*MAT_KINEMATIC_HARDENING_ BARLAT2000

This is Material Type 242. This model combines Yoshida non-linear kinematic hardening rule (*MAT_125) with the 8-parameter material model of Barlat and Lian (2003) (*MAT_133) to model metal sheets under cyclic plasticity loading and with anisotropy in plane stress condition. Also see manual pages in *MAT_226.

Card Format (I10, 3E10.0, 2X10, E10.0)

Card 1	1	2	3	4	5	6	7	8
Variable	MID	RO	E	PR			M	
Type	I	F	F	F			F	
Default	none	0.0	0.0	0.0			none	

Card Format (8E10.0)

Card 2								
Variable	ALPHA1	ALPHA2	ALPHA3	ALPHA4	ALPHA5	ALPHA6	ALPHA7	ALPHA8
Type	F	F	F	F	F	F	F	I
Default	0.0	0.0	0.0	0.0	0.0	0.0	0.0	none

Card Format (must leave as a blank line)

Card 3								
Variable								
Type								
Default								

Card Format (must leave as a blank line)

Card 4	1	2	3	4	5	6	7	8
Variable								
Type								
Default								

Card Format (7E10.0)

Card 5	1	2	3	4	5	6	7	8
Variable	CB	Y	C	K	RSAT	SB	H	
Type	F	F	F	F	F	F	F	
Default	none	none	none	none	none	none	none	

Card Format (I10, E10.0, I10, 2E10.0)

Card 6	1	2	3	4	5	6	7	8
Variable	AOPT		IOPT	C1	C2			
Type	I		I	F	F			
Default	none		none	0.0	0.0			

Card Format (6E10.0)

Card 7	1	2	3	4	5	6	7	8
Variable	XP	YP	ZP	A1	A2	A3		
Type	F	F	F	F	F	F		
Default	none	none	none	none	none	none		

Card Format (6E10.0)

Card 8	1	2	3	4	5	6	7	8
Variable	V1	V2	V3	D1	D2	D3		
Type	F	F	F	F	F	F		
Default	none	none	none	none	none	none		

VARIABLE	DESCRIPTION
MID	Material identification. A unique number must be specified.
RO	Mass density,
E	Young's modulus, E,
PR	Poisson's ratio, ν,
M	Flow potential exponent,
ALPHA1	α_1, material constant in Barlat's yield equation,
ALPHA2	α_2, material constant in Barlat's yield equation,
ALPHA3	α_3, material constant in Barlat's yield equation,
ALPHA4	α_4, material constant in Barlat's yield equation,
ALPHA5	α_5, material constant in Barlat's yield equation,
ALPHA6	α_6, material constant in Barlat's yield equation,

VARIABLE	DESCRIPTION
ALPHA7	α_7, material constant in Barlat's yield equation,
ALPHA8	α_8, material constant in Barlat's yield equation,
CB	The uppercase B defined in the Yoshida's equations,
Y	Anisotropic parameter associated with work-hardening stagnation, defined in the Yoshida's equations,
SC	The lowercase c defined in the Yoshida's equations,
K	Hardening parameter as defined in the Yoshida's equations,
RSAT	Hardening parameter as defined in the Yoshida's equations,
SB	The lowercase b as defined in the Yoshida's equations,
H	Anisotropic parameter associated with work-hardening stagnation, defined in the following Yoshida's equations,
AOPT	Material axes option (see MAT_*OPTION* TROPIC_ELASTIC for a more complete description): EQ.0.0: locally orthotropic with material axes determined by element nodes 1, 2, and 4, as with *DEFINE_COORDINATE_NODES. EQ.2.0: globally orthotropic with material axes determined by vectors defined below, as with *DEFINE_COORDINATE_VECTOR. EQ.3.0: locally orthotropic material axes determined by rotating the material axes about the element normal by an angle, BETA, from a line in the plane of the element defined by the cross product of the vector v with the element normal. LT.0.0: the absolute value of AOPT is a coordinate system ID number (CID on *DEFINE_COORDINATE_NODES, *DEFINE_COORDINATE_SYSTEM or *DEFINE_COORDINATE_VECTOR). Available with the R3 release of Version 971 and later.
IOPT	Kinematic hardening rule flag: EQ.0: Original Yoshida formulation, EQ.1: Modified formulation. Define C1, C2 below,
C1, C2	Constants used to modify R: $R = RSAT\left[(C_1 + \bar{\varepsilon}^p)^{c_2} - C_1^{c_2}\right]$
XP, YP, ZP	Coordinates of point **p** for AOPT = 1,

VARIABLE	DESCRIPTION
A1, A2, A3	Components of vector **a** for AOPT = 2,
V1, V2, V3	Components of vector **v** for AOPT = 3,
D1, D2, D3	Components of vector **d** for AOPT = 2.

Remarks:

1. A total of eight parameters (α_1 to α_8) are needed to describe the yield surface. The parameters can be determined with tensile tests in three directions and an equal biaxial tension test. For detailed theoretical background and material parameters of some typical FCC materials, please see remarks in *MAT_133 and Barlat's 2003 paper.

2. NUMISHEET 2005 provided a complete set of the parameters of AL5182-O for Benchmark #2, the cross member, as below (flow potential exponent M=8):

α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8
0.94	1.08	0.97	1.0	1.0	1.02	1.03	1.11

3. For a more detailed description on the Yoshida model and parameters, please see Remarks in *MAT_226 and *MAT_125.

4. For information on variable AOPT please see remarks in *MAT_226.

5. To improve convergence, it is recommended that *CONTROL_IMPLICIT_FORMING type '1' be used when conducting springback simulation.

6. This material model is available in LS-DYNA R5 Revision 58432 or later releases.