

SSNS111 - Inflection of a reinforced concrete flagstone under distributed load

Summary:

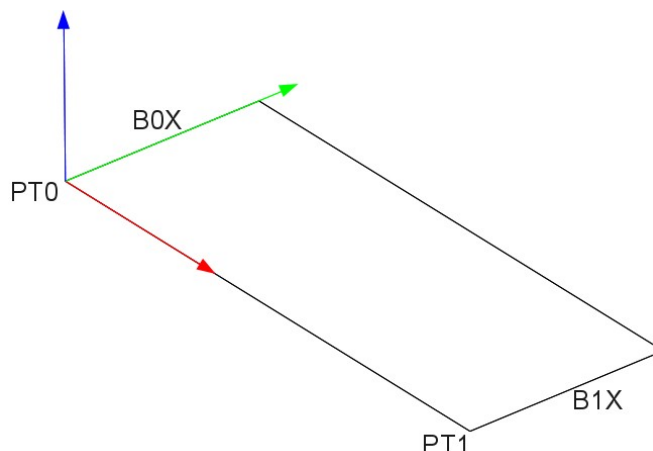
This test relates to a reinforced concrete flagstone subjected to a uniform distributed load.

This problem makes it possible to test:

- finite elements of type `DKT` multi-layer,
- finite elements of type `GRILLE_EXCENTRE`,
- laws of behavior associated with the studies with civil engineer: `MAZARS`, `VMIS_CINE`,

1 Problem of reference

1.1 Geometry



Flagstone: $5\text{m} \times 3\text{m}$, thickness 0.25 m , on simple supports in $B0X$ and $B1X$.
Higher tablecloth of reinforcements: $8\phi 12 = 9.0478\text{ cm}^2$, coating of 2.5 cm .
Lower tablecloth of reinforcements: $8\phi 25 = 39.27\text{ cm}^2$, coating of 2.5 cm .

1.2 Properties of materials

The order `DEFI_MATER_GC` is used to define the material concrete:

```
CONCRETE = DEFI_MATER_GC (
  MAZARS = _F (UNITE_LONGUEUR="M", FCJ=51.0E+06,
    EIJ=43.0E+09, FTJ=4.2E+06, AT=0.9 ),
)
```

The echo of the order:

```
== Paramètres of law MAZARS [Pa] ==
Elasticity part:
  E = 4.3000E+10, NAKED = 2.000E-01,
Non-linear part:
  BT = 1.02380952E+04, AC = 1.31859827E+00, SIGM_LIM = 3.0600E+07, AT = 9.000E-01,
  BC = 1.53770784E+03, K = 7.00000000E-01, EPSI_LIM = 3.5000E-03,
  EPSD0 = 9.76744186E-05,
For information:
  FCJ = 5.100E+07, FTJ = 4.200E+06, EPSI_C = 2.29922344E-03,
```

The order `DEFI_MATER_GC` is used to define the material steel:

```
STEEL = DEFI_MATER_GC (
  ACIER = _F (E=2.0E+11, SY=500.0E+06, NU=0.30),
)
```

The echo of the order:

```
== Paramètres of law ECRO_LINE ==
Elasticity part:
  E = 2.000E+11, NAKED = 3.000E-01,
Non-linear part:
  SY = 5.000E+08, SIGM_LIM = 4.54545E+08, EPSI_LIM = 1.00E-02, D_SIGM_EPSI = 2.00E+07,
For information:
  EPSI_ELAS = 2.5000E-03,
```

1.3 Conditions of loadings

Line *BOX* : blocking of the degrees of freedom *DX*, *DZ*

Line *BIX* : blocking of the degrees of freedom *DZ*

At the points *PT0* and *PT1* : blocking of the degrees of freedom *DY*

Distributed load on all surfaces of the flagstone: $P [N/m^2]$

2 Reference solution

2.1 Sizes and results of reference

The reference solution is determined by a checking of the reinforced concrete section led to the limiting states. The characteristics of materials are those resulting from the echo of the orders *DEFI_MATER_GC*.

The calculation of the constraints to the absolute limit of service is carried out with a distributed load on all the surface of the flagstone of $P = 80.5 \text{ KN} / \text{m}^2$. The ultimate stresses obtained are:

$$\begin{cases} \sigma_{bc} = 32.3 \text{ MPa} \\ \sigma_{sc} = 98.0 \text{ MPa} \\ \sigma_{st} = 319.0 \text{ MPa} \end{cases}$$

One of the assumptions of calculation to the absolute limit of service is that resistance in traction of the concrete is worthless. During calculation to the finite elements the material concrete follows a law of behavior of the type *MAZARS* who has a tensile strength. It will thus exist a light difference between the results resulting from a reinforced concrete calculation type and a calculation of type finite element.

Calculation with the ultimate absolute limit gives the ultimate load $P = 127.5 \text{ KN} / \text{m}^2$ (operation out of pivot *A*). Research by calculation with the finite elements of the ultimate load is rather delicate, because it should be increased until obtaining a horizontal asymptote in the diagram effort-displacement. This ultimate load must be close to that given by the approach reinforced concrete.

3 Modeling A

3.1 Characteristics of modeling and the grid

The grid of the flagstone is regular:

- cutting in 40 elements in the length, and 24 elements in the width is 960 elements *QUA4* .
- the steel tablecloths are obtained by duplication of the concrete meshes then by offsetting:

```
MAILTOT =CRÉA_MALLAGE (
  MAILLAGE=MAILL0,
  CREA_GROUP_MA= (
    _F (NOM='ACPLUS', GROUP_MA='FLAGSTONE', PREF_MAILLE='It, ),
    _F (NOM='ACMOINS', GROUP_MA='FLAGSTONE', PREF_MAILLE='You, ),
  ),
)

LACAR=AFFE_CARA_ELEM (
  MODELE=LEMOD,
  COQUE=_F (GROUP_MA=('FLAGSTONE', ), EPAIS= 25.0E-02, COQUE_NCOU= 5,
    ANGL_REP=(0.0,0.0, ), ),
  GRILLE= (
    _F (GROUP_MA='ACPLUS', SECTION= 9.0478E-04, ANGL_REP=(0,0, ),
      EXCENTREMENT= 0.10, ),
    _F (GROUP_MA='ACMOINS', SECTION= 39.2700E-04, ANGL_REP=(0,0, ),
      EXCENTREMENT=-0.10, ),
  ),
)
```

The load is distributed on all the surface of the flagstone:

Moments	Distributed load
Moment 1	80.5 KN/m ²
Moment 2	127.5 KN/m ²
Moment 3	132.0 KN/m ²

3.2 Sizes tested and results

The sizes of the type forced are tested with CRITERE=' ABSOLU'. TOLE_MACHINE is thus modified consequently (VALE_REFE * 1.0E-06), so that CRITERE=' ABSOLU' that is to say correctly taken into account.

The sizes tested and analyzed with the absolute limit of service are:

- the minimal value of the constraints for the concrete in compression,
- the maximum constraint for steels in traction,
- the minimal constraint for steels in compression.
- the variable SIGM_LIM for the concrete, steels.

ELS (Urgent 1)	Values	Tolerance	
Constraint	Compressed concrete	-33.10E+06	0.02%
	Compressed steel	-102.88E+06	0.01%
	Tended steel	313.0E+06	0.5%
SIGM_LIM	Compressed concrete	-1.08800	0.20%
	Compressed steel	-0.22634	0.20%
	Tended steel	0.15650	0.5%

The sizes tested and analyzed with the ultimate absolute limit are:

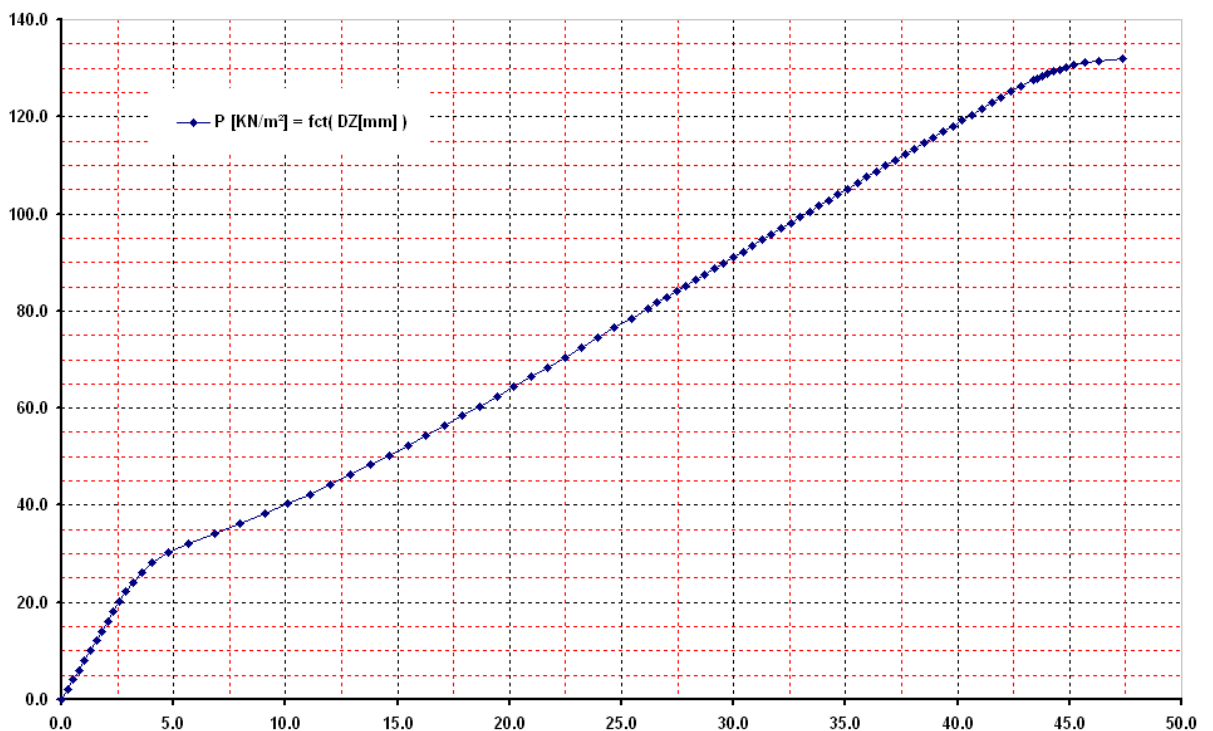
- the minimal value of the constraints for the concrete in compression,
- the maximum constraint for steels in traction,
- the minimal constraint for steels in compression.
- the variable `EPSI_LIM` for the concrete, steels

ELECTED OFFICIAL (Urgent 2)	Values		Tolerance
Constraint	Compressed concrete	-48.13E+06	0.01%
	Compressed steel	-169.64E+06	0.10%
	Tended steel	500.00E+06	0.01%
EPSI_LIM	Compressed concrete	-0.38357	0.20%
	Compressed steel	-0.08482	0.30%
	Tended steel	0.2686	1.0%

The size tested, corresponding to the beginning of the asymptote on the curve charges distributed according to maximum vertical displacement, and corresponds to the variable `EPSI_LIM` tended steels.

Moment 3	Values		Tolerance
EPSI_LIM	Tended steel	0.45935	1.5%

The curve below, distributed load according to maximum displacement, shows that one reached the asymptote when the distributed load is close to 132.0 KN/m^2 (moment 3).



4 Summary of the results

This case test shows the good correspondence between calculations with the finite elements and a lawful approach.