Basic Structural Collapse Operations

Student Manual

Technical Rescue
1602 (Rev. 1/05)

STATE OF NEW YORK DEPARTMENT OF STATE
OFFICE OF FIRE PREVENTION AND CONTROL

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Welcome to the New York State Fire Training Program

Basic Structural Collapse Operations

The Department of State recognizes that providing training for paid and volunteer firefighters and related officials is an important part of the services it makes available. Our Office of Fire Prevention and Control (OFPC) places a very high priority on training because we believe it is essential for the men and women of the fire and emergency services in New York State.

The Office of Fire Prevention and Control's programs include the most complete progression of training available today -- beginning with probationary firefighters and extending the full length of a firefighter's career with the fire service. While our training programs address specific fire and arson prevention and control issues, we also encourage expansion and improvement of local training facilities and programs in cooperation with fire companies, municipal corporations and districts.

Basic Structural Collapse Operations provides specialized training in the realm of building collapse rescue, a threat in every community. Content will include warning signs, collapse causes, void identification, safety precautions, search techniques, team operations, building construction awareness, and initial fire department operations. Several case studies will be discussed and a table top exercise is included. A test will be given at the end of the class.

Your comments and suggestions about this student manual, our training classes or any OFPC program are always welcome. Your input will help us build on our successes and make needed changes, when appropriate.

On behalf of the citizens you serve, we want you to know that your participation and commitment are greatly appreciated.

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BASIC STRUCTURAL COLLAPSE OPERATIONS

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Basic Structural Collapse Operations

Lesson 1.2: Overview & Objectives

Course Overview and Objectives

Course Overview

Basic Structural Collapse Operations is part of a series of courses designed to develop and enhance your skills as a rescuer. These courses are delivered both in the field as well being taught as part of the residential offerings at the New York State Academy of Fire Science to allow you the opportunity to continue your education and training as a rescuer.

Course breakdown is as follows:

UNIT 1 – INTRODUCTION TO STRUCTURAL COLLAPSE OPERATIONS
1.1 Introduction & Registration
1.2 Course Overview & Objectives
1.3 Introduction to Structure Collapse
1.4 Safety at Structural Collapse Operations
1.5 Regulations and Standards
1.6 Hazard Evaluation and Size Up
1.7 Void Identification
1.8 Structural Shoring Concepts

UNIT 2 – BUILDING CONSTRUCTION
2.1 Building Construction
2.2 Team Operations
2.3 Scenario
2.4 Course Review
2.5 Written Test

Course Objectives

Upon successful completion of this course, you shall be able to:

1. Identify personal safety issues involving structural collapse incidents.
2. Demonstrate knowledge of applicable regulations and standards.
3. Demonstrate knowledge of collapse causes & warning signs.
4. Understand the use and need of hazard evaluations & marking systems.
5. Understand the need for incident Size – Up and identify the necessary components.
6. Identify the various types of voids commonly found in structural collapse incidents.
7. Demonstrate a basic knowledge of basic shoring concepts.
8. Demonstrate a basic knowledge of building construction as it relates to structural collapse.
9. Understand the need for team operations and proper composition of a team.
10. Shall pass a written examination with a minimum score of 70%.

Basic Structural Collapse Operations

Lesson 1.3 : Introduction to Structure Collapse

Introduction to Structure Collapse

Introduction

The purpose of this course is to provide the student with a basic understanding of the key elements in any response to structural collapse incidents. The theme of Urban Search and Rescue is to save trapped victims while minimizing the risk to the victim as well as the urban search and rescue forces.

As with response to any incident, there are some key considerations we must keep foremost in our minds.

- Survival Rates in Structure Collapse Incidents - The faster we respond the better the survival rate. Figures are affected by how people are trapped, such as are they crushed or trapped in a void.
  - 30 MINUTES 99.3 %
  - 1 DAY 81 %
  - 2 DAY 36.7 %
  - 3 DAY 33.7 %
  - 4 DAY 19 %
  - 5 DAY 7.4 %

- Causation of collapse - was this the result of weather, impact load, natural causes such as deterioration or a terrorist act

Notes

Basic Structural Collapse Operations

Lesson 1.4 : Safety at Structural Collapse Operations

Safety at Structural Collapse Incidents

As emergency responders we take risks on a regular basis and it is easy to see how accidents happen. As is often the case, emergency scenes can be confusing and available resources taxed to the point where people are forced to do jobs with a minimum of personnel and equipment. Common sense often tells us when something is not safe, but a lack of training and incident confusion often leads to safety rules being broken.

Because of this, safety is everyone's job. The purpose of this section is to review both personal and scene safety and how each individual is responsible for safety.

Personnel Safety

Teamwork is critical. Rescuers should always work in teams of a minimum of 2 people. NYS USAR Rescue teams are comprised of 6 people which can be modified to meet different needs. This helps reduce "freelancing". You should always look out for your teammates - know where they are. Keep an eye out in all directions - up, down & sides and immediately stop unsafe operations.

At a collapse incident, often there will be numerous "untrained" personnel already operating within the collapse site, many times without the knowledge of or under the direction of the incident commander. These could include construction workers, other responders (Police, EMS & Fire) as well as civilians. You should always work in assigned teams under an established IC system with no use of unauthorized workers.

Personnel Accountability

Use of an accountability system is critical in the typical confusion surrounding a structural collapse incident. An accountability officer is assigned and will track rescuers using one or more of a variety of methods including: tags, list, electronic systems etc. The purpose of an accountability system is to keep track of individuals for organizational and safety reasons. As such, rescuers work with an assigned group in an assigned area and perform assigned functions.

Identification of Unsafe Areas

Identification of unsafe areas is key to a successful and injury free operation. When an unsafe area is found, notify everyone working in the area as well as operation supervisors. The entrance should be blocked and the area montiored from a safe area.

Safety Officer

The Safety Officer is responsible for: safe operations including the safety of firefighters and assigned rescue workers. Anyone can stop a potentialy dangerous operation but only the Safety Officer restarts it.

Personal Protective Equipment

Personal protective equipment includes:

- Rated helmet
- Gloves
- Eye protection
- Ear protection
- Safety boots
- Resiratory protection such as SCBA or particle masks
- Flash resistant clothing

General Scene Safety

General scene safety is everyones concern and includes a wide variety of hazard types. Responders should adhere to the following general rules:

- Control Utilities: Electric, Gas, , Water & Electrical
  - Eliminate shock or electrocution hazards and beware of alternate electrical systems; batteries, generators, windmills etc.
- Maintain proper monitoring: Use intrinsically safe equipment
- Water hazards: flooded areas need to be searched. Other coniderations include:
  - undermining of structure foundations and bearing walls
  - Careful of ice in cold weather
  - Have maps, specialists (such as utility companies) and specialized equipment readily available
- Observe Collapse Safety Zone:
  - Height of Building plus One Third. Take special consideration of high rise and odd shaped buildings or structures.

Rescue Shoring

The selection and placement of appropriate shoring provides safety from secondary collapse. To do this, you need a properly trained shoring team, equipment and materials. Additionally, structural engineers are frequently used to ensure the systems being constructed will adequately hold the load. Blueprints or building footprints

Prevent Vibrations

Bacause of the weakened nature of collapsed structures, vibration from outside sources can and do cause secondary collapses. Every effort must be made to eliminate these sources. Examples include:

- Traffic - Shut down local traffic and reroute away from the scene. Make sure you leave open an in/out route for emergency vehicles & specialized equipment. Consider a shuttle for Rescue Personnel. Remote staging improves scene security and accountability.

- Public Transportation - Shut down trains, subways, busses etc.
- Construction Projects – This is a common source of vibrations and includes the use of heavy machinery for the rescue effort.
- Industrial & Commercial Operations – Machinery may cause vibrations that radiate a distance.

Lighting

This is a critical resource needed for rescue operations. It allows for extended operations at night but you will still need portable & hand held lights for void search & interior operations. It should be set up before you need it so there is no delay or compromised safety.

Monitor Movement of The Structure

This is typically accomplished with the use of a transit or theodolite. It is set up remote from the site with a good vantage point of the structure. If at all possible, more than one is used to monitor several building locations at one time. Each transit is manned constantly and supplied with a horn & radio and the person manning them stops the operations immediately on detection of movement. Additionally, constant monitoring of cracks in the structure will give indications of building movement.

Atmospheric Monitoring

Atmospheric monitoring should be continuous to check for levels of oxygen, carbon monoxide, flammable gasses, as well as other hazards such as dust and asbestos. If possible, additional testing should be done for any other suspected (or even unsuspected) hazards.

NOTES

Basic Structural Collapse Operations

Lesson 1.5 : Regulations & Standards

Regulations and Standards

NFPA 1670 – Operations and Training for Technical Rescue Incidents

This national consensus standard is designed to assist organizations in developing a technical rescue capability in their community. It is commonly referred to as an "organizational standard" because the organization as a whole (as compared to individual members) must comply with the requirements of the standard.

Designed as a core + (plus) standard, the core requirements have provisions for all specialties including: medical care, hazard analysis & risk assessment, incident response planning, equipment, safety, Safety Officer, incident management system and fitness.

Specialty specific requirements are also included for: structural collapse, rope rescue, confined space, vehicle & machinery, water, dive, ice, surf, swift water, wilderness search & rescue and trench & excavation. Each one of these specialties includes 3 response levels: Awareness, Operations and Technician.

All members of any type of emergency response organizations (EMS, Police, Fire) should have at least the awareness level of training. Fire departments that respond to emergencies should be trained at least to the Operational level.

In structural collapse incidents, these response levels are broken down as such:

- Awareness level – includes: Size-up, site control, scene management, hazard identification and basic search & removal of readily accessible victims.
- Operations level – includes: Rescue from light frame, ordinary, unreinforced and reinforced masonry construction.
- Technician level – includes rescue from: Concrete tilt-up, reinforced concrete and steel construction.

NFPA 1006 – Rescue Technician Professional Qualifications

The purpose of this national consensus standard is to specify minimum job performance requirements for service as a rescuer in an emergency response agency. Commonly referred to as an "individual standard", this standard requires both knowledge and skills be demonstrated in various subject areas to become certified as a "Rescue Technician" in a given specialty.

Also designed as a core + (plus) standard, the course, Rescue Technician – Basic, with the addition to basic EMS training, is designed to meet the core requirements of this standard.

Core requirements for all specialties include: site operations (resource management, action planning, incident management system, search, helicopter ops and record keeping), victim management (victim access, stabilization, triage, packaging, moving and transfer) and ropes & rigging (low-angle rope rescue).

Specialty specific requirements are also included for: rope rescue, surface water, vehicle & machinery, confined space, structural collapse and trench & excavation.

New York State Response System

The NY State advisory system was established in 1995 and is designed to help coordinate rescue capabilities. It closely mirrors NFPA 1670 and is divided into 3 operational levels. They are:

- Basic Operational Level - Designed for minimal capability. It includes surface search at building collapse, basic rope and confined space rescue and awareness level in trench and other rescue areas

- Medium Operational Level – Includes: rescue from light frame (wood & steel) construction, reinforced & unreinforced masonry, concrete tilt-up & heavy timber construction and also provides for basic trench & high angle rope rescue cabilities.

- Heavy Operational Level – Includes: rescue from reinforced concrete or steel frame construction as well as advanced rope, trench & confined space rescue. The medium and heavy level staffing chart is based on US&R staffing.

US&R System

US&R teams respond with a capability roughly equivilant to the NYS heavy level with the major difference being some additional equipment (including medical & self-sufficiency supplies). This is primarily because they are designed to be unsupported for 72 hours.

Basic Structural Collapse Operations

Lesson 1.6 : Hazard Evaluation

Hazard Evaluation & Size-Up

Introduction

Understanding the causes of collapse and the warning signs will provide a wealth of information to be considered during the incident size-up. Without this information, it is virtually impossible to develop an operational plan that adequately safeguards the responders. Additionally, this unit will discuss the universal building marking system which plays a role during size-up as well as helping determine to operational status & needs.

Causes of Collapse & Warning Signs

Causes of collapse include:

- Explosions
  - Accidental causes include: Natural Gas, industrial dust, clandestine drug labs, explosive storage, flammable liquids/gasoline tankers, malfunctioning utilities
  - Intentional causes include: demolition (controlled), mining (below grade), road construction (blasting) and Terrorism
- Overloading of Structural Components
  - Primarily occurs with roofs and floors. Examples include: water (clogged drains, pooled water), snow (uniform or concentrated), building materials (roofing, lumber, security etc), HVAC equipment & water tanks, any additional material exceeding floor load capacity (i.e. product, equipment etc.) and change in occupancy.
- Structural Fatigue
  - Considerations include: age of structure, quality of materials & workmanship, maintenance of the structure, occupied or vacant, weather exposure (water, wind, hot & cold), breakdown of mortar, rotting of structural members, expansion and contraction, undermining of foundation, insect infestation, improper or non-engineered alteration (primary responses for collapse emergencies), removal of structural components, change in occupancy and type of occupancy.
- Natural Disasters
  - Includes: earthquake, building & bridge collapse, flooding, undermining & floating of structure, mudslides, hurricane, tornado and wind storm.
- Collision Impact
  - Includes impact from: vehicles, aircraft, train, debris/materials (storm or explosion), construction equipment etc.
  - Can cause disruption in placement of structural components and thereby cause collapse. Remember that the causal factor (vehicle etc.) may now be a supporting component of the building.
- Security Measures
  - This factor is primarily found in urban/remote industrial areas. Typically, additional weight (i.e. steel sheeting on roof) is a primary reason. Additional considerations include: roll down gates covering large openings as well as grates, bars, sheeting etc. causing access problems.

- Collapse by Fire
    - Flashover needing heat and backdraft needing oxygen could both result in explosive force resulting in structural damage or collapse. You need a rapid determination if the fire is confined to contents or has extended to structural members. These are predictable scenarios and must be addressed early in ops.
    - Prolonged burning indicates that it is likely the fire has spread to structural members and collapse is possible.
    - Additional considerations include: repeated fire, lack of water runoff, unprotected steel and lightweight construction.

Collapse Warning Signs

Collapse warning signs include:

- Bulging walls
- Cracks in walls, columns or foundation
- Unusual sounds
- Sliding plaster & dust
- Vibrations
- Sagging floors or roof
- Separating walls
- Columns or walls out of plumb
- Swinging doors
- Doors or windows out of rack / stuck
- Missing / broken structural elements

Monitor the structure continuously and investigate thoroughly any warning signs. You should always proceed with caution and bring in competent assistance (such as engineers or other specialists). Be careful of shifting loads and debris. Remember that partition walls may now be bearing walls and jammed doors could be supporting a load. These should be shored before being opened or removed.

Size-Up

When sizing up a structural collapse incident, the following factors should be taken into consideration:

- Building condition including:
    - Is it an old or new building
    - Alterations
    - Construction Type
    - Collapse extent - localized or extensive
    - Potential for a secondary collapse.
- Surface victims
    - Remove victims that are readily removable.
    - Ascertain from them whereabouts of other victims.
    - Survey area for other victims and exposure damage.

- Number of victims - needs to be assessed early in operation
- Mutual Aid / Outside assistance
  - When in doubt call them out! You can always send them home. Should be pre-planned.
  - Includes: specialized rescue teams, other FD's, local contractors and engineers.

Using "FAST VOIDS"

Fast Voids is an acronym for items that should be addressed before entering any void in a building collapse – a "check list" of procedures. It stands for:

Fire Suppression
Additional collapse potential
Structure type & condition
Trapped victim rescue

Void Types & location
Occupancy type / hazards
Immediate utilities shutdown
Day or Night
Situation - Cause of collapse

- Fire Suppression - Small fires can become big fires in a very short time. Remember, smoke kills!
- Additional collapse potential - Is building or its components moving? What about loose / hanging debris.
- Structure type & condition – Is it old, new, maintained, under construction or demolition?
- Trapped victim rescue – Regarding the trapped victim: is it confirmed / unconfirmed? Are they crushed, impaled, pinned, dead or alive?
- Void Types & location – You need to size-up the location and number
- Occupancy type / hazards – Examples include a private dwelling vs. commercial, nursing home etc.
- Immediate utilities shutdown - Who should handle this?
- Day or Night – This may dictate occupancy.
- Situation - Cause of collapse – an example was it a gas explosion or a terrorist attack.

US&R Marking System

The US&R marking system was developed for use by response teams for hazard evaluation & search marking. The building hazard evaluation system (Figure 1-1) is used to indicate the condition of the structure and identify safe ingress/egress routes. The search marking system (Figure 1-4) is used to indicate victim search areas and results. The site plan (Building Marking System) is US&R's System for section a building. Natural barriers are between quadrants (Fig. 1-5)

Figure 1-1

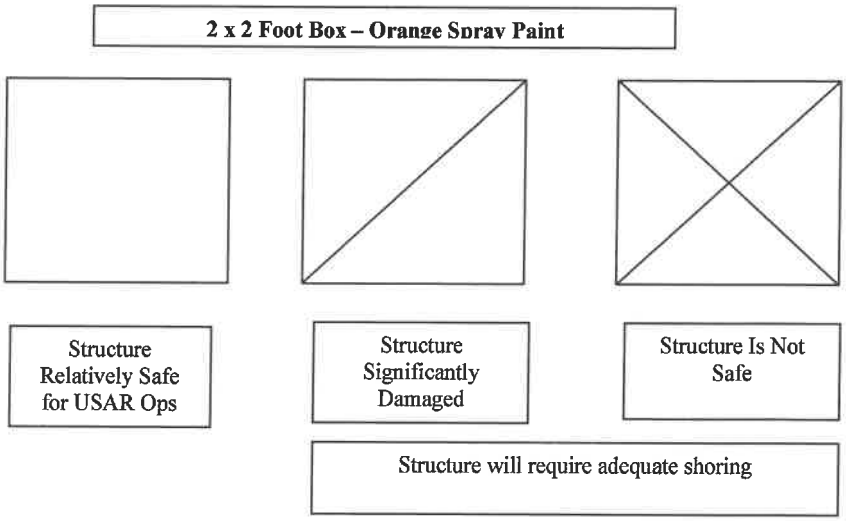


Figure 1-2

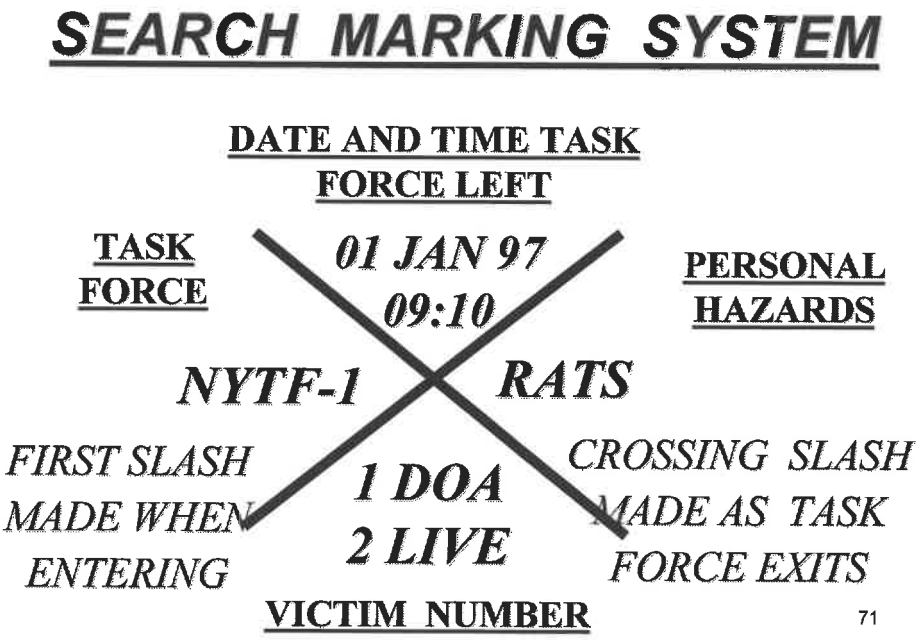


Figure 1-3

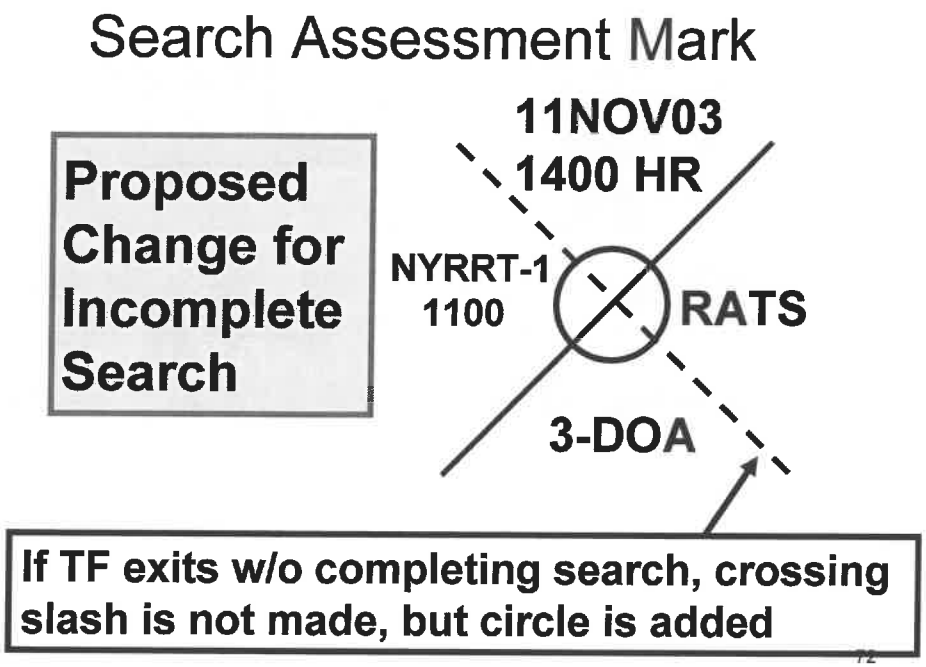

Search Assessment Mark
Proposed Change for Incomplete Search
11NOV03
1400 HR
NYRRT-1
1100
RATS
3-DOA
If TF exits w/o completing search, crossing slash is not made, but circle is added
72

Figure 1-4

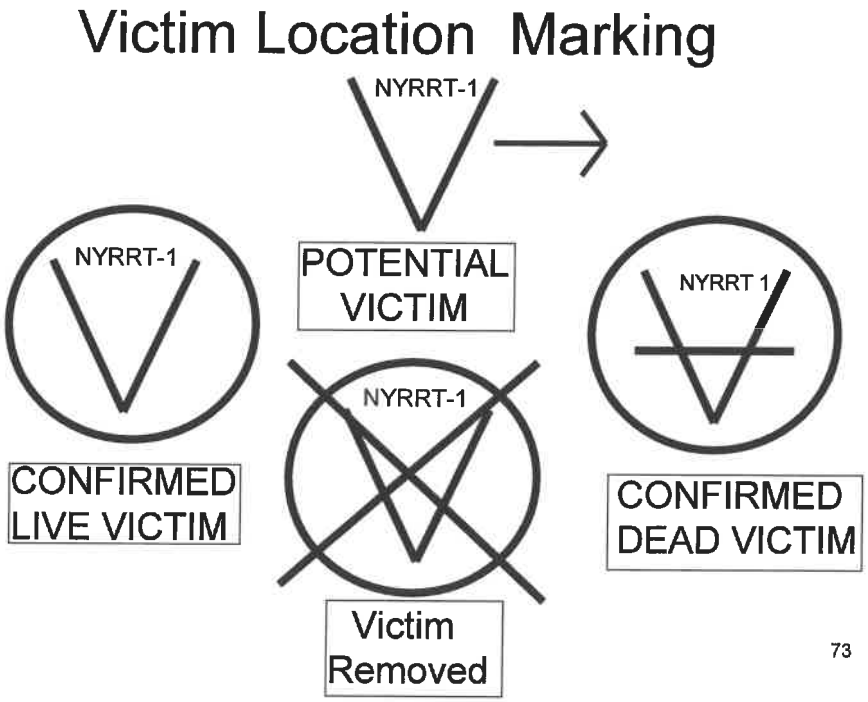
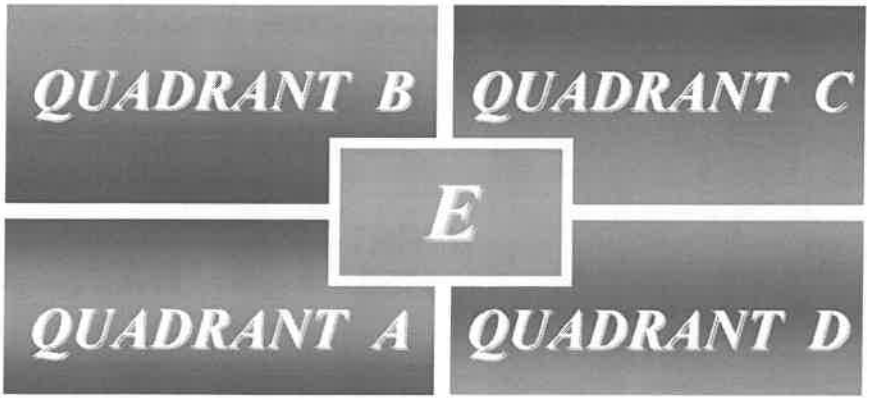

Victim Location Marking
NYRRT-1
POTENTIAL VICTIM
NYRRT-1
CONFIRMED LIVE VICTIM
NYRRT-1
Victim Removed
NYRRT 1
CONFIRMED DEAD VICTIM
73

Figure 1-5



Notes

Basic Structural Collapse Operations

Lesson 1.7 : Void Identification

Void Identification

Introduction

Understanding the types of collapse patterns will provide valuable information in determining everything from the need for shoring, the types of shoring to be used, possible victim location, and victim access to the probability of victim survivability. It is not unusual to have more than one collapse type in addition to the primary type at a given incident.

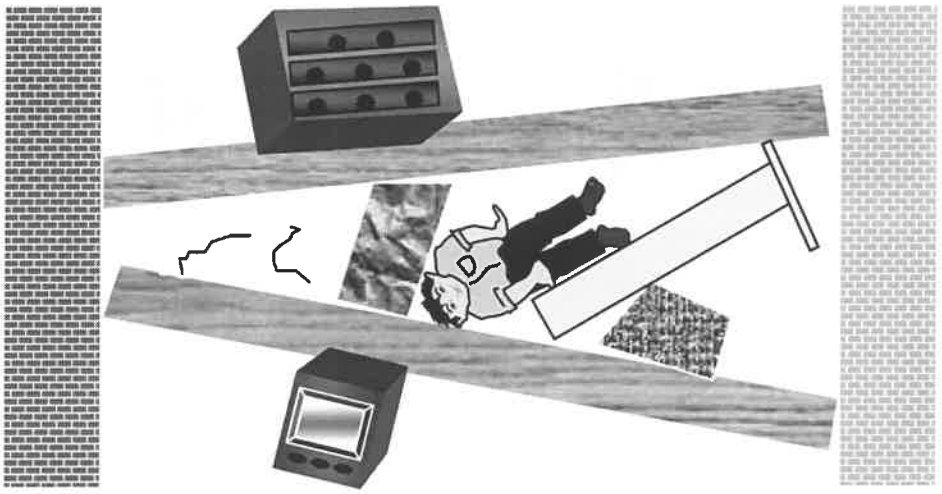
Collapse Types

- Pancake Collapse (Figure 1-6)

This type of collapse is formed when floors let go from bearing walls and stack up on top of each other. The floor drops for some reason and the impact loads the next floor bringing that one down. It may stop at the first floor because that floor possibly having additional foundation support which holds up the weight of the collapse debris.

Amount and weight of debris on the floors (i.e. strength and size of the material on the floors i.e. furniture, machinery, appliances) dictates where and how many voids there are. Typically, access is through natural openings such as a roof hatch, stairs or an elevator shaft. Access can also be made by breaching through the floors or walls.

Figure 1-6



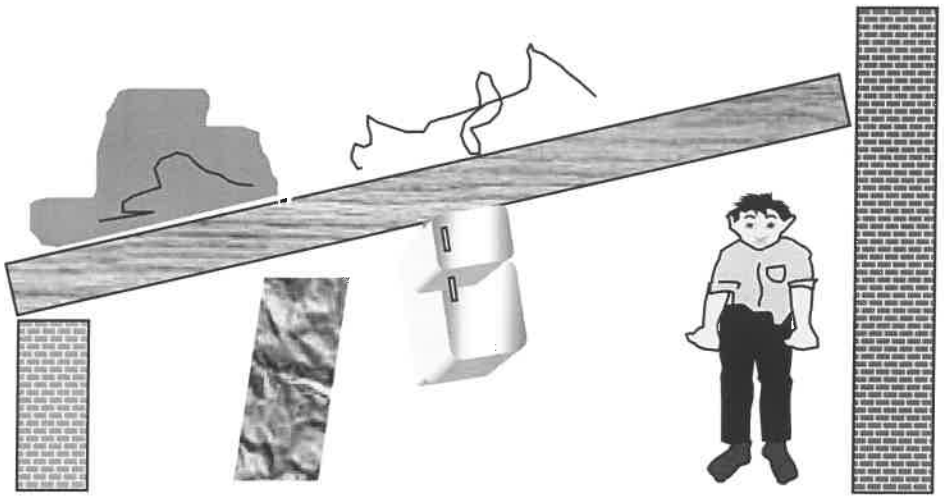
➢ Supported Lean-To Collapse (Figure 1-7)

This type of collapse is formed by the failure of a bearing wall or floor. The beams pull away from their supports on one side of the structure and other side may stay anchored. This type of failure may be caused by foundation failure, rotten beams, fire, vibrations, fatigue or overloading.

People may be found on top of the floor near the bottom by the wall where debris has slid to. It is normally easier to access this type of void and there may be times when minimal or no shoring is required for searching. Be careful when moving debris because once we move or shift without shoring we could have problems.

Question witnesses on what was in the room with the victim so we know what we would be looking for in the voids (i.e. red carpet, blue bed). Access can also be made by breaching through the floors or wall.

Figure 1-7

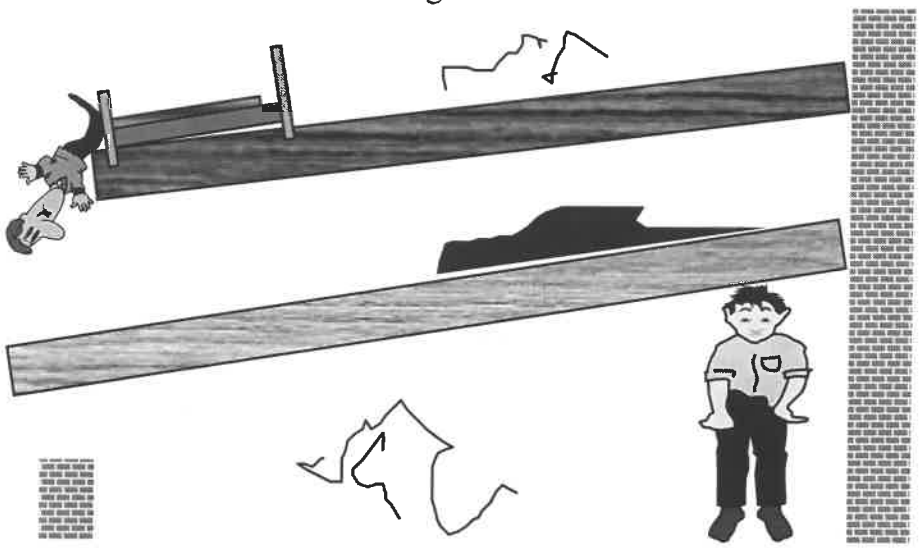


- Cantilever Collapse (Unsupported Lean-To) (Figure 1-8)

This type of collapse is formed by the failure of a bearing wall. The beams pull away from their supports on one side of the structure and the other side stays anchored while the floor stays suspended, leaving the failed ends hang precariously. This type of collapse is the most unstable and dangerous. With no solid support, it could be hanging on electric cable or pipes. The slightest additional impact could cause secondary collapses. This type of failure may be caused by foundation failure, rotten beams, fire, vibrations, fatigue or overloading.

Victims can be found near walls, above or below a floor, under a lean-to or hung up on objects. Secure and shore unsupported floor first before searching. Shore from the bottom up and keep responders to a minimum.

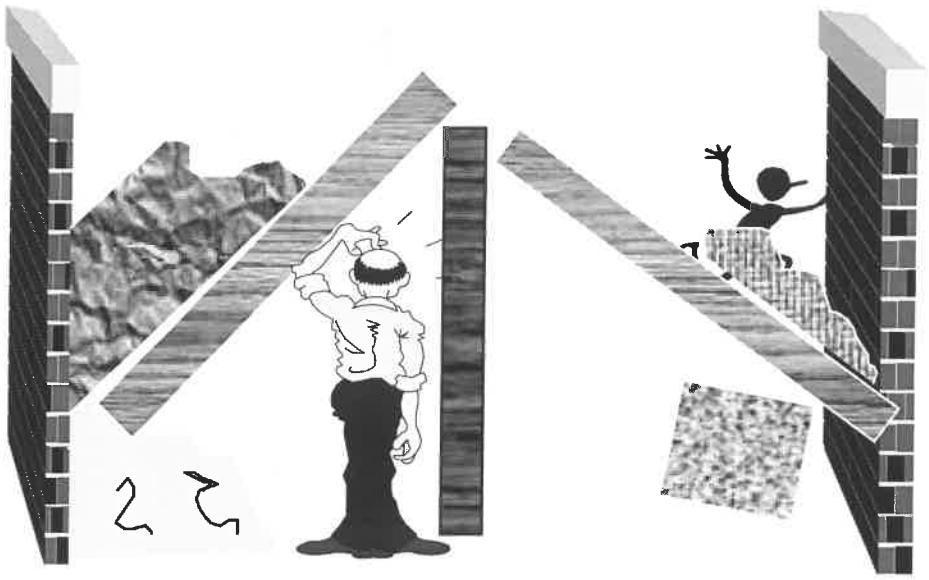
Figure 1-8



- A - Frame Collapse (Figure 1-9)

This type of collapse is the opposite of a V collapse. The flooring separates from exterior bearing walls but is still supported by interior bearing or non bearing walls. This type of failure may be caused by earthquakes, foundations failure, excavation of adjoining area and flooding. The highest survival rate for victims is for those found near a partition in the center of the collapse. If the victim is on the floor that collapses, they could be pinned near exterior walls and have a lower survival rate.

Figure 1-9

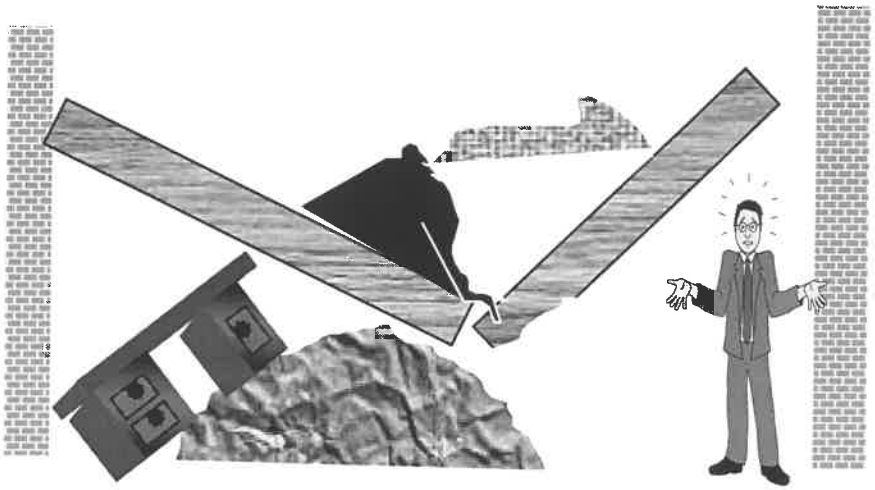


- "V" Collapse (Figure 1-10)

This type of collapse is the opposite of an A frame collapse. The bearing partition fails and the floor breaks in center and hinges. This type of failure may be caused by overloaded floors, heavy machinery vibrations, beam failure, water damage or column failure.

This type of collapse can be localized with voids created on both sides of load failure. Occupants below generally have a better survival rate sheltered by the floor. Occupants on top of the collapsed floor typically found near the center of the V with a low survival rate due to the concentration of heavy debris.

Figure 1-10



Notes

Basic Structural Collapse Concepts
Unit 1.8 : Structural Shoring Concepts

Structural Shoring Concepts

Introduction

The use of rescue shoring has been in use for many years. The purpose of this lesson is to give the student a basic understanding of the typical shoring systems used while understanding their limitations.

Principals of Rescue Shoring

Rescue Shoring is defined as the temporary support of a partially collapsed structure for the search and rescue of trapped victims. This may be a temporary support but we don't remove it without other shoring in place (we don't just pull out our Paratech struts at the end of the operation without replacing it with wood).

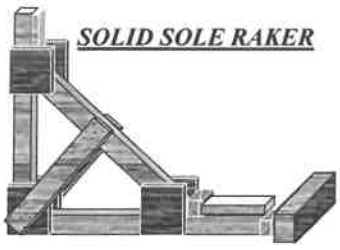
Shoring is performed in order to reduce the risk of potential secondary collapse to give victims and rescuers some degree of safety during rescue operations. If no one is trapped in the collapse, we should not get involved.

Exterior raker shores are erected in emergency situations primarily to stabilize and re-support existing bearing or nonbearing exterior walls. These walls may be cracked, damaged, leaning, bulged, or in some way not properly supporting their loads. In general, the solid sole raker is utilized in urban environments where concrete and asphalt commonly cover the ground. This raker can also be used on soil conditions.

- Solid sole raker (Figure 1-11)

The solid sole raker is a fixed rake shore meaning the shore itself is stable and will be able to stand up to unexpected forces applied to it whether they are from a secondary collapse or vibrations from earthquake - related after shocks. This style of shoring is recommended for rescue situations because of its ability to stay together after additional unexpected stresses are applied to it. The shores extra strength and stability add an additional degree of safety to rescue operations, hopefully preventing any unforeseen problems.

Figure 1-11



- Split sole raker (Figure 1-12)

Also a fixed shore and is generally used in suburban areas where open or uneven ground is prevalent.

Figure 1-12

SPLIT SOLE RAKER

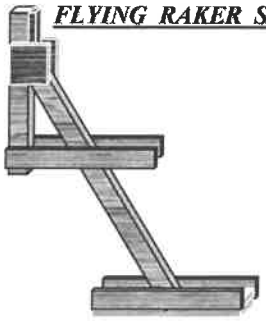
- Flying raker shore (Figure 1-13)

This is a friction raker shore whose stability relies on the compression force applied to the rake itself. The raker generally is installed against the object or wall to be supported and then wedged tightly into position. The only way this type of raker usually can stay in position is by being kept under constant compression.

In a rescue situation where fire department personnel will be operating, this style of raker generally is not recommended. If any movement, shifting or secondary collapse occurs, this type of raker may loosen, slip or fail entirely, placing the rescuers in jeopardy.

Figure 1-13

FLYING RAKER SHORE



➢ The Vertical Shore or Dead Shore (Figure 1-14-16)

The main purpose of this vertical shore is to stabilize damaged floors, ceilings or roofs. It can also be used to replace missing or unstable bearing walls or columns. This is one of the most commonly used shores.

Figure 1-14

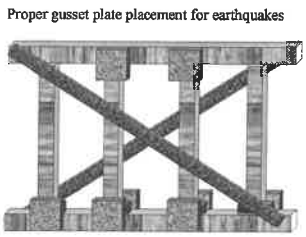


Figure 1-15

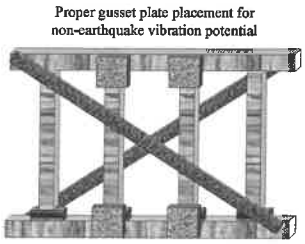
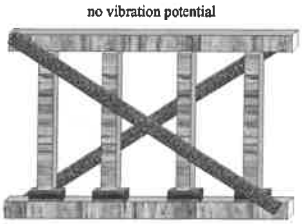


Figure 1-16

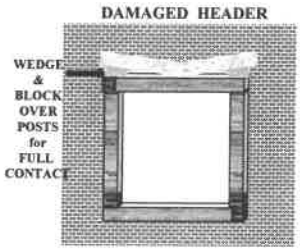


➢ Window and Door Shore (Figure 1-17-18)

The main purpose of the window and door shore is to stabilize a window, doorway or other access way. An extensive collapse can generate a tremendous amount of debris blocking the primary entrances into a building and sometimes requires a window entry.

Figure 1-17

Figure 1-18



➢ Horizontal Shore (Figure 1-19 and 1-20)

The main purpose of the horizontal shore is to stabilize a damaged wall against an undamaged wall in hallways, corridors, or between buildings.

Figure 1-19

HORIZONTAL SHORE

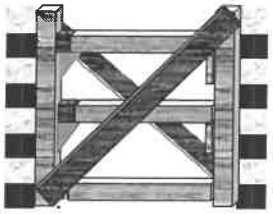
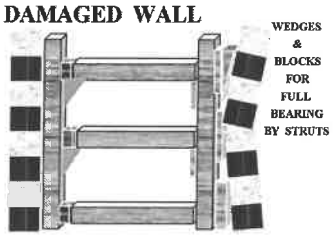


Figure 1-20

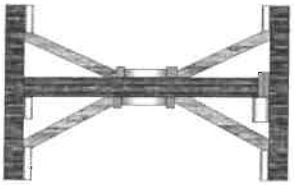


➢ Flying shore (Figure 1-21)

This shore serves the same purpose as the Horizontal Shore however it is used to span a greater distance. Rakers are added to the struts to increase their strength.

Figure 1-21

FLYING SHORE



- T Shore (Figure 1-22)

This is a one column vertical shore. It can be used as a temporary support and should be replaced as soon as conditions allow. It is used as an initial safety shore and its stability is marginal at best. Box cribbing or a vertical shore would be better.

Figure 1-22

T SHORE

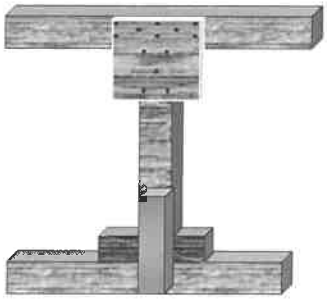


Figure 1-23

Double T shore

Building Construction

Lesson 2.1: Building Construction

Building Construction

Introduction

A basic understanding of building construction is critical not only in structural collapse but also in firefighting. Understanding the dynamic stresses involved in structural collapse will not only assist us at an incident scene but may also help identify the most likely candidates for collapse.

Construction Types

- Wood Frame - exterior walls and interior structural members are entirely of wood.
- Ordinary - exterior walls are non-combustible. All or part of the interior structural members is combustible. Also referred to as URM (unreenforced massonary) or brick & joist construction.
- Heavy Timber - exterior walls of brick or stone. Interior structural members of large dimension , 8" or larger.
- Non-combustible - interior and exterior structural elements are non-combustible. Limited amounts of combustible material may be used if fire resistive covering is applied to them.
- Fire Resistive – constructed of steel or concrete and protected with fire resistive material.

Load Transference

All members are interconnected from the floor we walk on to the foundation and the ground. One supports the other. If we don't transmit the load down through the foundation and the ground we will have failure.

Beams

Beams transfer vertical loads horizontally to points of support foundations, columns, girders, etc. There are several different types of beams and they are classified by the way they are supported, how many supports and the spans that are involved. Beams are further classified by the way the ends are supported. They can either be fixed or they can be propped.

States of Stress

Stress is the load being placed on a member which results in a deflection. The three states of stress are:

- Compression - whenever we apply a downward load on a beam or girder, that member reacts with an upward force and that member would be said to be in compression. When something gets compressed (shortens) (concrete is good in compression) the member shortens.

- Tension - the state of stress that acts when the member is being pulled apart (elongates). When something is in tension, it gets bigger. Concrete is poor in tension so we add rebar to give concrete strength.

- Shear - the state of stress that deals with one part of the building trying to resist the force of the other part slipping past. An example of this would be a hi-rise building and the wind

Loads on Structures

Application of loads

Loads may be applied differently to a structure. Two types of loads are concentrated or distributed. A concentrated load may cause excessive stress to structural members and result in failure. A distributed load will allow the structure to support it uniformly. These loads may be in the form of snow, rain, dead load, impact load, etc. A beam will support twice the distributed load as opposed to a concentrated load. A member (beam) can take 1/2 the concentrated load as opposed to a distributed load.

Types of Loads

- Dead Loads - Are non moving, permanent parts of the structure. A bank vault is an example.
- Live Load - Are non stationary items such as, the movement of people and furnishings. All structures experience live loads.

- Dynamic Load - Heavy mechanical equipment that moves people, elevators or escalators, large industrial machiner or, forklifts. Office buildings, parking garages and industrial buildings have significant dynamic loads.
- Impact Load – a sudden shock to the structure, from heavy equipment operating in the area and colliding, other structures collapsing on or into or aircraft collisions.

- Wind Load - This is a form of stress on structure Adverse weather will substantially increase this load. Wind load is figured into the engineering of the building.

- Thermal Load - changes in structure occur as a result of expansion and contraction. This sometimes results in damage to the structure. Cracks in wall, facing masonry, etc.

- Static Load – The upper floors of a warehouse would experience a change in static load as stock is moved. This load is moved slowly.

Common Building Construction Hazards

Hazards – Includes:

- Loose HVAC equipment. We must get to the roof to check for weight load and hazards. Things might be hanging or not properly supported ready to fall and injure.
- AC and gas heaters etc.
- Cripple wall failure. Cripple wall is any short wall built to take some of the weight of a building on uneven ground or flat ground - i.e. a knee wall

Utilities

- Shutting down utilities is critical. Gas (explosion-pooling), water (weight, drowning), electric is often over looked.

Masonry failure – Includes:

- House sliding off foundation. You don't necessarily need the force of a hurricane. Just high winds, rain, snow, flooding - adverse weather.
- Separating roofs and second floor
- Racking or separating of walls

Trusses

Trusses are used so as to have a large clear span, thus minimizing the need for vertical supports. Gangs nails are pressed in connectors and some are defective already. If any part of the truss fails, it could cause the entire truss to fail. Used mainly for roofs and floors, they are pre-made. They are low cost and save time.

Truss Types

- Bowstring – It is critical that you identify these immediately. They have the same characteristics as arch heavy timber. If you loose one member you could have a catastrophic failure. These are found in bowling alleys, supermarkets, roller rinks and warehouses. It is a very common practice to have stock piled inside the trusses.

- Parallel Cord - Common in modern strip malls and arenas, they provide for flat roofs & floor beams. The only thing separating the truss from the fire load might be acoustical tiles - the fire load impinging on the truss could be great. Never lift or put weight on the bottom chord - collapse potential.

- Peaked roof - this shape truss is very common. It is very hard to tell from the outside - you physically have to see the arrangement of lumber in the attic. Common in office buildings & houses, this arrangement is used so the layout can be changed often at very low cost. You might see walls that you think are bearing but they are actually partition walls.

Notes

Building Construction

Unit 2.2: Team Operations

Team Operations

Introduction

A technical rescue operation will run more effectively and safely when an Incident Command System (ICS) is utilized. By employing an incident command system to organize all rescue incidents, rescuers will gain the necessary confidence to organize even the most complex technical rescue incidents.

In this lesson we demonstrate ways in which the familiar model ICS plans used to organize fire operations can be modified to manage a structure collapse rescue incident. The techniques discussed in this lesson will be continually reinforced during the practical applications of this and advanced courses. We will also be discussing collapse specific operational concepts and guidelines which must be considered while establishing the incident command system.

Overview of Collapse Operations

Five Phases of Rescue:

- Spontaneous rescues - victims are not pinned or trapped. Include the walking wounded - these rescues are made first.
- Light in-place rescues - victims not pinned that bad. A quick air bag lift or cut to free someone impaled. Typically involves patient packaging.
- Heavy careful removal – involves victims who are trapped or pinned in debris. Possible crush syndrome is setting in and shoring, wall breaching and/or heavy lifting may have to be done. This rescue is going to take some time.
- Body recovery - usually when you switch to this mode we stop the operation and regroup. You are no longer saving a life so rescue personnel should not take unnecessary risks.
- Demolition - the building or structure is taken down usually with heavy equipment, crane, bulldozer or front end loader. Debris is spread out in the street for a final search. After that, it is put in a dump truck or dump body tractor trailer and hauled away.

Five Stages of Collapse Operations

- Reconnaissance and site survey
- Surface Victim Removal
- Void space exploration and removal of victims
- Selected debris removal and shoring operations
- General debris removal (supervised)

Incident Command Overview

A rescue scene can be one of confusion if a command system is not established early in the incident. The command system must be versatile, adaptable to any type or size of emergency or incident, relatively familiar if it is going to be useable throughout the state and be expandable in a logical manner if changing conditions dictate. The majority of technical rescue operations will be most efficiently managed with a pared down version of the full blown ICS model. It will be the rare technical rescue incident that will require filling positions such as Planning, Logistics, Finance, etc.

Span of Control

The ICS allows for a manageable span of control of people and resources. Utilizing an ICS takes much of the pressure off of the Incident Commander. The **maximum** span of control is 7 (seven) persons while the **recommended** effective span of control of 5 to 1 allows for the most effective management. The system is set up so that the IC is only **communicating to** and **receiving information from** a maximum of five people, rather than the whole assignment of personnel at the scene. Individual managers of personnel and resources within ICS are also working within a manageable span of control.

ICS Positions for the Typical Rescue Scenario

The **Incident Commander** (IC) or "command" is the individual responsible for the management of all incident operations. The IC does not need to be well versed in technical rescue, however he/she should be well versed in the ICS. The IC should be stationed at a command post outside the collapse zone. On large, complex, and or protracted incidents, the **I.C**. may delegate functional responsibilities by appointing an:

Operations Officer (Operations)

Planning Officer (Planning)

Logistics Officer (Logistics)

Finance Officer (Finance)

The IC also communicates directly with Command Staff:

Public Information Officer (PIO)

Safety Officer (Safety)

Liaison Officer (Liaison)

The **Operations Officer** is responsible for direction and coordination of all tactical operations. On modest sized rescue incidents, Operations may fulfill the functions of a Technical Rescue Officer (TRO). At large scale rescues, Operations may designate a TRO. Operations may also interface with the media and other appropriate agencies as necessary in the absence of the PIO and Liaison Officer.

The **Safety Officer** (SO) is responsible for enforcing general safety rules and developing measures for ensuring personnel safety. When manpower is limited the SO position may be combined with the TRO and/or Operations positions. The SO can bypass the chain of command when necessary to stop unsafe acts immediately.

The **Technical Rescue Officer** (TRO) or **"Rescue Team Leader"** is responsible for the rescue operation. This person is normally the most experienced rescue technician on the team and assumes the lead role in designing and setup of the necessary rescue systems. When the set-up is complete the TRO will check the entire system. The TRO is the liaison between the rescue site and the command post and designates "tactical" level positions in the ICS as needed.

Sample Initial Response

NOTE: The following segment is designed as a sample only. Locally available equipment and personnel will dictate actual capabilities. Missing resources should be considered in determining mutual aid requests and pre-plans.

- Chief Officer (IC)
  - Assumes command
  - Identifies collapse zone
  - Identifies staging area
  - Ensures utilities are made safe
  - Utilizes 6 sided approach to size-up - Top, Bottom, all 4 sides
  - Takes input from company officers
  - Divides structure (operationally) if necessary
  - Ensures ICS is utilized
  - Reviews 5 stages of collapse
  - Controls rescuers such as firefighters, police officers, civilians and other spontaneous rescuers

- Rescue Officer
  - Directs & oversees actual rescue operation
  - Establishes rescue sectors
  - Makes assessment and size-up
  - Reports to IC for inclusion in overall assessment and size-up
  - Establishes rescue staging area(s)
  - Constantly gathering information and providing progress reports.
  - Establishes stand by or backup plan for rescue operation
  - Communicates effectively up & down the chain of command.
  - Should use operational checklists.

- First Due Engine
  - Establishes initial water supply
  - Attacks the fire with first line

- Stretches a backup line if manpower permits
- Operate front to rear of building
- Do not place apperatus in front of building
- Leave space for the ladder (and Rescue)

➢ Second Due Engine

- Establishes secondary water supply
- Provide backup to first engine
- Assists first engine with front to rear suppression
- Checks exposures for extension and secondary collapse potential.

➢ Third Due Engine

- Responds to the rear of structure
- Establishes alternate water supply
- Stretches a line if necessary
- Looks for rescue access in rear
- Reports to command post for further assignment

➢ First Due Ladder

- Removes surface victims
- Does site survey – reports to IC
- Positions ladder for rescue effort & observation
- Identifies location & type of voids
- Identifies hazards & corrects them if possible
- Reports uncorrected problems to IC

➢ Second Due Ladder

- Shuts down utilities if possible
- Positions ladder for rescue effort & observation
- Begins void search
- Identifies hazards & corrects them if possible
- Reports uncorrected problems to IC
- Reports to command post for further assignment

➢ Heavy Rescue

- Establishes grid search to cover all areas of collapse
- Void search in established victim locations
- Performs shoring operations
- Performs victim removal
- Treatment and packaging according to local protocol.
- Additional teams can be formed by using rescue members as core.

Void Search Operations

A specially trained six-member void search team, consisting of one officer and five firefighters, generally works well. The team is divided into two sub teams, the search team and the support team.

Search Team

The primary function of the void search team is to search any existing natural voids (voids that already have been created by the collapse) instead of debris trenching and tunneling which is an extremely complicated, extensive and time consuming operation. These voids will be the fastest and easiest to explore and the majority of victims found alive will be trapped in them. The search team consists of the void team officer, the void entry firefighter and the shoring firefighter.

- Void team officer

The void team officer is in charge of the void team and their operations. He/she is responsible for safe void exploration operations and evaluates each step of the exploration and determines whether to continue or adjust the operation based on a wide variety of scene factors. Safety dictates that, in general, the officer takes a position that allows him/her to closely supervise the void entry team, usually at the void access point and be able to monitor actions of the support team.

The officer must be in constant communication with team members, particularly those operating in the void and provide status reports to the rescue officer or I.C. He/she gives out team assignments, direction of tactics and procedures and is responsible for coordination of victim assistance and removal as well as crew rotation and relief.

- Void entry firefighter

The void entry firefighter is the first to enter the collapse void area. The main objective is to locate existing voids, penetrate them and search them under the supervision of the team officer. This firefighter must be a knowledgeable and experienced firefighter who can operate in confined void spaces with minimal adverse effects. They are probably subject to the most danger during the void operation and must evaluate each action completely and methodically for safety and effectiveness. They determine what debris material can be removed and must make a determination if structural members have to be cut and removed for greater void penetration.

- Shoring firefighter

The shoring firefighter assists the void entry firefighter and is the second member to enter the collapse void. The primary function is to assist the void entry firefighter whenever necessary, whether it is by passing debris out of the hole, shoring structural members or

searching in tandem. They must always stay in visual and voice contact with the void entry firefighter and must stay in close physical proximity in case problems should arise. They must maintain constant communication with the void team officer must make sure that the egress for himself and the void entry firefighter remains open and that a secondary collapse does not occur. He/she also erects structural shoring members whenever necessary, with the assistance of the void entry firefighter and the void expander whenever necessary.

The Support Team

- Void Expander Firefighter

Initially positioned at the mouth of the void, this person should be a versatile firefighter with a varied range of experience because they are the member of the support team closest to the void entry team and may be called on to perform functions of both the entry and support teams. They will pass debris out of the void or pass tools and equipment in or out. Since he/she is positioned at the mouth of the void, he is in the best position to relay information from the officer to the void entry team and vice versa. He/she stays in direct contact with the entry team throughout the operation, widens the void when possible, assists the void entry team and becomes the void entry team relief.

- Support firefighter

This firefighter clears debris as it is passed out of the void entrance to an area of safety away from the operation. Usually, this debris is passed to other fire personnel who have formed a human chain to quickly and easily remove material out of the building. Once removed outside the collapse zone, the debris can be examined by legal authorities, if necessary, without interrupting the search and rescue operations. Larger pieces of debris such as wood and furnishings can be removed by hand. Smaller pieces of debris easily can be placed in buckets and then quickly and efficiently removed from the building.

The support firefighter requests and receives from the tools/equipment firefighter tools and equipment needed by the void entry team and makes sure that all tools are operational and set up properly before sending them into the void. He/she ensures that hoses and cables have enough slack to make the stretch into the void and do not become entangled. If necessary, he/she assists the void expander firefighter in enlarging the mouth of the void and shoring near the void entrance and may be utilized to relieve a member of the void entry team.

- Tools and equipment firefighter

This firefighter sets up the tool staging area, where all tools and equipment are sent into and received from the collapsed structure. The staging area should be set up as close to scene as is safe & practical. This person facilitates repairs when needed, tests equipment for proper operation before tool goes into collapse site, checks blades or bits (inc. extras) and maintains tool log including:

  - Who requested the tool
  - What time it was requested & delivered

- Who delivered and received
- Delivered to where
- Time returned
- Who returned & received

Collapse Search Tips

- General Considerations

  - "Round the Clock" call out for victims - rescuers call out for victim one at a time and listen for an answer. This helps zero in on victims we can't see trapped in debris.
  - Vertical access through floor - cutting through floors to get into voids.
  - Canine search potential - dogs can be an additional resource to find victims:
  - Avoid cutting walls - the wrong hole in the right wall can cause failure, extensive damage and further collapse.
  - Roof/floor beam support should not be cut and should be resupported when necessary.
  - Consider the basement for access - Shore from below the collapse.
  - If a complete collapse has occurred, shoring should be started at the lowest level.
  - Falling Hazards - something small dropped from high up can take out a rescuer or victim. Something very heavy dropped only a few inches can also cause significant injuries.

- Initial First Aid Considerations

  - Follow local protocols
  - Spinal immobilization
  - Administer oxygen
  - Use proper packaging techniques
  - Be conscious of the possibility of crush injury syndrome
  - Transportation

- Emergency signaling

Effective emergency signaling and evacuation procedures are essential for the safe operation of all personnel operating at a disaster site. The signal must be clear and must be universally understood by **ALL** involved in the rescue effort.

  - Air Horn Signaling System
    - Cease Operation / All Quiet - 1 Long Blast (3 seconds)
    - Evacuate the Area - 3 Short Blasts (1 Second Each)
    - Resume Operations - 1 Long & 1 Short Blast

NOTES

Introduction to Structural Collapse Operations / Building Construction

Lesson 2.3: Scenario

Basic Structural Collapse Operations

Scenario

The student, as a member of a team, shall:

- Given the information presented, develop answers to the stated questions and develop an appropriate response plan for the given scenario.

Procedure

- The class will be broken down into teams based on class size.
  - Optimum team size is 5-10.
  - Each group will be allowed at least 20 minutes to review the scenario and prepare their responses to the questions and tasks contained in the scenario.
  - Each group will appoint a member to present their findings to the class.
  - Either a chalkboard or easel shall be provided for each groups use.
- The instructor will review the scenario presented on the following page with the students.

Basic Structural Collapse Operations
Student Scenario Exercise Scenario #1

Scenario:
Monday 4:00 PM – Clear, No wind
FD arrives at building collapse in 3 story ordinary construction.
Music Store 1st floor, Apartments 2nd floor, Vacant 3rd Floor
6 occupants in music store (accounted for by owner @ arrival), unknown in apartments.
Excavation occurring in vacant lot adjacent to collapse.
Backhoe operator in lot next door accounted for.

Responsibility and Resources:
You are the responding agency responsible for fire suppression and US&R operations.
Initial assignment includes:

- 1 Chief
- 2 Engines
- 1 Ladder
- 1 Heavy Rescue

Your group is responsible for all operations at this incident.

Items to be covered:
ICS
Size Up
Hazard identification
Exposures
Fire Suppression
Victim search
Rescue
Void Search
Shoring
Any other considerations you identify

Introduction to Structural Collapse Operations / Building Construction

Lesson 2.4: Course Review

Basic Structural Collapse Operations

Lesson Objective:

- Review course material in preparation of written exam.

Introduction to Structural Collapse

- Theme of US&R
- Survival rates in structure collapse incidents
- Okalahoma City Bombing Overview

Safety

- Personal safety
- Teamwork
- Personal accountability
- Accountability system
- Safety Officer
- PPE
- Scene safety
- Utilities
- Collapse safety zone
- Rescue shoring
- Prevent vibrations
- Lighting
- Monitor movement of structure
- Monitor atmosphere
-

Regulations and Standards

- NFPA 1670
- Team standard
  - 3 levels
  - multiple disciplines

NYS Response System

- 3 operational levels
- Advisory system
- Multi-discipline
- US&R System
-

Hazard Evaluation & Size-Up

- Causes of collapse
- Collapse warning signs
- Size-up
- FAST VOIDS
- FEMA marking system

V. Void Identification

- 5 types of collapse.
- Common void types for each collapse type.
- Identifying and accessing voids in each type.

Structural Shoring Concepts

- Principals
- Definition
- Principals
- Considerations
- Types of structural shores
- Uses of various shores

Building Construction

- Construction types
- Structural Hierarchy

States of stress

Loads on structures

- Application of loads
- Types of loads

Light frame hazards

Team Operations

- 5 phases of rescue
- 5 stages of collapse rescue
- Incident Command System
- Initial response
- Initial response
- Void search operations
- Collapse search tips
- Initial first aid
- Emergency signaling

Basic Structural Collapse Operations
Student Scenario Exercise #2

Scenario:
Monday 10:00 AM – Clear, No wind

FD arrives at building collapse in 1 story residential structure
.
Contractor demolishing structure from the rear when laborer enters front of structure and becomes entrapped in collapsing debris.

Laborer is on the second floor 8 feet in from stairway. He is pinned from his waist down from roofing materials.
Contractor sees laborer waving a board and shuts down equipment, upon doing so he can smell natural gas leaking from the structure.

Responsibility and Resources:
You are the responding agency responsible for fire suppression and US&R operations.
Initial assignment includes:

- 1 Chief
- 2 Engines
- 1 Ladder
- 1 Heavy Rescue

Your group is responsible for all operations at this incident.

Items to be covered:
ICS
Size Up
Hazard identification
Exposures
Fire Suppression
Victim search
Rescue
Void Search
Shoring
Any other considerations you identify

Notes