









Structural Collapse Operations II




Course Objectives:

-  Describe the six sided survey
-  State the principle weakness of light frame and heavy URM structures
-  State 3 methods to monitor structural stability
-  State the two main objectives of a shoring system

Objectives Continued:

-  State three areas where shoring placement should be considered
-  Calculate the estimated weight of a given rubble pile
-  State the components of a shoring system
-  State greatest safety concern when performing lifting operations

Objectives Continued:

-  State the possible indicators of secondary collapse
-  State the duties of a given team assignment
-  Construct a horizontal shore, vertical shore, T-spot shore and raker shores

Six Sided Survey



SIDES OF STRUCTURE

-  Street or address side is side 1

Quadrants within Structure





-  Also use and **MARK** column grid

MULTI - STORY STRUCTURES







-  Ground Floor is 1, Second is 2, Third is 3, etc.
-  First Floor below grade is B-1, Second is B-2, etc.

Basic Building Types

Review

-  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 Frame – House





Racked House

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 Buildings

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 Wall - TU Buildings

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

Precast Concrete Building

May Co Garage






Badly damaged in Whittier 87 EQ

Simple Hazard Mitigation

-  Avoid
- 2 **Need effective barrier system**
-  Removal
- 4 **Lift off, push over, pull down**
-  Exposure reduction
- 6 **How long do we need to be in the area?**
- 7 **Risk is a function of severity and exposure**
- 8 **limit time exposed to hazard**
- 9 **limit number of personnel exposed**

Similar to Time, Distance, & Shielding Rule used in Hazmat

Other Hazard Mitigation

-  Vertical & Lateral Shoring
- 2 **system with slow failure mode**
-  Lateral Bracing
-  Vertical Tieback
- 5 **use crane to hang structure**
-  Monitor - with alarm & escape system
-  Recognize & Refer Hazard (hazmat)

Methods to Monitor STABILITY

Devices Previously Used in US&R

- ☞ Plumb bob
- ☞ Levels
- ☞ Engineers transit
- ☞ Electronic tilt meter & levels
- ☞ Crack measuring devices

Levels placed to monitor column rotation (buckling) between 2nd & 3rd floors

Use of Devices

- ☞ Plumb Bob hung from small structure to compare to a point on the ground - observe change in a leaning structure
 - 2 Use of Laser Pointer or Laser Level could be more accurate & effective
- ☞ Transit / theodolite to establish a vertical line that will compare a point on a dangerous building to a point on the ground to detect additional tilt / movement

Shoring

BASIC DEFINITION

SHORING for US&R is the TEMPORARY SUPPORT of ONLY THAT PART of a DAMAGED STRUCTURE that is REQUIRED for CONDUCTING OPERATIONS at REDUCED RISK

WE INSTALL RESCUE SHORING TO PROTECT “US”

SHORING SIZE-UP

- ☞ *identify structural hazards, damage and potential victim locations*
- ☞ *determine best method to mitigate the hazard and damage*
- ☞ *determine the type & placement of shoring systems in relation to structural hazards and potential victim location*

DOUBLE FUNNEL PRINCIPLE

- ☞ NEED POSTS / SHORES with ADJUSTABILITY & POSITIVE CONNS
- ☞ NEED LATERAL BRACING
- ☞ NEED SYSTEM with FORGIVENESS

The SHORING SQUAD SHORING TEAM

SHORING OFFICER

MEASURING FF

SHORING FF **CUTTING TEAM**




LAYOUT FF

CUTTING FF



TOOL & EQUIP FF

GENERAL RULES OF THUMB


NORMAL CAPACITY OF UNDAMAGED CONSTRUCTION

-  One undamaged wood framed floor will support one damaged wood floor
-  One undamaged steel framed floor will support one damaged steel floor
-  It takes two undamaged reinforced concrete floors to support one damaged concrete floor





NORMAL CAPACITY OF UNDAMAGED CONSTRUCTION

-  Useful info for shoring multi-story buildings.
 - 2 shoring should be placed under damaged beams, etc.
 - 3 multi-level shoring should align from story to story
-  The thickness of debris from heavy, exterior walls, etc. must also be taken into account
 - 5 In URM buildings, wall debris can easily weigh more than a normal story

VERTICAL SHORING SYSTEMS

-  WOOD POSTS
-  ELLIS CLAMPS
-  T - SPOT SHORE
-  WINDOW / DOOR
-  LACED POSTS
-  CRIBBING
-  STEEL PIPE
-  TRENCH SHORES
-  METAL FRAMES & JOIST
-  PNEUMATIC SHORES
-  SPECIALTY SHORES

SCREW JACK by ELLIS

-  Adjustable metal foot for 4x4 and 6x6 wood posts
-  6 inch adjustment - set half way to get 3 in. up & down
-  Metal Foot is stronger than wood post
-  Use sole to spread load

ELLIS SHORES - 4x4 adjustable

- 📁 Need 2 Ellis Clamps to make a pair of 4x4 into Adjustable 4x4 shore
 - 📄 Need Ellis Jack
 - 📄 Failure Mode is by clamp crushing the side grain of the post - Gives Warning
- Ellis jack, clamps
Vertical Shores

Ellis clamps

Ellis Foot

PNEUMATIC SHORES

PNEUMATIC SHORES

- 📁 **Adjustable shore with length up to 16 ft - Manufactured by Airshore, Paratech, & Holmatro**
- 📄 **Have swivel & other feet**
- 📄 **Should be set manually using adjustable collar or sleeve nut - DON'T USE AIR SET IN US&R**
- 📄 **Working Load decreases with length and should be based on tests using swivel ends**
- 📄 **Best use is as initial shore**

Airshore - A.R.T

Shown as single, vertical shore - plus

triple, column shore w/special plate at each end
Airshore - A.R.T

showing window & door shores w/U type connection at top
"T" Spot Shore for initial stabilization only

The WINDOW SHORE

STABILIZE WINDOW OPENING

SUPPORT DAMAGED HEADER

1 inch THICKNESS FOR EVERY FOOT OF HEADER OPENING

THE DOOR SHORE

RESUPPORT ENTRANCE

SUPPORT WALL BREACH

1 inch THICKNESS FOR EVERY FOOT of HEADER LENGTH

VERTICAL SHORE

RESUPPORT UNSTABLE FLOORS OR ROOFS

POSTS UNDER FLOOR BEAMS

MID-POINT BRACING AT 9 ft CEIL. HT (Posts over 8ft plus header & sole)







VERTICAL WOOD SHORING

HORIZONTAL SHORE

STABILIZE PASSAGEWAYS

2 - 3 SUPPORT STRUTS

DEBRIS WEIGHT WILL DETERMINE THE SIZE

-  **The Raker Shore of Choice**
-  **Generally Erected at 45 Degree Angle**
-  **Can Be Utilized on Solid Ground As Well As Earth**
-  **Pre-assemble and Carry Into Position**
-  **Must Erect Minimum of Two Shores**
-  **Used to Re-support Unstable or Leaning Walls**


RAKER SHORE ANGLES


DEGREE PITCH LENGTH

45 deg 12/12 17

60 deg 12/7 14

Calculating length of rake:

-  60 degree angle raker: Insertion height in feet multiplied x 14 = length of rake
2 Example: 8' x 14 = 112" (9' 4")

-  45 degree angle raker: Insertion height in feet multiplied x 17 = length of rake
2 Example: 8' x 17 = 136" (11' 4")

Raker end cuts






ANGLE CUTS

SOLID SOLE RAKER

FULL TRIANGLE (FIXED) RAKER SOLID SOLE TYPE

Solid sole rakers

SPLIT SOLE RAKER

-  **Second Option for Raker Shoring**
-  **Generally Utilized in Earth or Where Debris is at the Base of the Wall**
-  **Erected the Same Except for the Base of the Shore**
-  **Can Be Partially Pre-erected Before Installation**
-  **Should be erected at 60 degree angle, whenever possible**

SPLIT SOLE RAKER

SPLIT SOLE RAKER BASE

(also use for Sloped Floor Shore on Earth)

HIGH PRESSURE AIR BAGS

HIGH PRESSURE AIR BAGS

 **Characteristics**

- 2 Neoprene/butyl rubber**
- 3 Steel kevlar reinforced**
- 4 Variety of sizes**
- 5 Maximum capacity is calculated at 1 inch of lift**
- 6 Very low capacity at max height**

HIGH PRESSURE AIR BAGS

 **Application**

- 2 Maximum stack of two high**
- 3 Lift is limited to capacity of small bag**
- 4 Larger bag on bottom**
- 5 Keep pressure in large bag less than small bag**
- 6 Centers of bags MUST be aligned**

HIGH PRESSURE AIR BAGS

HIGH PRESSURE AIR BAGS

HIGH PRESSURE AIR BAGS

I.D. Tag is right on Bag

HIGH PRESSURE AIR BAGS & CRIBBING

SPREADING & PUSHING

LIFTING AND STABILIZING IRREGULAR OBJECTS

PIPES & CYLINDERS

WEDGES AND CRIBBING

SHIMS (WEDGES)

“MARRYING” WEDGES

CRIBBING

CRIB STABILITY

CRIBBING

CALCULATING WEIGHTS

CALCULATING THE WEIGHTS OF COMMON MATERIALS


LENGTH x WIDTH x HEIGHT = CUBIC FT

 **Steel 490 lbs. per cubic foot (pcf)**


 **Concrete 150 pcf**

 **Earth 100 pcf**

 **Wood 40 pcf**

 Arrow next to Marking Box indicates the direction of Safest Entry to Structure

STRUCTURE / HAZARDS MARK

 HM indicates hazardous material condition in or adjacent to structure. S&R Ops normally will not be allowed until condition is better defined or eliminated.

STRUCTURE / HAZARDS MARK - SUMMARY

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HM NATURAL GAS

OR-1

BUILDING MARKING SYSTEM

SEARCH ASSESSMENT MARKING

SEARCH ASSESSMENT MARK




BUILDING MARKING SYSTEM

VICTIM LOCATION MARKING

VICTIM LOCATION MARKING

Concrete Breaching









WARNING:

-  **If cutting is necessary consult engineer**
-  **Avoid cutting Beams and Stems of Single & Double Tees.**
- 3 May carefully cut these when collapsed and are part of rubble pile.**
- 4 Avoid cutting near the ends (all cases)**
-  **May cut Slabs, including Slabs of Tees**
- 6 Cut access holes, centered on the joint between two adjacent members**













Categories of Tools

-  **Cutting**
-  **Breaking**
-  **Breaching**
-  **Torches**
-  **Support**

Cutting Tools

-  **Circular saws with diamond blades**
-  **Diamond tip chain saws**
-  **Wizzer saws, electric or pneumatic**
-  **Reciprocating saws, electric or pneumatic**
-  **Chainsaws (electric and fuel)**
-  **Rebar cutters, manual and hydraulic**
-  **Hacksaws, bolt cutters, chisels**
-  **Hydraulic rescue tools**






Breaching/Breaking Tools

-  **Hydraulic breakers**
-  **Manual, mauls and sledge hammers**
-  **Pneumatic chipping hammers**
-  **Electric rotary hammers**
-  **Electric demolition hammers**
- Methods to Defeat Concrete
-  **Relief cuts**
-  **Bevel cuts**
-  **Step cuts**
-  **Stitch cuts**
-  **Bolting**
-  **Wetting**
-  **Burning and cutting**

Relief Cuts



Bevel Cut

Basic Approach to US&R

-  **Identify the Problem**
- 2 **Prioritize**
-  **Find Victims**
- 4 **Re-prioritize**
-  **Mitigate Hazards**
- 6 **Risk vs Reward**
-  **Remove Victims**
- 8 **Medically stabilize**
-  *Create no new victims*


Basic Building SAR Plan

(initial phases)

-  **Reconnoiter**
- 2 **determine structure type**
- 3 **obtain / draw plans**
- 4 **access hazards**
- 5 **interview neighbors, etc.**
-  **Prioritize Site**
- 7 **develop hazard mitigation alternatives**
- 8 **callout / listen search**
- 9 **condition of voids & basement**

Basic Building SAR Plan


(initial phases)

-  **Initial Search**
- 2 **use K-9 in safe & less safe areas**
- 3 **use technical search equip.**

- 4** use existing vertical shaft opngs
- 5** use existing horizontal openings with great care
- 6** search from stable to un-stable
- 7** re-prioritize vs live finds

Basic Building SAR Plan

(main phase - days long ?)

 Selected cutting / removal

- 2** cut vert opngs & re-search
- 3** initial shoring for access
- 4** avoid unshored overhead slabs, etc.
- 5** re-check shoring after cutting & removal
- 6** continue - cut opng & re-search
- 7** shore victim area for rescue ops
- 8** Struc Spec gives continuing aid to rescue