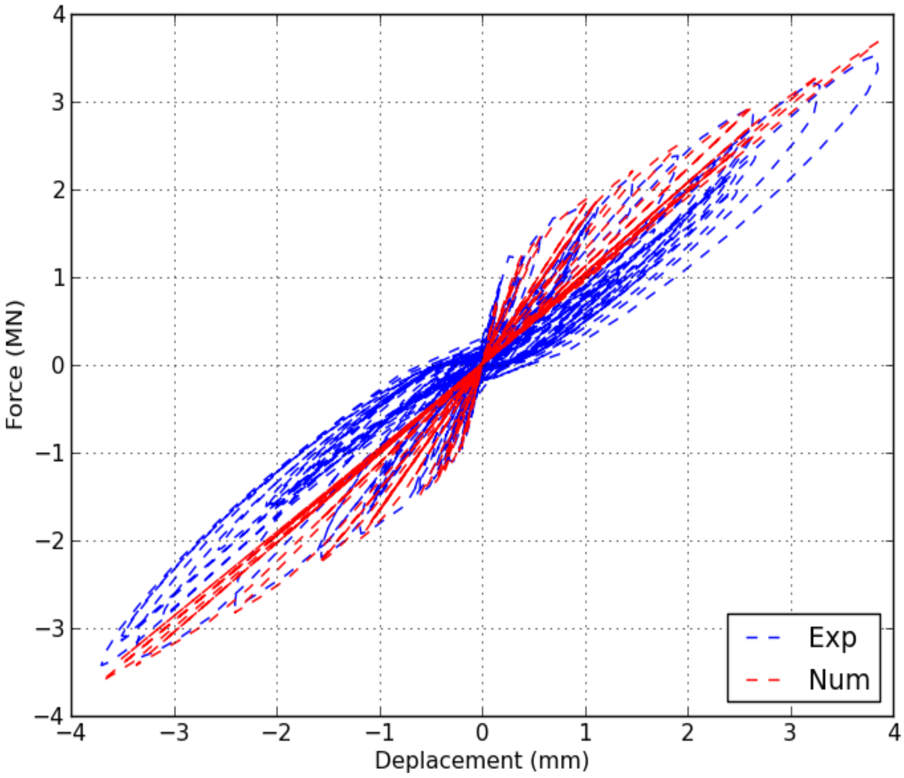


Figure 3.4-1: Comparison between the answer of model GLRC_DM and the experimental data

4 Modeling B

4.1 Characteristics of modeling

The various veils are modelled by elements DKTG. 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. The law of behavior used is DHRC.

4.2 Characteristics of the grid

The grid contains 308 elements of the type QUAD4 and is represented on [Figure 4.2-1].

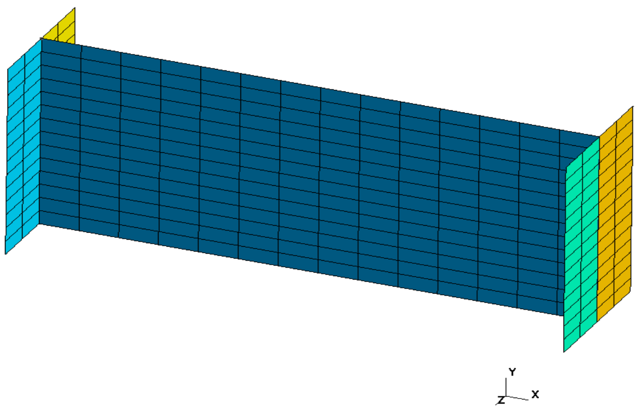


Figure 4.2-1: Grid of the T5 model

4.3 Sizes tested and results

One tests the horizontal force of reaction of the wall calculated on the higher edge of the veil.

Identification	Type of reference	Value of reference	Tolerance
Moment 11.07s	'SOURCE_EXTERNE'	2.9087E+06	14,00%
Moment 11.96s	'SOURCE_EXTERNE'	-3.2389E+06	12,00%
Moment 12.13s	'SOURCE_EXTERNE'	2.6812E+06	17,00%
Moment 13.09s	'SOURCE_EXTERNE'	-2.873E+06	8,00%
Moment 13.3s	'SOURCE_EXTERNE'	3.1698E+06	13,00%
Moment 13.47s	'SOURCE_EXTERNE'	-3.4344E+06	12,00%
Moment 14.03s	'SOURCE_EXTERNE'	2.3883E+06	9,00%
Moment 16.34s	'SOURCE_EXTERNE'	-3.1527E+06	9,00%
Moment 16.53s	'SOURCE_EXTERNE'	3.3595E+06	9,00%
Moment 16.72s	'SOURCE_EXTERNE'	-3.0954E+06	9,00%

4.4 Remarks

Parameters of the law of behavior DHRC were not readjusted and are resulting from the data of the test or the values by default. The got results are satisfactory in comparison with the experimental answer in term of initial stiffness and threshold of cracking. The answer post-peak could however be improved.

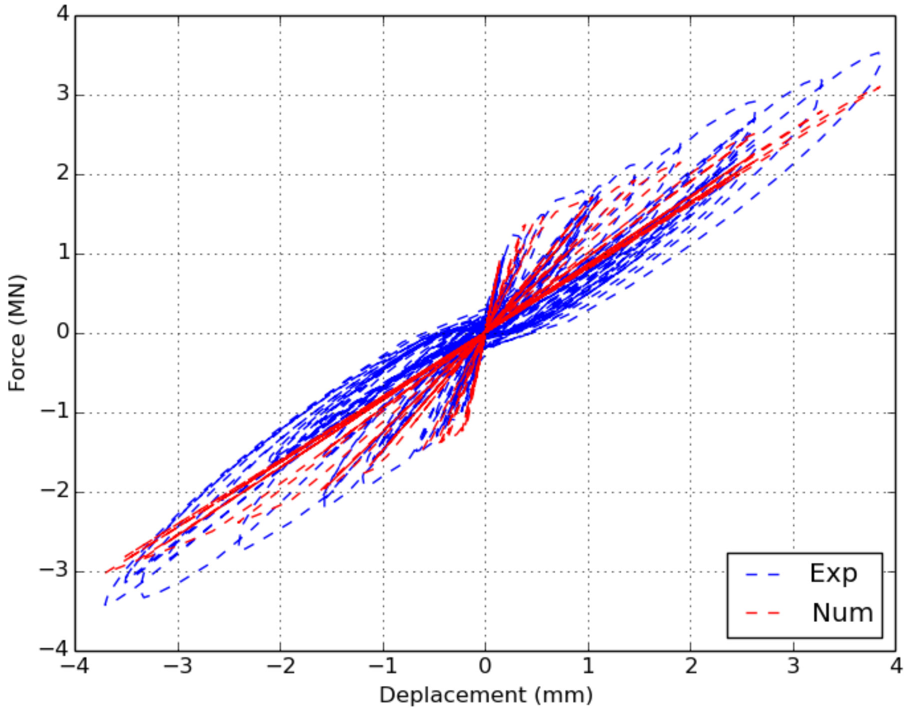


Figure 4.4-1: Comparison between the answer of model DHRC and the experimental data

5 Summary of the results

Modelings installation make it possible to find the experimental results satisfactorily.