

### Course Objectives:

- State the four operational levels of collapse rescue
- State the four structure types
- State the four types of structural collapse
- State the hazards associated with collapse
- Control hazards associated with collapse

### Objectives cont. :

- Describe the factors that determine size-up of collapse incident
- State the three zones associated with collapse rescue
- Describe USAR marking system
- Describe USAR emergency signaling method

### Why do we undergo Search and Rescue training????

Search and rescue is one of the most dangerous types of emergency response activities that can be performed. It exposes rescuers to many hazards for which they have little training and virtually no experience to combat.

The application of the most current SAR techniques and safe methods of operation are vital to the accomplishment of the rescue operation.

### Structural Forces

- Tension
- Compression
- Bending
- Shear

### Tension

- Stretches members of steel or wood
- Concrete and masonry have **NO** reliable tension strength

### Compression

- Force pushes on members and can lead to crushing of materials

### Bending

- Occur as a result of vertical loads from gravity and are applied to floor slabs and beams

### Shear

- The tendency to tear the beam surfaces apart, greatest in adjacent supports
- Ex.-roll of coins

### Reasons for Structural Collapse

- Earthquakes
- Windstorms
- Explosions (Interior and Exterior)
- Fire
- Flood

### Reasons for structural collapse:

- Earthquakes:

- Catastrophic events that occur when movement along a fault line creates movement in the earth's crust.
- Extent of damage determined by type of shaking that occurs coupled by the response of the structure

Earthquakes cont. :

- Aftershocks: smaller quakes after ALL earthquakes
- They can cause substantial re-shaking of already damaged structures
- Diminish in intensity and # with time

Earthquake Loading

Wind Storms

- Forces generated on the exterior of structures based on its height, ground roughness, and the wind velocity.
- All force applied to exterior of structure unless structure is penetrated
- Pressure acts inward on windward side and outward on all others/roof surfaces

Wind Loading

Cranberry: Oct 2003

Explosions

A rapid release of energy consisting of a sound wave, heat and light and a shock wave that propagates radially outward from the source.

High explosives (HE)-denotation occurs at 4 miles per second

Low explosives (LE)-denotation occurs at 900 feet per second

Exterior explosion: bomb

- Shock wave initially reflected and amplified by the building face and then penetrates through openings subjecting floor and wall surfaces to great pressure
- Finally, the entire building is engulfed by shock wave subjecting all structure surfaces to over-pressure

Explosion loading: Exterior

Murrah Building

Natural gas explosions

- Large, weak, and lightly attached walls may be blown away.
- Columns and beams in steel frame construction may remain intact but stability may be compromised by the removal of their bracing elements (walls, roof, floors)

Canonsburg: Jan. 04

Explosion Loading

Fire

- Wood or metal/wood floors often collapse due to burn through
- Can pull masonry or concrete walls in or leave them standing un-braced (URM)
- Cast concrete walls can be cracked due to expansion of floors

Flood

- Forces from lateral hydrostatic pressure
- Lifting forces and debris impacts
- Hydrostatic pressures can highly load foundations, basement walls and lift structures

## Flood Loading

### Basic Building Types

- Light frame-Wood frame
- Heavy wall-URM, tilt-up, low rise walls
- Heavy floor-concrete frame buildings/bridges
- Pre-cast concrete buildings

### Light (Wood) Frame

- 1-4 stories in height
- Principal weakness in lateral strength of the walls
- Walls become “wracked” causing offsetting of the floors
- Masonry chimneys can crack and fall
- Structures can shift off of foundation
- Fire load significant

### Light Wood Frame

#### Heavy wall URM

- Parapets, full walls fall off due to inadequate anchors
- Often times weak mortar
- Walls can separate from wood floors/roof
- Broken bricks often line streets

#### Heavy Wall URM

#### Heavy Floor Concrete Frame

- Columns break at intersections with floor beam
- Short columns in exterior walls get high tension/shear forces by surrounding concrete
- Bending/punching shear failure at intersections of flat slabs and columns
- Weak concrete can compound problems

#### Heavy Floor Concrete Frame

#### Pre-Cast Concrete Buildings

- Joint failures between roof/floors/walls
- Wall panels separate from the building and fall
- Progressive collapse can be caused by joint failure between column and beam or slab and wall panel

### Pre-Cast Concrete

#### Basic Collapse Patterns

- Most building collapse due to lack of stability
- The basic shape is significantly changed when subjected to a combination of forces
- The new changed shape is much less capable of carrying the forces, therefore;
- The structure will rapidly continue to change until it finds a new stable shape

#### Light Frame Collapse

- Collapse usually occurs when lower walls have insufficient strength to resist wracking
- Structure projected away from its original foundation by the height of the story walls that fail

- Additional stories can collapse due to the impact of first story
- Usually leaves many voids easily accessible

#### Light Frame Collapse

#### Heavy Wall URM Collapse

- Collapse is usually partial, strongly related to the heavy, weak bearing walls falling away from the floors
- In URM buildings the walls normally fall away from their original position
- When the wood roof and/or floors collapse, many easily accessible voids can be created.

#### Heavy Wall cont.

- Areas adjacent to the walls where the heavy debris fall often contain badly injured or dead victims
- The combination of broken gas lines and debris can lead to fire
- The falling walls can cause the roof and floors that they support to collapse in patterns of Lean-to, Vee, Pancake, and Cantilever

#### Heavy Wall Collapse

#### Collapse Patterns

- Lean-to
- Vee
- Pancake
- Cantilever

#### Lean-to collapse

- Formed when one wall collapses leaving other end in hazardous condition.
- May occur in TU, heavy floor and precast

#### Vee collapse

- Occurs when interior support fails
- More common in decay, overload column failure. Can occur in heavy floor, precast

#### Pancake Collapse

- Occurs when most all vertical supporting members fail and allow floors to collapse on top of each other
- Common for heavy floor, precast const.

#### Cantilever Collapse

- Pancake with extended floors
- May also occur in heavy floor, precast const

#### Pre-Cast Collapse Patterns

- Collapse is usually caused when the precast parts become disconnected from each other
- Structure very rapidly loses stability
- Normally contains numerous layers of broken unbroken pieces of slabs, walls, beams, and columns

#### Pre-Cast cont.

- The voids can be difficult to access, but the slab can be removed, layer by layer, since interconnections is normally poor to non-existent.

#### Hazards, Hazard Control

- Falling: where part of the structure or its contents are in danger of falling
- Collapse: Where the volume of the enclosed space made by the structure is reduced
- Other: toxic gas, Co, asbestos, Haz-Mat, aftershocks, electrical, fire,

#### Light Frame House Hazards

#### Heavy Wall Construction Hazards

#### Heavy Floor Construction Hazards

#### Precast Construction Hazards

#### Operational Phases

- **Access collapse area**
- **Remove all surface victims**
- **Check all voids and accessible spaces for viable victims**
- **Do selected debris removal to rescue immediate viable victims**
- **Do general debris removal for missing victims**

#### Hazard Mitigation

- First Question???
- Do we need to be in this area at all?
- Hazard avoidance in the preferred option
- Look up first-small nonstructural elements may be the greatest hazards
- Can the hazard be mitigated to an acceptable level? (risk management)

#### Hazard Mitigation

- Avoid-plan direction of SAR activities away from hazards, start from the top when dealing with collapsed structures
- Exposure protection-limit the time of exposure and # of rescuers exposed to hazards
- Remove-if possible, lift off, push over or pull down safely, remove by hand

#### Hazard Mitigation

- Shore-provide both vertical and lateral support, build safe haven areas
- Monitor-crack measuring devices, line on a damaged wall,
- Recognize-presence of Haz-Mat

#### Respiratory Protection

- Protect the airway!! – concrete dust when inhaled is an irritant to the alveoli of the lungs
- Unprotected rescuers and patients can contract pneumonia as a result
- Doctors have calculated the danger of inhaling small amounts of toxins over time,

they cannot predict results of inhaling large amounts of toxins over a short period of time  
Respiratory Protection Devices

- Dust mask-simple paper/cloth mask, filters non-toxic particles, cannot be used in O2 deficient atmospheres (19.5%)

- Respirator-normally made of plastic, covers entire face, with appropriate filters, can filter some toxic particles. Cannot be used in O2 deficient atmospheres (19.5%)

Respiratory Devices

- SCBA-can be used in toxic, O2 deficient atmospheres, tends to be bulky for C-space

- Supplied Air Breathing Apparatus-supplies air for unlimited amount of time, supplied through a line, easier to use in a C-space but limited due to length of supplied air line

5 Step Process

- **Size-up (I.C.S.)**
- **Hazard recognition and control**
- **What types of structures have collapsed**
- **Structural stability**
- **Access and continued shoring**

Operations

**A. Size-up (I.C.S.)**

**1. Dispatch**

**2. Approach**

**3. On scene**

- **I.C.S. / Site control**
- **Type of structure(s)**
- **Type of occupancy(s)**

Operations cont.

**-Extent of collapse**

- **Six sided survey**
- **Witnesses**

**B. Surface victims - rescue first**

**C. Zones & Personnel accountability**

**D. Technical search**

**E. Physical search**

## **STRUCTURAL COLLAPSE SCENE ASSESSMENT**

- **STRUCTURAL INSTABILITY**
- **SURFACE HAZARDS**
- **DAMAGED UTILITIES**
- **OVERHEAD HAZARDS**
- **BEOW-GRADE HAZARDS**
- **HAZARDOUS MATERIALS**
- **TIME : \_\_\_\_:\_\_\_\_ DATE: / /**
- **ADDRESS: \_\_\_\_\_**

Patient Search Methods

- **Hailing method**

- Physical void search
- Search cameras
- IR/Thermal imaging
- Electronic listening devices
- Canine search

#### Hailing Method

- Use a bull horn to “hail” victims, “Anybody in there?” “Can you hear me?”
- Ask patient, “Can you knock on something?”
- No special equipment required
- Unconscious, physically weak, or a very young person may not be heard

#### Physical Void Search

- Grid method/pattern
- Make separate visual assessments in voids and confined space areas for any indication of victims
- Hailing device could be used to provide direction to trapped victims
- Area is then quieted and the personnel listen to pinpoint area of noise

#### Physical Void Search

- Does not necessarily require specialists, canine, or sophisticated electronic equipment

#### Search Cameras

- Cameras have been made available designed specifically for search and rescue applications
- Make use of available holes and openings to look inside voids
- Holes can be drilled to allow camera access

#### Search Cameras

- Easily understood
- Possibility to record picture
- Remote viewing
- Costly

#### IR/Thermal Imaging

- Unique way of seeing through smoke and dust is infrared/thermal imaging
- Resolution is poorer than on a typical black and white TV
- Can be used to survey large, open, dark areas
- Sources of heat other than persons buried under debris are also indicated

#### Electronic Listening Devices

- Detects sounds from the victim
- Deployment of an array of two or more pick-up probes around the perimeter of a building

- Victims should be directed to make a repetitive sound
- **Sensors best in solid/dense materials**
- **Takes time to locate victims**

#### Canine Search

- **Need to consider:**
  - **Time of day & temperature**
  - **Type & direction of wind**
  - **Size of search area & type of collapse**
  - **Alert is marked only after confirmation by a 2nd team**

#### Victim Location Marking System

- Large 2 ft. "V" is painted near the location of the known or potential victim
- Arrow may be added next to the "V" pointing towards the victims location
- Paint circle around "V" when victim location has been confirmed

#### Victim Location Marking

##### Structure Hazard ID

- Structure safe for operations
- Structure may be significantly damaged
- Structure not safe for rescue
- Indicates direction for safe access
- Indicates Haz-Mat

##### Structure Hazard ID Sample

##### Search Assessment Marking System

##### Safety: Emergency Alerting System

- Evacuate -3 short blasts (1 second each)
- Cease Operations - 1 long blast (3 seconds duration)
- Resume Operations -1 long and 1 short blast

#### Examples:

- By placing two radios together, speaker to microphone, and depressing the transmit buttons a loud tone is heard on all other radios tuned to that frequency
- Air horns, car horns, whistles, the P.A.S.S. device and clear text over the radio are all excellent methods for signaling

#### Safety Briefing

- Before beginning to work, identify the specific methods of signaling that will be used at the work site should a problem arise during that operational period.

#### Operational Considerations

- **Victim determination**
- **Survivability**
- **Resources**

#### Collapse Trauma

- **Victim dies within minutes of collapse from multi-organ system failure**
- **Victim lives for hours after injury, usually suffers from uncontrolled hemorrhage, most can be saved with rapid rescue and care**
- **Victim dies days or months after injury from related trauma**