Evaluating the Predictive Capability of Fire and Egress Models

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Consensus Standards


- ASTM standards provide methodology for fire model evaluation:
  - ASTM E 1355 defines methodology for model evaluation.
  - ASTM E 1472 defines documentation requirements.
  - ASTM E 1895 assists model user in identifying model limitations.

- **ISO 16730:2008** provides a framework for assessment, verification and validation of all types of calculation methods used as tools for fire safety engineering.

- **IMO MSC/Circ. 1238** includes guidelines for evacuation analysis for passenger ships.
Data, Data, Data (and Documentation)

• Model documentation forms the core of needed information about a model
  – Technical documentation provides in-depth explanation of scientific basis of models
  – User’s manual provide reference to inputs and output
  – V&V guides detail available code verification and comparisons with experimental and other data

• Bulk of validation efforts are comparison with experimental data
Qualitative (and Quantitative)

- Typical comparisons between models and experimental data quoted from actual papers
  - “good to excellent”
  - “favorable”
  - “quite satisfactorily”
  - “reasonably accurate” “none of the models did well”
  - “achieved in a qualitative sense”
  - “well predicted”

- While qualitative comparisons serve a purpose, engineering applications require quantitative comparisons
Qualitative (and Quantitative)

• For egress/movement models, IMO specifies a series of component and qualitative tests.
  – Walking speed in corridors and stairs
  – Exit flow rate
  – Exit route allocation

• Common sense tests to provide a level of confidence that model is operating as expected.
Qualitative (and Quantitative)

- ASTM E 1355 for fire models only provides general guidance on verification and sensitivity analysis.
- Model documentation includes a wide range of detail and topics.
  - CFAST includes chapters on model structure and sensitivity analysis
  - FDS has entire volume on verification that includes numerous analytical tests
- Fire modeling guides are ripe for further guidance on verification
(Qualitative and) Quantitative

Tree 4 HGL Temperature
NBS Multiroom, Test 100A

Temperature (°C)
0 20 40 60 80 100 120 140 160

Time (min)
0 5 10 15 20

Exp TIME vs UP 18
CFAST Time vs HGL Temp 4

Tree 4 HGL Height
NBS Multiroom, Test 100A

Height (m)
0.0 0.5 1.0 1.5 2.0

Exp TIME vs HGT 18
CFAST Time vs HGL Height 4

Occupant Egress Times
Regression ignoring tails

Time Out (s from Alarm)
0 200 400 600 800 1000 1200 1400 1600 1800

Occupant
0 100 200 300 400 500 600 700
(Qualitative and) Quantitative

- Bulk of validation efforts are comparisons to experimental data
  - Nearly 1600 comparisons of FDS with 42 different test series and growing
  - About 800 comparisons of CFAST with 12 different test series and growing
  - FDS_Evac compared to a number of different evacuation geometries and scenarios

- Significant efforts required to obtain high quality data compared correctly to high quality simulations
Data, Data, Data, and more data

- Data for comparison exists; **high quality data is more scarce**
  - http://fire.nist.gov/fds
  - http://www.nist.gov/el/fire_research/egress.cfm

- **Range of data is limited** for many fundamental submodels
  - Heat transfer to objects and surfaces during a fire
  - Vent flows, particularly mechanical ventilation
  - Stairwell data for tall buildings; elevator data
  - Human behavior
Data, Data, Data, and more data

- Quality of comparisons depends on quality of underlying data and model simulations
- Blind experiments useful exactly once; better to have numerous well-documented data sets
What you do with the Data, and more data

- How do you compare model and experiment?
  - Peak values
  - Average values
  - Range of relative differences
  - Time-integrated values
  - Norms for magnitude and functional form
- Guidance on which is appropriate for a given application is limited and may depend on application
- **Research on expressing agreement including uncertainty is ongoing**
Standards, Documentation, and Data

• Consensus standards exist and continue to evolve; need more effort for movement models
• Documentation by model developers is key to V&V efforts
• Both qualitative and quantitative assessments contribute to V&V
• Data exists, but significant data needs still exist