

## Using the Augmented Hybrid Model UMAT Code

The provided Fortran code can be used to create an LS-DYNA ([www.lstc.com](http://www.lstc.com)) executable that contains the augmented Hybrid Model material model.

Creating the appropriate executable involves several steps:

1. You must obtain a set of files from LS-DYNA that will enable you to create your own executable with your user-defined material model (in this case, the Hybrid Model) included. This set of files will contain: Fortran files, include files, object file libraries, and other file types. The files that you will be focusing on are called: dyn21.F, makefile, and nmake. Put all of these files in the folder where you will create your new executable, and put the augmented Hybrid Model code there as well.
2. Open dyn21.F. Search for “subroutine umat45”. Once you get to this subroutine, you will need to comment out the entire subroutine (including the subroutine umat45 line). Also comment out “subroutine umat45v”, “subroutine utan45”, “subroutine utan45v”, and all of their included components. Save the file. These subroutines are commented out because our user-defined material model will provide the new umat45, umat45v, utan45, and utan45v subroutines.
3. Open makefile. At the end of the “OBJS=” line, add the name of the current HM code followed by .obj (e.g., HMp\_20081201.obj). When you get to the line “ls971.exe: \$(OBJS)” and the line after it, in both lines, change “ls971.exe” to a name of your choice (e.g., ls971\_HMp\_20081201.exe). Two lines below the “dyn21.obj: dyn21b.F” line, enter: “Name\_of\_HM\_Code.obj: Name\_of\_HM\_Code.F” in the first line and “\$(FC) \$(FFLAGS) Name\_of\_HM\_Code .F” in the second line (following the format used in the previous lines), where Name\_of\_HM\_Code is the specific name of the current version of the Hybrid Model that is being used (must be the same as the one entered above--e.g., HMp\_20081201). Save the file.
4. To compile a new LS-DYNA executable, you need to use one of the programs listed in the readme.txt file that comes as part of the set of files that you will get from LS-DYNA.
5. To use the Intel ® Fortran compiler, open a command prompt and navigate to where your files are located. Then type “nmake”. This will generate a new LS-DYNA executable. (Note: you may need to add a few more library files to your folder).

Notes about using the current version of the augmented Hybrid Model Fortran code:

Currently, the code will only work for 3D elements.

To call the Hybrid Model material formulation from an LS-DYNA file, use a card like the following:

```
*Mat_User_Defined_Material_Models
$ HMv3:
$ (For simulations using the new ls971)
$. . . . . 1 . . . . . 2 . . . . . 3 . . . . . 4 . . . . . 5 . . . . . 6 . . . . . 7 . . . . . 8
$      MID,          RO,          MT,          LMC,          NHV,          IORTHO,          IBULK,          IG,
```

```

1,933e-12,45,14,34,0,5,1,
$ IVECT, IFAIL, I THERM, I HYPER,
0,0,0,1,
$ EE, NUE, MUA, LAMLOCKA, KAPPAA, QA, SBI, SBF,
2000,0.46,8.1,4.3,2000,.2,40.0,10.0,
$ PB, TAUBASEB, MB, PHAT, TAUBASEC, MC,
27.5,25.1,9.6,175.0,8.2,3.3,

```

Where the variables are defined as follows [1]:

```

MID = MATERIAL ID
RO = MASS DENSITY
MT = NUMBER TO DIRECT TO THE DESIRED USER SUBROUTINE. IN THIS CASE MT=45 BECAUSE
WE HAVE UMAT45 -- MUST SET TO 45
LMC = LENGTH OF MATERIAL CONSTANTS ARRAY (THE HYBRID MODEL CONSTANTS) -- MUST SET
TO 14
NHV = NUMBER OF HISTORY VARIABLES -- MUST SET TO 34
IORTHO = ORTHOTROPIC FLAG -- MUST SET TO 0
IBULK = BULK MODULUS LOCATION IN THE MATERIAL CONSTANTS ARRAY -- MUST SET TO 5
IG = SHEAR MODULUS LOCATION IN THE MATERIAL CONSTANTS ARRAY -- MUST SET TO 1
NOTE: IBULK AND IG ARE SET TO VALUES THAT ARE OF A REASONABLE ORDER. THEY ARE ONLY
USED DURING CONTACT PROBLEMS AND HAVING THE EXACT VALUES MAY NOT MATTER
IVECT = VECTORIZATION FLAG -- MUST SET TO 0
IFAIL = FAILURE FLAG. MAKES IT POSSIBLE FOR THERE TO BE FAILURE OF SHELL AND SOLID
ELEMENTS -- CAN SET TO 0 -- NOT CURRENTLY USED IN THE CODE FORMULATION
ITHERM = TEMPERATURE FLAG -- MUST SET TO 0
IHYPER = DEFORMATION GRADIENT FLAG. COMPUTES CURRENT DEFORMATION GRADIENT AND
MAKES IT AVAILABLE TO THE SUBROUTINE (WILL COME AFTER THE DEFINED HISTORY
VARIABLES) -- MUST SET TO 1
THE REMAINING VARIABLES ARE MATERIAL PROPERTIES USED IN THE HYBRID MODEL. THE
CURRENT MODEL FORMULATION DOES NOT USE PHAT, SO THAT VARIABLE CAN JUST BE SET TO 1

```

If you want to know the final chain-stretch value, it is stored as the third history variable and can be accessed using LS-PrePost.

If you have any questions/concerns about the augmented Hybrid Model code, please contact Erin Oneida ([eko4@cornell.edu](mailto:eko4@cornell.edu)).

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1. Livermore Software Technology Corporation. LS-DYNA® Keyword User's Manual. 2007.