RCCM14 – Analysis with POST_RCCM in B3200: groups of division, situations of passage

Summary:

This test is an elementary test of validation of the order POST_RCCM with TYPE_RESU_MECA='B3200'.

The analytical solution is simple, and makes it possible to test postprocessing within the meaning of the RCC-M. The constraints are not calculated but are not extracted from tables.

More precisely, modeling A makes it possible to test L'option TIREDNESS for results of the type B3200 with the taking into account of groups of division, situations of passage, noncombinable situations. One tests also the taking into account of the under-cycles in the fatigue analysis.

1 Problem of reference

1.1 Material properties

The properties material and characteristics suitable for calculation RCC-M are the following ones:

1) module of Young: $E=2.E+05\,MPa$;
2) constant material for the calculation of Ke : $n=0.2$, $m=2$;
3) Young modulus of reference: $E_{REFE}=2.E+05\,MPa$;
4) working stress: $Sm=200\,MPa$.

The curve of Wöhler is analytically defined: $N_{adm}=\frac{5.10^5}{S_{alt}}$

1.2 Evolution of the constraints

The constraints on the segment of analysis are not calculated but are not read directly in a table. The only nonworthless component of the tensor of the constraints is σ_{yy} . Several situationS are consideredEs. These situationS do not aim representing a specific real transient, but at covering the whole of the possible constraints (constant, linear or non-linear evolution of the constraint in the thickness).

Moment	**Constraints thermic situations 1 and 2**			Moment	**Constraints thermic situation 3**		
	X-coordinate				*X-coordinate*		
	0	1	2		0	1	2
1	50	100	150	1,5	50	100	150
2	0	50	-100	2,5	0	50	-100
3	0	0	50	3,5	0	0	50
4	0	0	0				

Table 1.2-1 : Definition of the constraints σ_{yy} (in MPa) for the moments of situation 1 and of situation 2 according to the X-coordinate curvilignE

In this example, moments and pressure are defined by two torques and four unit tensors. Here also only the constraint σ_{yy} is nonworthless in these tensors.

Unit tensor	σ_{yy}		
	X-coordinate		
	0	1	2
Mom_X	50	0	0
Mom_Y	0	50	0
Mom_Z	0	0	100
$Pres$	50	0	0

	P_A	P_B	M_{xA}	M_{yA}	M_{zA}	M_{xB}	M_{yB}	M_{zB}

Situation 1	1	10	1	-1	-1.5	-10	1	0.1
Situation 2	1	10	1	-1	-1.5	-10	1	0.1
Situation 3	0.4	1	0.4	0	-0.6	1	-1	-1.5

Table 1.2-2 : Definition of torques at the time (in N.mm) and pressure (in MPa) pour situationS 1, 2 and 3

2 Reference solution

2.1 Results of reference

2.1.1 First case

There is only one group of operation which contains situations 1.2 and 3 but situation 1 is declared with combinable=' NON', i.e. that it can even combine only with it.

Only the calculation of the factor of total use in the beginning is detailed. One seeks to fill out the table of the elementary factors of use.

One calculates initially the sizes by situations then by combination.

<u>**Situation 1**</u>

Sn of the situation is calculated.

Moment	Constraints Thermic situation 1			σ^{moyen}	$\sigma^{flexion}$	σ_0^{lin}	σ_L^{lin}
	X-coordinate						
	0	1	2				
1	50	100	150	100	50	50	150
2	0	50	-100	0	-50	50	-50
3	0	0	50	12.5	25	-12.5	37.5
4	0	0	0	0	0	0	0

Unit tensor	Constraint σ_{yy}			σ^{moyen}	$\sigma^{flexion}$	σ_0^{lin}	σ_L^{lin}
	X-coordinate						
	0	1	2				
Mom_X	50	0	0	12.5	-25	37.5	-12.5
Mom_Y	0	50	0	25	0	25	25
Mom_Z	0	0	100	25	50	-25	75
$Pres$	50	0	0	12.5	-25	37.5	-12.5

$$\sigma_{LIN,0}^{SITU\,1}=(P_A-P_B)\sigma_{PRES}^{LIN,0}+(M_{XA}-M_{XB})\sigma_{MX}^{LIN,0}+(M_{YA}-M_{YB})\sigma_{MY}^{LIN,0}+(M_{ZA}-M_{ZB})\sigma_{MZ}^{LIN,0}$$
$$\pm\|\sigma_{THER}^{LIN}(t_1)-\sigma_{THER}^{LIN}(t_2)\|$$

$$\sigma_{LIN,0}^{SITU\,1}=(1-10)*37,5+(1--10)*37,5+(-1-1)*25+(-1,5-0,1)*-25\pm\|50--12,5\|$$

$$Sn_0^{SITU\,1}=127,5$$

One calculates Sp of the situation.

$$\sigma_{TOT,0}^{SITU\,1}=(P_A-P_B)\sigma_{PRES}^{0}+(M_{XA}-M_{XB})\sigma_{MX}^{0}+(M_{YA}-M_{YB})\sigma_{MY}^{0}+(M_{ZA}-M_{ZB})\sigma_{MZ}^{0}$$
$$\pm\|\sigma_{THER}(t_1)-\sigma_{THER}(t_2)\|$$

$$\sigma_{TOT,0}^{SITU\,1}=(1-10)*50+(1--10)*50+(-1-1)*0+(-1{,}5-0{,}1)*0\pm\|50-0\|$$

$$Sp_0^{SITU\,1}=150$$

For $Sm=200\,MPa$, one thus has $Ke=1$ and $Salt_0=\frac{1}{2}\frac{E_c}{E}Ke\,Sp_0=75\,MPa$. According to the curve of Wöhler one thus has $Nadm_0=\frac{500000}{Salt_0}=6667$ that is to say $FU_0^{SITU\,1}=1{,}5\,10^{-4}$.

Situation 2

In a similar way for situation 2 who has the same thermal transient and the same torques in moments and pressure that situation 1 , one has

$Sn_0^{SITU\,2}=127{,}5$, $Sp_0^{SITU\,2}=150$ and $FU_0^{SITU\,2}=1{,}5\,10^{-4}$.

Situation 3

Sn of the situation is calculated.

$$\sigma_{LIN,0}^{SITU\,3}=(0{,}4-1)*37{,}5+(0{,}4-1)*37{,}5+(0--1)*25+(-0{,}6--1{,}5)*-25\pm\|50--12{,}5\|$$

$$Sn_0^{SITU\,3}=105$$

One calculates Sp of the situation.

$$\sigma_{TOT,0}^{SITU\,3}=(0{,}4-1)*50+(0{,}4-1)*50+(0--1)*0+(-0{,}6--1{,}5)*0\pm\|50-0\|$$

$$Sp_0^{SITU\,3}=110$$

For $Sm=200\,MPa$, one thus has $Ke=1$ and $Salt_0=\frac{1}{2}\frac{E_c}{E}Ke\,Sp_0=55\,MPa$ that is to say $FU_0^{SITU\,3}=1{,}1\,10^{-4}$.

Combination of the situations 2 and 3

Situation 1 being combinable only with it even, one calculates combination of the situations 2 and 3.

Sn of the situation is calculated.

One maximizes the part at the time and the pressure, there are 4 possibilities:

- State A of situation 2 and state A of situation 3 .

$$\sigma_{LIN,0}=(1-0{,}4)*37{,}5+(1-0{,}4)*37{,}5+(-1-0)*25+(-1{,}5--0{,}6)*-25=42{,}5$$

- State A of situation 2 and state B of situation 3 .

$$\sigma_{LIN,0}=(1-1)*37{,}5+(1-1)*37{,}5+(-1--1)*25+(-1{,}5--1{,}5)*-25=0$$

- State B of situation 2 and state B of situation 3 .

$$\sigma_{LIN,0}=(10-1)*37{,}5+(-10-1)*37{,}5+(1--1)*25+(0{,}1--1{,}5)*-25=-65$$

- State B of situation 2 and state A of situation 3 .

$$\sigma_{LIN,0}=(10-0{,}4)*37{,}5+(-10-0{,}4)*37{,}5+(1-0)*25+(0{,}1--0{,}6)*-25=12{,}5$$

With final one has $Sn_0^{SITUS\,2,3}=-65\pm\|50--12{,}5\|=127{,}5$.

One calculates Sp of similar combination of manner . One maximizes the part at the time and the pressure, there are 4 possibilities:

- State A of situation 2 and state A of situation 3 .

$$\sigma_{LIN,0}=(1-0{,}4)*50+(1-0{,}4)*50+(-1-0)*0+(-1{,}5--0{,}6)*0=60$$

- State A of situation 2 and state B of situation 3 .

$$\sigma_{LIN,0}=(1-1)*50+(1-1)*50+(-1--1)*0+(-1{,}5--1{,}5)*0=0$$

- State B of situation 2 and state B of situation 3 .

$$\sigma_{LIN,0}=(10-1)*50+(-10-1)*50+(1--1)*0+(0{,}1--1{,}5)*0=-100$$

- State B of situation 2 and state A of situation 3 .

$$\sigma_{LIN,0}=(10-0{,}4)*50+(-10-0{,}4)*50+(1-0)*0+(0{,}1--0{,}6)*0=-40$$

With final one has by combining moments 1 and 2.5 $Sp_0^1=-100\pm\|50-0\|=150$ who is not taller than the Sp amplitude of situation 2 only, the combination of situations 2 and 3 is thus these two taken situations separately i.e.:

$Sp_0^1=Sp_0^{SITU\,2}$ and $Sp_0^2=Sp_0^{SITU\,3}$ and thus

$$FU=FU_0^{SITU\,2}+FU_0^{SITU\,3}=1{,}5.10^{-4}+1{,}1.10^{-4}=2{,}6.10^{-4}$$.

The table of the elementary factors of use at the origin is thus

	Situation 1	Situation 2	Situation 3
Situation 1	$1{,}5\,10^{-4}$		
Situation 2		$1{,}5\,10^{-4}$	$2{,}6\,10^{-4}$
Situation 3			$1{,}1\,10^{-4}$

Knowing that $Nocc_1=1$, $Nocc_2=7$ and $Nocc_3=10$ one has,

$$FU_{TOTAL}^{ORI}=7*2{,}6.10^{-4}+1*1{,}5.10^{-4}+3*1{,}1.10^{-4}=2{,}3.10^{-3}$$.

2.1.2 Second case

One has two group S of operation. Group 1 contains situations 1.2 and group 2 contains the situation 3 but situation 1 is declared with combinable=' NON', i.e. which it can even combine only with it.

Only the calculation of the factor of total use in the beginning is detailed. One knows already the table of the elementary factors of use. It is the same one as in the first example except that situations 2 and 3 cannot combine any more because they are not in the same group.

	Situation 1	Situation 2	Situation 3
Situation 1	$1{,}5\,10^{-4}$		
Situation 2		$1{,}5\,10^{-4}$	
Situation 3			$1{,}1\,10^{-4}$

Knowing that $Nocc_1=1$, $Nocc_2=7$ and $Nocc_3=10$ one has,

$$FU_{TOTAL}^{ORI}=1*1{,}5.10^{-4}+7*1{,}5.10^{-4}+10*1{,}1.10^{-4}=2{,}3.10^{-3}$$.

2.1.3 Third case

One has two group S of operation and a situation of passage . Group 1 contains the situations 1 and 2 and group 2 contains L be situation S 1 and 3. L situation 1 has is a situation of passage enters groups 1 and 2, i.e. that situations 2 and 3 can be combined only via this passage.

Only the calculation of the factor of total use in the beginning is detailed. One knows already certain terms of the table of the elementary factors of use. It misses the combination of situations 1 and 2 and the combination of 1 and 3. One does not detail the calculation of these elementary factors of use.

	Situation 1	Situation 2	Situation 3
Situation 1	$1{,}5\,10^{-4}$	$1{,}5\,10^{-4}$	$2{,}5\,10^{-4}$
Situation 2		$1{,}5\,10^{-4}$	$2{,}6\,10^{-4}$
Situation 3			$1{,}1\,10^{-4}$

Knowing that $Nocc_1=1$, $Nocc_2=7$ and $Nocc_3=10$ one has,

$FU_{TOTAL}^{ORI}=1*2{,}6.10^{-4}+6*1{,}5.10^{-4}+9*1{,}1.10^{-4}=2{,}15.10^{-3}$ .The first part of this factor of use is due to the combination of 2 and 3 to which one applies the number of occurrences $Nocc=min(Nocc_{2,}Nocc_{3,}Npass)=min(Nocc_{2,}Nocc_{3,}Nocc_1)=1$.

2.1.4 Fourth case

One has two group S of operation. Group 1 contains situations 1.2 and group 2 contains the situation 3 but situation 1 is declared with combinable=' NON', i.e. which it can even combine only with it. There exists a group of division but which contains only situation 3.

This fourth case is thus similar to the second case. That is to say

$$FU_{TOTAL}^{ORI}=1*1{,}5.10^{-4}+7*1{,}5.10^{-4}+10*1{,}1.10^{-4}=2{,}3.10^{-3}$$

2.1.5 Cinqu ième case

One has two group S of operation. Group 1 L contains has situation 1 and group 2 contains L be situation S 2 and 3. There exists a group of division which contains L be situation S 2 and 3.

The table of the elementary factors of use is L

	Situation 1	Situation 2	Situation 3
Situation 1	$1{,}5\,10^{-4}$		
Situation 2		$1{,}5\,10^{-4}$	$2{,}6\,10^{-4}$
Situation 3			$1{,}1\,10^{-4}$

Knowing that $Nocc_1=1$, $Nocc_2=10$ and $Nocc_3=10$ one has,

$$FU_{TOTAL}^{ORI}=10*2{,}6.10^{-4}+1*1{,}5.10^{-4}=2{,}75.10^{-3}$$

2.1.6 S ix ième case

One has two group S of operation. Group 1 L contains be situation 1 and 2 but situation 1 is combinable only with it even. L E groups 2 contains L has situation 3. There exists a group of division which contains L be situation S 2 and 3.

The table of the elementary factors of use is L

	Situation 1	Situation 2	Situation 3
Situation 1	$1{,}5\,10^{-4}$		
Situation 2		$1{,}5\,10^{-4}$	
Situation 3			$1{,}1\,10^{-4}$

Knowing that $Nocc_1=1$, $Nocc_2=7$ and $Nocc_3=10$ one has,

$$FU_{TOTAL}^{ORI}=1*1{,}5.10^{-4}+7*1{,}5.10^{-4}+3*1{,}1.10^{-4}=1{,}53.10^{-3}$$

2.2 Uncertainty on the solution

Analytical solution.

3 Modeling A

3.1 Characteristics of modeling

No thermal or mechanical calculation is carried out in this test: the tables of statements of constraints are directly provided to the operator POST_RCCM. Results of type B3200 are analyzed for the option TIREDNESS.

3.2 Sizes tested and results

On this case simple test, the whole of the results tested is in agreement with the reference solution with a precision of 10^{-4} %

- for the calculation of Sn, of Sp, of $Salt$ and of the factor of use,
- with situations of passage
- with groups of division
- with taking into account of the under-cycles.

4 Summary of the results

The results are exact and show that the operator `POST_RCCM` select the quantities correctly to be treated and correctly calculates the integrals (average on the segments) for the results of the type `B3200`.