

SIMPLIFIED CONCRETE MODELING

WITH

***MAT_CONCRETE_DAMAGE_REL3**

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Len Schwer

Schwer Engineering & Consulting Services
Windsor CA USA
Len@Schwer.net

L. Javier Malvar

Karagozian & Case Structural Engineers
Burbank CA USA
malvarl@adelphia.net

PRESENTATION OUTLINE

I. *Simple Concrete Model Motivation*

II. Mat 72R3 User Inputs

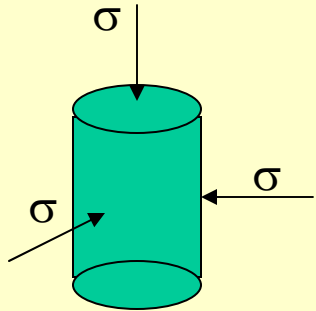
III. Laboratory Data & Mat 72R3 Comparisons

APPLICATIONS with CONCRETE

STRUCTURES MODELING:

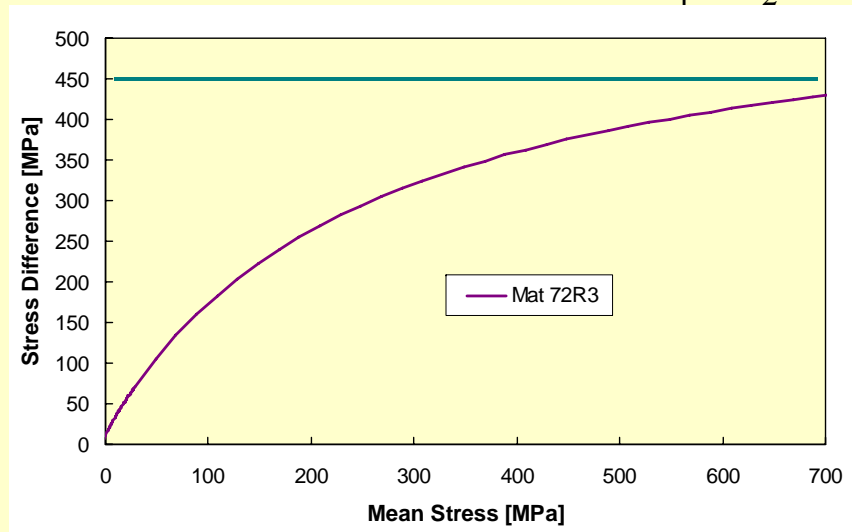
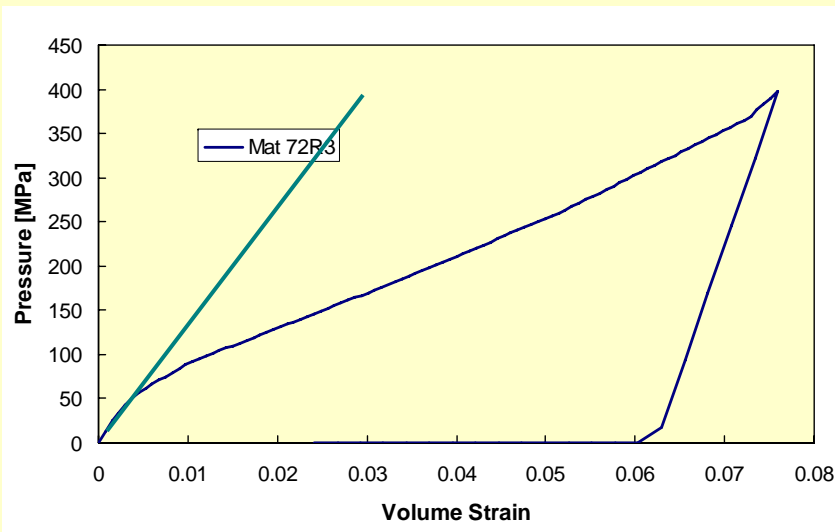
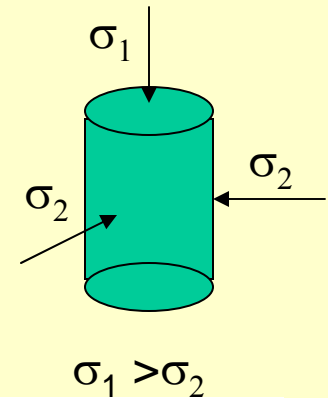
- Civilian
 - Roadside Barrier Impacts
 - Earthquake Response
 - Defense
 - Penetration & Perforation
 - Blast Protection
-

CONCRETE is COMPLEX



Concrete is *porous* with a nonlinear bulk modulus.

Concrete has a nonlinear *pressure dependent* yield strength.



—— Typical metal response.

LS-DYNA CONCRETE MODELS

Soil and Foam Model (Mat 5)
Pseudo-TENSOR (Mat 16)
Orientated Crack (Mat 17)
Geological Cap (Mat 25)
Concrete Damage (Mat 72)
Concrete Damage Rel3 (Mat 72R3)
Brittle Damage (Mat 96)
Soil Concrete (Mat 78)
Winfrith Concrete (Mat 84)
Johnson Holmquist Concrete (Mat 111)
Schwer Murray Cap (Mat 145)
CSCM Concrete (Mat 159)

THREE SIMPLIFIED
CONCRETE MODELS
ARE AVAILABLE

Simplified Model =
Minimum User Input
1 or 2 Parameters

Mat 25 Requires
12 User Inputs

MAT CONCRETE DAMAGE REL3

Mat 72R3 can be used either with complete user specified inputs or internal *parameter generation*.

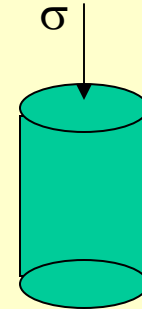
Internal parameter generation is based upon the concrete's unconfined *compressive strength*.

As an example, the concrete's *tensile strength* is obtained from the relation:

$$f'_t = 1.58 \left(\frac{(f'_c)^2}{a_0} \right)^{1/3}$$

MAT 72R3 INPUTS

Example for a 45.6 MPa concrete,
the non-zero user inputs are:



Card 1 – RO – concrete density ($2.17\text{E-}3 \text{ g/mm}^3$)

Card 2 – A0 – **negative** of the unconfined compressive strength (-45.6 MPa)

Card 3 – RSIZE & UCF – conversion factors for length $3.972\text{E-}2$ for inches-to-millimeters and 145 for psi-to-MPa.

All of the other input parameters are blank, or zero.

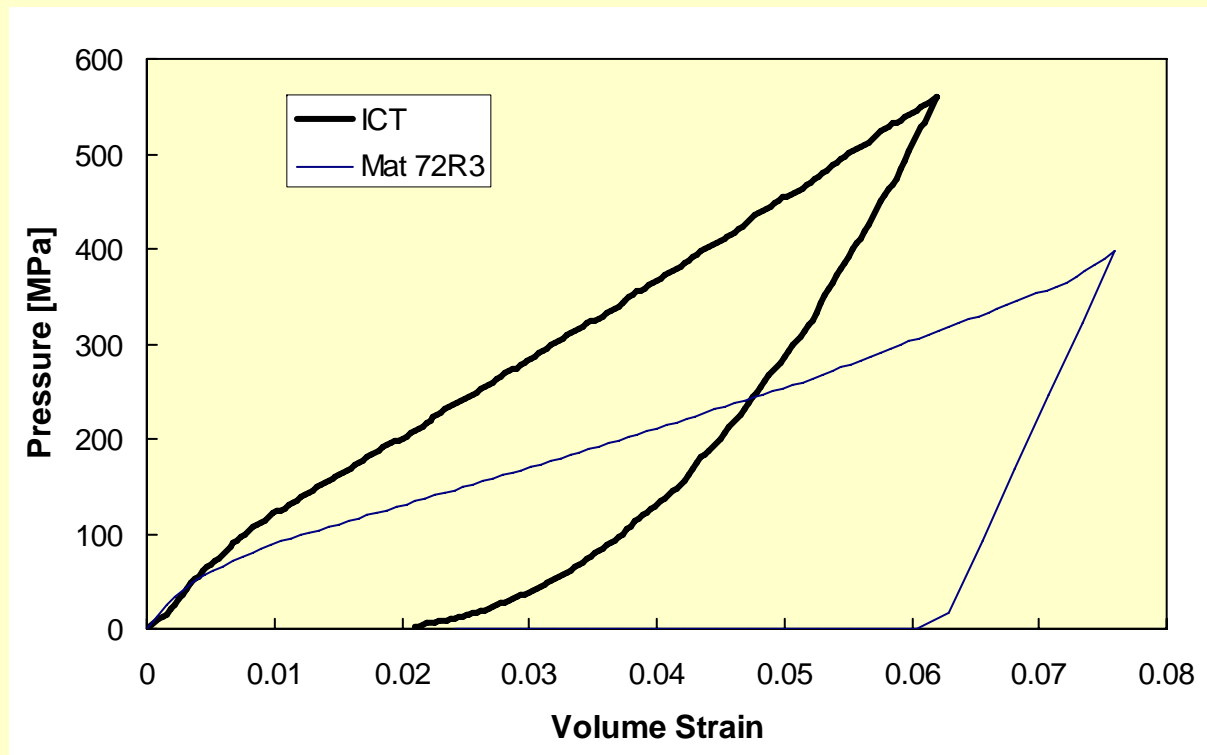
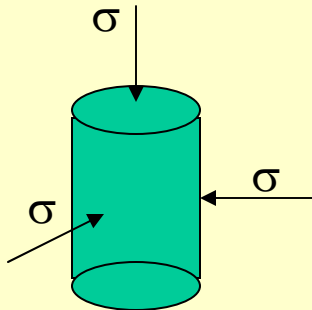
MAT CONCRETE DAMAGE REL3

- Mat 72R3 generated parameters are written in keyword format to the LS-DYNA “messag” file. This includes the required Equation-of-State.
- The user can modify these generated parameters, e.g. change the tensile strength, and use the modified inputs to update the model parameters.

```
$
$----- MATERIAL CARDS -----
$ LS-DYNA Keyword Generated Input for Release III
$   [Default values = K&C generic f'c=6580 psi concrete]
$   >>> Users need to change/check: MatID & RO & Rsize & LocWidth for units <<<
*MAT_Concrete_Damage_Rel3
$   MATID      RO      PR
$       72 2.120E-04 1.900E-01
$   f't      A0      A1      A2      B1      OMEGA      A1F
$   3.518E+00 1.182E+01 4.463E-01 2.020E-03 1.600E+00 5.000E-01 4.417E-01
$   sLambda   NOUT    EDROP   RSIZE    UCF    LCRate  LocWidth  NPTS
$   1.000E+02 2.000E+00 1.000E+00 3.937E-02 1.450E+02 0.000E+00 2.540E+01 1.300E+01
$   Lambda01 Lambda02 Lambda03 Lambda04 Lambda05 Lambda06 Lambda07 Lambda08
$   0.000E+00 8.000E-06 2.400E-05 4.000E-05 5.600E-05 7.200E-05 8.800E-05 3.200E-04
$   Lambda09 Lambda10 Lambda11 Lambda12 Lambda13      B3      A0Y      A1Y
$   5.200E-04 5.700E-04 1.000E+00 1.000E+01 1.000E+10 1.150E+00 8.928E+00 6.250E-01
$   Eta01     Eta02     Eta03     Eta04     Eta05     Eta06     Eta07     Eta08
$   0.000E+00 8.500E-01 9.700E-01 9.900E-01 1.000E+00 9.900E-01 9.700E-01 5.000E-01
$   Eta09     Eta10     Eta11     Eta012    Eta13      B2      A2F      A2Y
$   1.000E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.350E+00 2.958E-03 6.438E-03
$
```

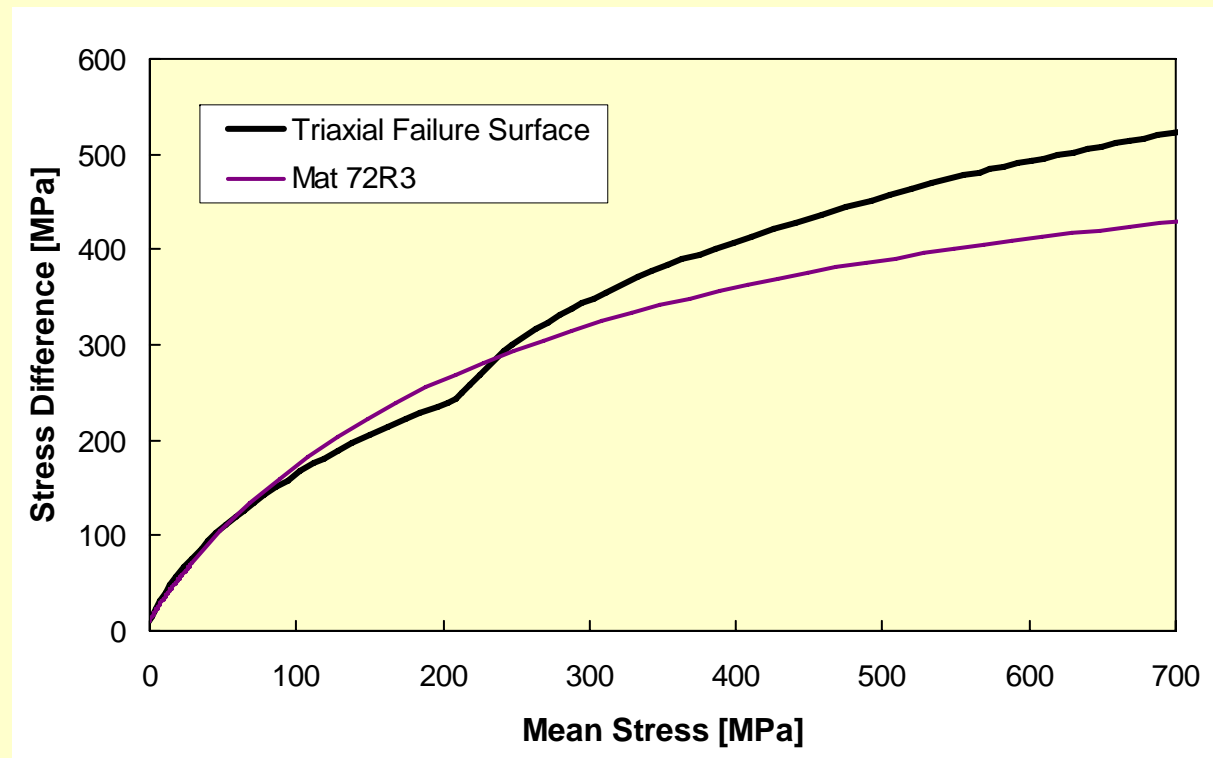
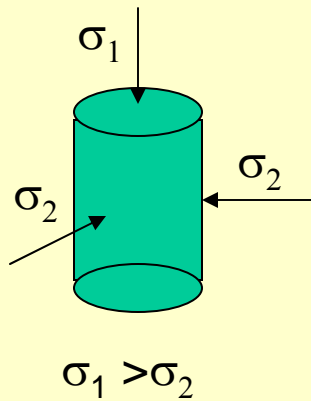
45.6 MPa Concrete & MAT 72R3

Isotropic Compression Test - Laboratory Data (ICT) and MAT 72R3



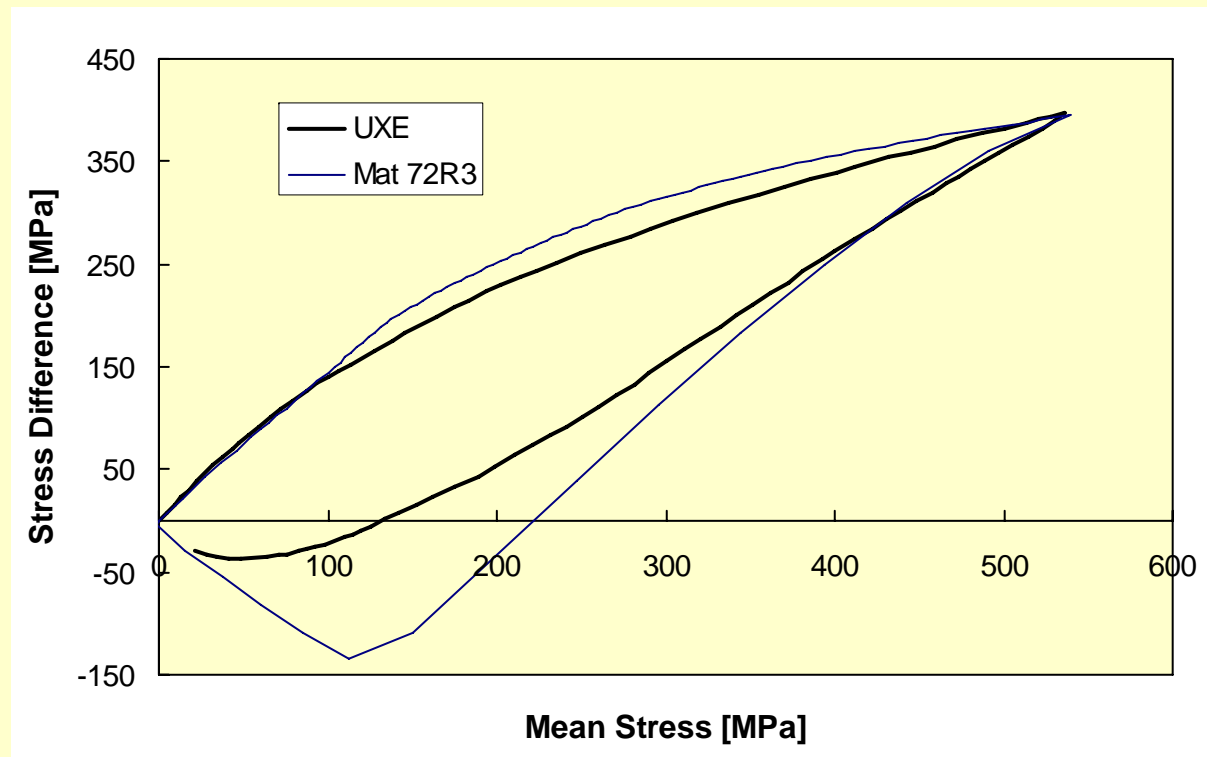
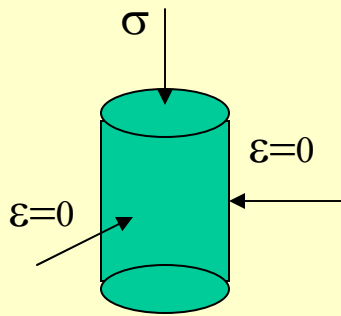
45.6 MPa Concrete & MAT 72R3

Triaxial Compression Test - Laboratory Data and MAT 72R3



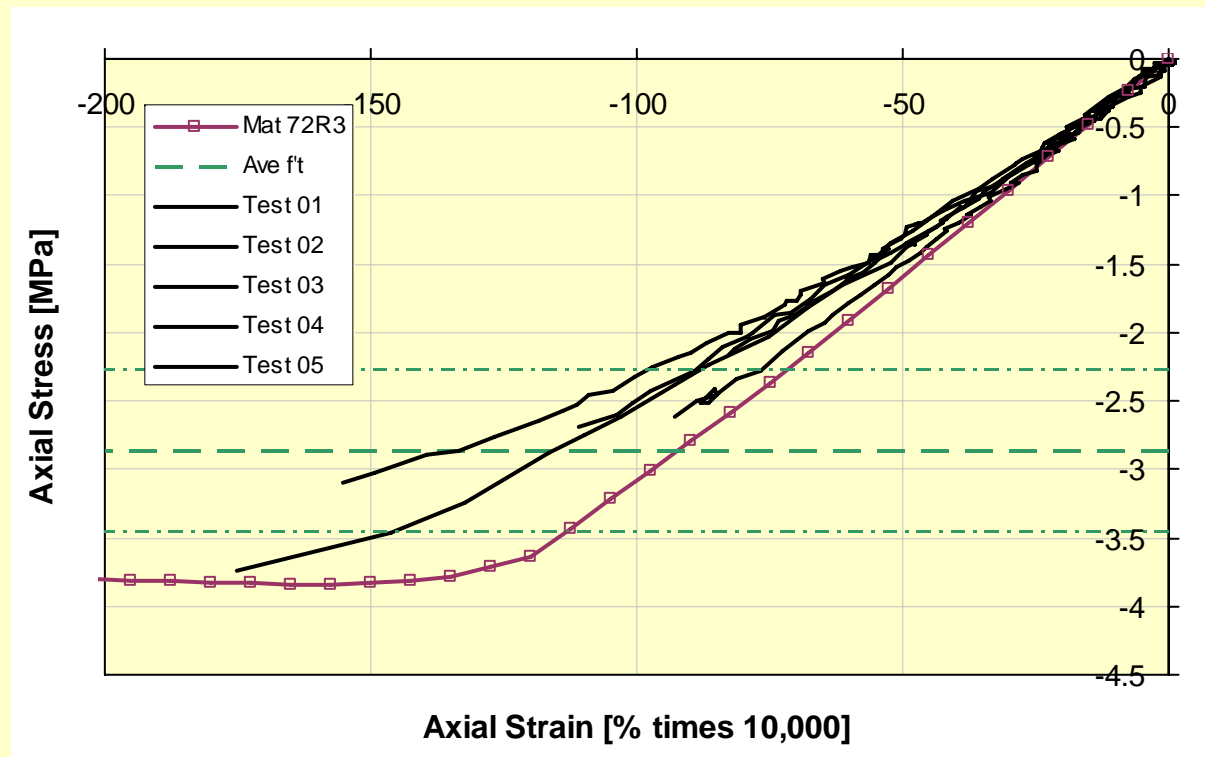
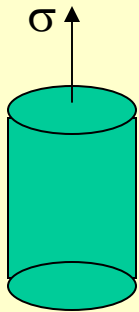
45.6 MPa Concrete & MAT 72R3

Uniaxial Strain Test - Laboratory Data (UXE) and MAT 72R3



45.6 MPa Concrete & MAT 72R3

Direct Pull Test - Laboratory Data and MAT 72R3



SUMMARY

- The latest release of the **Concrete Damage Model**, i.e. Release 3, provides a robust representation of complex concrete laboratory responses.
- Mat 72R3 requires minimal user inputs, i.e. unconfined compression strength.
- Mat 72R3 is intended as a *replacement* for Mat 72, although Mat 72 is retained for backward compatibility.
- Users may want to evaluate the other two minimal input concrete models: *Pseudo-TENSOR* (Mat 16) and *CSCM Concrete* (Mat 159)

REFERENCES

Malvar, L.J., Simons, D., “Concrete Material Modeling in Explicit Computations,” Proceedings, Workshop on Recent Advances in Computational Structural Dynamics and High Performance Computing, USAE Waterways Experiment Station, Vicksburg, MS, April 1996, pages 165-194. (*LSTC may provide this reference upon request.*)

Malvar, L.J., Crawford, J.E., Wesevich, J.W., Simons, D., “A Plasticity Concrete Material Model for DYNA3D,” International Journal of Impact Engineering, Volume 19, Numbers 9/10, December 1997, pages 847-873.

Malvar, L.J., Ross, C.A., “Review of Static and Dynamic Properties of Concrete in Tension,” ACI Materials Journal, Volume 95, Number 6, November-December 1998, pages 735-739.

Malvar, L.J., Crawford, J.E., Morrill, K.B., “K&C Concrete Material Model Release III — Automated Generation of Material Model Input,” K&C Technical Report TR-99-24-B1, 18 August 2000 (*Limited Distribution*).
