

# **\*DEFORMABLE\_TO\_RIGID**

The cards in this section are defined in alphabetical order and are as follows:

**\*DEFORMABLE\_TO\_RIGID**  
**\*DEFORMABLE\_TO\_RIGID\_AUTOMATIC**  
**\*DEFORMABLE\_TO\_RIGID\_INERTIA**

If one of these cards is defined, then any deformable part defined in the model may be switched to rigid during the calculation. Parts that are defined as rigid (\*MAT\_RIGID) in the input are permanently rigid and cannot be changed to deformable.

Deformable parts may be switched to rigid at the start of the calculation by specifying them on the \*DEFORMABLE\_TO\_RIGID card.

Part switching may be specified on a restart (see RESTART section of this manual) or it may be performed automatically by use of the \*DEFORMABLE\_TO\_RIGID\_AUTOMATIC cards.

The \*DEFORMABLE\_TO\_RIGID\_INERTIA cards allow inertial properties to be defined for deformable parts that are to be swapped to rigid at a later stage.

It is not possible to perform part material switching on a restart if it was not flagged in the initial analysis. The reason for this is that extra memory needs to be set up internally to allow the switching to take place. If part switching is to take place on a restart, but no parts are to be switched at the start of the calculation, no inertia properties for switching and no automatic switching sets are to be defined, then just define one \*DEFORMABLE\_TO\_RIGID card without further input.

## \*DEFORMABLE\_TO\_RIGID

\*DEFORMABLE\_TO\_RIGID

### \*DEFORMABLE\_TO\_RIGID

Purpose: Define parts for which the material will be switched to rigid at the start of the calculation.

**WARNING:** This keyword is only supported for switching between finite elements and rigid bodies.

**WARNING:** \*PART\_MODES is not supported when using this keyword.

Card	1	2	3	4	5	6	7	8
Variable	PID	LRB	PTYPE					
Type	I	I	A					
Default	none	0	PART					

#### VARIABLE

#### DESCRIPTION

PID                   Part ID for the part that will be switched to a rigid material; also see \*PART.

LRB                   Part ID of the lead rigid body to which the part is merged. If zero, the part becomes either an independent or lead rigid body.

PTYPE               Type of PID:

EQ.“PART”: PID is a part ID.

EQ.“PSET”: PID is a part set ID. All parts included in part set PID will be switched to rigid at the start of the calculation.

**\*DEFORMABLE\_TO\_RIGID\_AUTOMATIC**

Purpose: Define a set of parts to be switched to rigid or to deformable at some stage during the calculation.

**WARNING:** This keyword is only supported for switching between finite elements and rigid bodies.

**WARNING:** \*PART\_MODES is not supported when using this keyword.

**Card Summary:**

**Card 1.** This card is required

SWSET	CODE	TIME1	TIME2	TIME3	ENTNO	RELSW	PAIRED
-------	------	-------	-------	-------	-------	-------	--------

**Card 2.** This card is required.

NRBF	NCSF	RWF	DTMAX	D2R	R2D	OFFSET	
------	------	-----	-------	-----	-----	--------	--

**Card 3.** Include D2R of this card.

PID	LRB	PTYPE					
-----	-----	-------	--	--	--	--	--

**Card 4.** Include R2D of this card.

PID	PTYPE						
-----	-------	--	--	--	--	--	--

**Data Cards:**

Card 1	1	2	3	4	5	6	7	8
Variable	SWSET	CODE	TIME1	TIME2	TIME3	ENTNO	RELSW	PAIRED
Type	I	I	F	F	F	I	I	I
Default	none	0	0.	$10^{20}$	0.	0.	0	0
Remark		1				1, 2		3

## \*DEFORMABLE\_TO\_RIGID

## \*DEFORMABLE\_TO\_RIGID\_AUTOMATIC

VARIABLE	DESCRIPTION
SWSET	Set number for this automatic switch set. Must be unique.
CODE	Activation switch code. Defines the test to activate the automatic material switch of the part:  EQ.0: Switch takes place at time 1. EQ.1: Switch takes place between time 1 and time 2 if rigid wall force (specified below) is zero. EQ.2: Switch takes place between time 1 and time 2 if contact surface force (specified below) is zero. EQ.3: Switch takes place between time 1 and time 2 if rigid wall force (specified below) is nonzero. EQ.4: Switch takes place between time 1 and time 2 if contact surface force (specified below) is nonzero. EQ.5: Switch is controlled by *SENSOR_CONTROL with TYPE = DEF2RIG; see *SENSOR_CONTROL. When CODE = 5, inputs of column 3 to column 8, TIME1 to PAIRED, are ignored.
TIME1	Switch will not take place before this time
TIME2	Switch will not take place after this time:  EQ.0.0: Time 2 set to $10^{20}$
TIME3	Delay period. After this part switch has taken place, another automatic switch will not take place for the duration of the delay period. If set to zero, a part switch may take place immediately after this switch.
ENTNO	Rigid wall / contact surface number for switch codes 1, 2, 3, 4
RELSW	Related switch set. The related switch set is another automatic switch set paired to this one so the switches can be activated more than once.  EQ.0: No related switch set
PAIRED	Specify how the related switch sets are paired (if there are paired switches):  EQ.0: SWSET is not paired to another switch set.

<b>VARIABLE</b>	<b>DESCRIPTION</b>							
EQ.1: SWSET is paired with switch set RELSW and is the first switch set to be activated.								
EQ.-1: SWSET is paired with switch set RELSW and is the second switch to be activated.								

Card 2	1	2	3	4	5	6	7	8
Variable	NRBF	NCSF	RWF	DTMAX	D2R	R2D	OFFSET	
Type	I	I	I	F	I	I	F	
Default	0	0	0	0.	0	0	0.	
Remark	4	4	4					

<b>VARIABLE</b>	<b>DESCRIPTION</b>
NRBF	Nodal rigid body flag. For all values of NRBF, nodal rigid bodies defined using *CONSTRAINED_NODAL_RIGID_BODY and *CONSTRAINED_GENERALIZED_WELD_OPTION, which share any nodes with a rigid body created by deformable-to-rigid switching, are merged with the latter to form a single rigid body. Other actions dependent upon the value of NRBF are:  EQ.0: No further action EQ.1: Delete all remaining nodal rigid bodies, that is, delete those nodal rigid bodies that do not share any nodes with a rigid body created by deformable-to-rigid switching. EQ.2: Activate nodal rigid bodies.
NCSF	Nodal constraint set flag. If nodal constraint / spot weld definitions are active in the deformable bodies that are switched to rigid, then the definitions should be deleted to avoid instabilities.  EQ.0: No change EQ.1: Delete EQ.2: Activate
RWF	Flag to delete or activate rigid walls:

## \*DEFORMABLE\_TO\_RIGID

\*DEFORMABLE\_TO\_RIGID\_AUTOMATIC

VARIABLE	DESCRIPTION
	EQ.0: No change EQ.1: Delete EQ.2: Activate
DTMAX	Maximum permitted time step size after switch
D2R	Number of deformable parts to be switched to rigid plus number of rigid parts for which new merged (lead/constrained) rigid body combinations will be defined.  EQ.0: No parts defined
R2D	Number of rigid parts to be switched to deformable.  EQ.0: No parts defined
OFFSET	Optional contact thickness for switch to deformable. For contact, its value should be set to a value greater than the contact thickness offsets to ensure the switching occurs prior to impact. This option applies if and only if CODE is set to 3 or 4. For CODE = 3 all rigid wall options are implemented. For CODE = 4, the implementation works for the contact type CONTACT_AUTOMATIC when the options: ONE_WAY_SURFACE_TO_SURFACE, NODES_TO_SURFACE, and SURFACE_TO_SURFACE are invoked.

**Deformable to Rigid Cards.** D2R additional cards with one for each part.

Card 3	1	2	3	4	5	6	7	8
Variable	PID	LRB	PTYPE					
Type	I	I	A					
Default	none	0	PART					

VARIABLE	DESCRIPTION
PID	Part ID of the part which is switched to a rigid material. When PID is merged to another rigid body by the LRB field, this part is allowed to be rigid before the switch.

VARIABLE	DESCRIPTION
LRB	Part ID of the lead rigid body to which part PID is merged. If zero, part PID becomes either an independent or lead rigid body.
PTYPE	Type of PID: EQ.PART: PID is a part ID. EQ.PSET: PID is a part set ID.

**Rigid to Deformable Cards.** R2D additional cards with one for each part.

Card 4	1	2	3	4	5	6	7	8
Variable	PID	PTYPE						
Type	I	A						
Default	none	PART						

VARIABLE	DESCRIPTION
PID	Part ID of the part which is switched to a deformable material
PTYPE	Type of PID: EQ.PART: PID is a part ID. EQ.PSET: PID is a part set ID.

#### Remarks:

- Allowed Contact Types.** Only surface to surface and node to surface contacts can be used to activate an automatic part switch.
- Rigid Wall Numbering.** Rigid wall numbers are the order in which they are defined in the deck. The first rigid wall and the first contact surface encountered in the input deck will have an entity number of 1. The contact surface ID is that as defined on the \*CONTACT\_....\_ID card.
- Paired Switches.** Switch sets may be paired together to allow a pair of switches to be activated more than once. Each pair of switches should use consistent values for CODE, meaning 1 & 3 or 2 & 4. Within each pair of switches, the related switch, RELSW, should be set to the ID of the other switch in the pair. The first

## **\*DEFORMABLE\_TO\_RIGID**

## **\*DEFORMABLE\_TO\_RIGID\_AUTOMATIC**

switch (PAIRED = 1) will be activated before the second switch (PAIRED = -1). Pairing allows multiple switches to take place as for example when contact is made and lost several times during an analysis.

```
$ Define a pair of related switches that will be activated by force/no force on
$ Contact 3. To start with, switch set 20 will be activated (PAIRED = 1),
$ swapping the PARTS to RIGID. When the contact force is non-zero, switch set
$ 10 will be activated, swapping the PARTS to DEFORMABLE. If the contact force
$ returns to zero, switch set 20 will be activated again, making the PARTS
$ RIGID.
$
*DEFORMABLE_TO_RIGID_AUTOMATIC
$....>....1....>....2....>....3....>....4....>....5....>....6....>....7....>....8
$    swset      code      time 1      time 2      time 3      entno      relsw      paired
$          20          2                  1                  3          10          1
$    nrbf      ncsf      r wf      dtmax      D2R      R2D
$                      1
*DEFORMABLE_TO_RIGID_AUTOMATIC
$....>....1....>....2....>....3....>....4....>....5....>....6....>....7....>....8
$    swset      code      time 1      time 2      time 3      entno      relsw      paired
$          10          4                  3          20          -1
$    nrbf      ncsf      r wf      dtmax      D2R      R2D
$                      1
```

4. **Delete Switch.** If the delete switch is activated, *all* corresponding constraints are deactivated regardless of their relationship to a switched part. By default, constraints which are directly associated with a switched part are deactivated/activated as necessary.

**\*DEFORMABLE\_TO\_RIGID\_INERTIA****\*DEFORMABLE\_TO\_RIGID****\*DEFORMABLE\_TO\_RIGID\_INERTIA**

Purpose: Inertial properties can be defined for the new rigid bodies that are created when the deformable parts are switched. These can only be defined in the initial input if they are needed in a later restart. Unless these properties are defined, LS-DYNA will recompute the new rigid body properties from the finite element mesh. The latter requires an accurate mesh description. *When rigid bodies are merged to a lead rigid body, the inertial properties specified for the lead rigid body apply to all members of the merged set.*

Card 1	1	2	3	4	5	6	7	8
Variable	PID							
Type	I							
Default	none							

Card 2	1	2	3	4	5	6	7	8
Variable	XC	YC	ZC	TM				
Type	F	F	F	F				

Card 3	1	2	3	4	5	6	7	8
Variable	IXX	IXY	IXZ	IYY	IYZ	IZZ		
Type	F	F	F	F	F	F		
Default	none	0.0	0.0	none	0.0	none		

**VARIABLE****DESCRIPTION**

PID      Part ID, see \*PART.

XC      *x*-coordinate of center of massYC      *y*-coordinate of center of mass

**\*DEFORMABLE\_TO\_RIGID****\*DEFORMABLE\_TO\_RIGID\_INERTIA**

<b>VARIABLE</b>	<b>DESCRIPTION</b>
ZC	z-coordinate of center of mass
TM	Translational mass
IXX	$I_{xx}$ (the $xx$ component of inertia tensor)
IXY	$I_{yy}$
IXZ	$I_{xz}$
IYY	$I_{yy}$
IYZ	$I_{yz}$
IZZ	$I_{zz}$