West Fertilizer Explosion
Source Energy and Structural Damage

Presented by
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Technical Director
ABS Group

August 9, 2018
Acknowledgements

• Victims of the West Fertilizer Explosion
  – Fatalities
    • 12 First Responders
    • 3 Members of the Public
  – Injured
    • Over 260

• United States Chemical Safety and Hazard Investigation Board
  – Donald Holmstrom, JD
    Director, Retired
  – Johnnie Banks, CFEI
    Supervisory Investigator, Retired
April 17, 2013

- Fire reported at 7:29 pm
- Explosion involving bulk storage of ammonium nitrate at 7:51 pm
- 15 Deceased and over 260 injured
- Crater measured 90 ft in diameter
Background

April 17, 2013
7:51 pm
Background

- Production Building
- Corn Silo
- Misc. Grain Silos
- Scale House
- Office / Chemical Storage
Investigation Goals

- Summary of the damage
- Source energy of the explosion that best explains the observed damage
West Fertilizer - Damage

Production Building - Crater
Railway Damage at 100 ft. – K3.4
West Fertilizer - Damage

Office / Chemical Storage Building at 85 ft. – K3

Scale House at 445 ft. – K15
Nursing Home Damage at 650 ft. – K22
Nursing Home Crater Ejecta at 910 ft. – K30
West Intermediate School at 700 ft. – K24
West Intermediate School at 700 ft. – K24
Residential Damage at 700 ft. – K24
Residential Damage at 1,470 ft. – K50
West High School at 1,500 ft. – K50

- Spectator Gym
- Practice Gym
- Entry
- Auditorium
West High School at 1,500 ft. – K50

Spectator Gym
Determine the Source Energy

- Damaged metal buildings
- Evaluate additional structures using ETL 1110-3-495
- Survey and evaluate drag loaded damage indicators
- Develop a possible range of charge weights
- Reconstruct West, TX in a 3D model to make final determination of the net explosive weight by evaluating
  - Residential damage
  - Damage to the High School
  - Damage of the Intermediate School
## Damage Assessments Utilizing ETL 1110-3-495


<table>
<thead>
<tr>
<th>Damage Category</th>
<th>Percent Total Building Damage</th>
<th>Damage Description</th>
<th>Repairable and Reusable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>60 to 100</td>
<td>Frame collapse and massive destruction. Little left standing. Majority of personnel will suffer fatalities.</td>
<td>No</td>
</tr>
<tr>
<td>Heavy</td>
<td>40 to 60</td>
<td>Large deformation of structural members and major nonstructural component damage. Majority of personnel will suffer serious injuries with 10 to 40 percent suffering fatalities.</td>
<td>Very unlikely</td>
</tr>
<tr>
<td>Moderate</td>
<td>20 to 40</td>
<td>Some deformation of structural members and extensive nonstructural damage. Majority of personnel will suffer lacerations and blunt trauma from window glazing fragments or other nonstructural member debris. Zero to 10 percent of personnel suffer fatalities.</td>
<td>Possible</td>
</tr>
<tr>
<td>Minor</td>
<td>10 to 20</td>
<td>Little or no damage to major structural members and some damage to nonstructural. Personnel will suffer mostly minor and some serious lacerations and blunt trauma from window glazing fragments or nonstructural member debris.</td>
<td>Most probably</td>
</tr>
<tr>
<td>Minimal</td>
<td>0 to 10</td>
<td>Window damage extensive and light or local damage to nonstructural members. Personnel will suffer minor lacerations from window glazing fragments or other nonstructural member debris.</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Potential Range of Charge Weights

[Diagram showing potential range of charge weights]
**Range of Potential Charge Weights**

- **Preliminary Assessment Results**
  - Metal Building Assessment
    - Average Charge Weight of data
    - 20,000 lb\textsubscript{TNT}
  - Apartment Complex and Nursing Home
    - Range of potential Charge Weights
    - 10,000 lb\textsubscript{TNT} to 40,000 lb\textsubscript{TNT}

- **Detailed Assessment of Community Damage**
  - Residences
  - High School
  - Intermediate School
    - Evaluate Range of Explosion Energies
    - 20,000 lb\textsubscript{TNT} to 30,000 lb\textsubscript{TNT}
Residential Damage from FACET3D & CFD

**BDL 5:** Reflected wall has collapsed. Other walls and roof have substantial plastic deformation that may be approaching incipient collapse.

<table>
<thead>
<tr>
<th>$\text{TNT}_{\text{eq}}$</th>
<th>CDL1</th>
<th>CDL2</th>
<th>CDL3</th>
<th>CDL4</th>
<th>CDL5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20,000-lb</td>
<td>6%</td>
<td>20%</td>
<td>22%</td>
<td>16%</td>
<td>36%</td>
<td>100%</td>
</tr>
<tr>
<td>22,500-lb</td>
<td>6%</td>
<td>12%</td>
<td>20%</td>
<td>19%</td>
<td>43%</td>
<td>100%</td>
</tr>
<tr>
<td>25,000-lb</td>
<td>6%</td>
<td>8%</td>
<td>18%</td>
<td>13%</td>
<td>55%</td>
<td>100%</td>
</tr>
<tr>
<td>27,500-lb</td>
<td>6%</td>
<td>2%</td>
<td>11%</td>
<td>16%</td>
<td>64%</td>
<td>100%</td>
</tr>
<tr>
<td>30,000-lb</td>
<td>5%</td>
<td>2%</td>
<td>10%</td>
<td>12%</td>
<td>72%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**BDL 4:** Reflected wall components are collapsed or very severely damaged. Other walls and roof have permanent damage requiring replacement.

<table>
<thead>
<tr>
<th>$\text{TNT}_{\text{eq}}$</th>
<th>CDL1</th>
<th>CDL2</th>
<th>CDL3</th>
<th>CDL4</th>
<th>CDL5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20,000-lb</td>
<td>8%</td>
<td>66%</td>
<td>20%</td>
<td>5%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>22,500-lb</td>
<td>5%</td>
<td>59%</td>
<td>23%</td>
<td>11%</td>
<td>2%</td>
<td>100%</td>
</tr>
<tr>
<td>25,000-lb</td>
<td>3%</td>
<td>51%</td>
<td>27%</td>
<td>14%</td>
<td>6%</td>
<td>100%</td>
</tr>
<tr>
<td>27,500-lb</td>
<td>2%</td>
<td>38%</td>
<td>28%</td>
<td>14%</td>
<td>17%</td>
<td>100%</td>
</tr>
<tr>
<td>30,000-lb</td>
<td>2%</td>
<td>28%</td>
<td>30%</td>
<td>18%</td>
<td>22%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**BDL 3:** Reflected wall components sustain permanent damage requiring replacement, other walls and roof have visible damage that is generally repairable.

<table>
<thead>
<tr>
<th>$\text{TNT}_{\text{eq}}$</th>
<th>CDL1</th>
<th>CDL2</th>
<th>CDL3</th>
<th>CDL4</th>
<th>CDL5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20,000-lb</td>
<td>30%</td>
<td>59%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>22,500-lb</td>
<td>20%</td>
<td>78%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>25,000-lb</td>
<td>10%</td>
<td>84%</td>
<td>6%</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>27,500-lb</td>
<td>2%</td>
<td>86%</td>
<td>10%</td>
<td>1%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>30,000-lb</td>
<td>0%</td>
<td>81%</td>
<td>16%</td>
<td>3%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Residential Damage from FACET3D & CFD

- Charge Weights Consistent with Residential Damage on Reagan St.

<table>
<thead>
<tr>
<th></th>
<th>1100 - 1200 Block of N. Reagan St.</th>
<th>1400 - 1500 Block of N. Reagan St.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BDL</strong></td>
<td>20,000-lb</td>
<td>20,000-lb</td>
</tr>
<tr>
<td></td>
<td>22,500-lb</td>
<td>22,500-lb</td>
</tr>
<tr>
<td></td>
<td>25,000-lb</td>
<td>25,000-lb</td>
</tr>
<tr>
<td></td>
<td>27,500-lb</td>
<td>27,500-lb</td>
</tr>
<tr>
<td></td>
<td>30,000-lb</td>
<td>30,000-lb</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td><strong>6</strong></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td><strong>7</strong></td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>
Construct 3-D CFD and FACET3D Model of West
CFD Simulation – from West
West Fertilizer Explosion and Fire

Accident Description

Accident: West Fertilizer Explosion and Fire
Location: Location: West, TX
Accident Type: Chemical Distribution - Fire and Explosion
Investigation Status: The CSB’s investigation was approved by a unanimous board vote at a public meeting in West, TX, on January 28, 2016.

A massive explosion at a fertilizer storage and distribution facility fatally injured twelve volunteer firefighters, two members of the public and caused hundreds of injuries.

Final Reports

- FINAL REPORT: West Fertilizer Final Investigation Report