

Why DTRA Needs V&V of CSD Codes

- DTRA planning and assessment tools require fast running algorithms
- Fast running algorithms require calibration data
- High fidelity physics based (HFPB) modeling will assume an ever-increasing role compared with experiments as a source of calibration data
- Substantial uncertainties remain in some aspects of HFPB models of dynamic structural response
 - Concrete behavior after initial cracking (softening)
 - Bomb case fragmentation
 - Bomb fragment impulse coupling
 - Secondary debris characteristics
 - Concrete-rebar interaction
 - Dynamic strength and fracture/failure energy (data gap)



Applying V&V to HFPB Structural Dynamics Codes

- Formal V&V procedures have limited applicability to HFPB CSD codes
 - Validity of CSD simulations depends as much on analyst as code
 - Code configuration control is hampered by
 - Frequent revision of material models, especially concrete
 - Proliferation of different versions of same code, especially DYNA3D
 - Because strain-softening in most common concrete models varies with mesh-size, convergence tests are problematic
- DTRA has used a less structured approach for CSD methods
 - Multiple participants
 - Extensive peer review at every stage
 - Verification through round robin calculations without experiment
 - Validation through round robin calculations with precision or full scale experiments
 - Accreditation is out of the question



V&V of CSD Methods

Summary of Past Exercises on Plain and Reinforced Concrete

Exercise	Type*	Date	Subject
Benchmark Round A	BS	4/93	Single plain concrete elements in isotropic compression, uniaxial strain compression, triaxial compression at various confining pressures, unconfined tension; cuboids with 3 levels of discretization, fixed or lubed ends, unconfined or plane-strain on lateral surfaces.
Task 19 Test 2	XD	8/93	1/6-scale, 4-room R/C structure, uncased internal explosion, very light damage.
Benchmark Round B	B S/D	9/93	Same as Benchmark Round A, but add independent specification for extension strength and strength enhancement at elevated strain rate.
DEINT-3/4	XD	9/93	Same structure as Task 19 Test 2, moderate damage.
Benchmark Round C	BS	1/94	Single elements in biaxial stress at various ratios; stacks of elements with linearly varying strain to simulate slab bending.
DIPOLE EAST 21	XD	3/94	Full scale BLU-109 internal explosion (cased), severe damage (air-backed walls in test room destroyed).
Benchmark Round D	BD	5/94	Slab dynamics in plane strain under wide range of loading magnitudes.
DIPOLE EAST 51	XD	5/94	Full scale BLU-109 internal explosion (cased), severe damage (air-backed wall and ceiling in test room destroyed).
Numerical Simulations of Lab Load Paths	BS	7/94	Single plain concrete elements under conventional and unconventional load paths

*B:"benchmark" (no experiment); X:experiment; S:static; D:dynamic



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Summary of Past Exercises on Concrete (concluded)

Exercise	Type	Date	Subject
PWT-1	XD	9/94	1/4-scale, 3-room linear structure, uncased charge, very light damage.
Dilatancy Tests of Concrete Material Models	BS	1/95	Single elements with full strain control in pure shear, shear+tension, shear+compression; also unconfined compression.
PWT-1a	XD	12/95	Same structure as PWT-1, larger charge, light damage
Benchmark Round E	B/X S	1/96	Slab in plane strain, loaded quasistatically with water pressure.
PWT-2	XD	1/96	Like PWT-1 but thicker walls, larger charge. Severe damage.
BLU-113 Arena Test Slabs	XS	5/96	Quasistatic 4-point bending of 15-, 21-, and 27-inch-thick by 42-inch wide undamaged and fragment-damaged slabs.
PWT-3	XD	6/96	Like PWT-2 but thicker walls, larger charge. Light damage.
DIPOLE EAST 146	XD	8/96, 3/97	1/2-scale prescored BLU-109 inside bunker, pre-and postdiction, moderate damage
DIPOLE EAST 142/150	XD	5/97	1/2-scale prescored BLU-113 inside bunker, prediction, moderate damage
MEA Wall Damage	BD	2/99	Full scale wall response to BLU-109, parametric study



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