Section 1-5 Intro to Hazard Assessment and Monitoring Tools

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US&R Structures Specialist Training – StS-1

Section StS1-1-5:

Intro to Hazard Mitigation & Monitoring Tools

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Terminal Objectives

- **The Student shall understand the Basic, US&R Approach to Mitigating Damaged Structures, including use of forms**
- **The Student shall familiar with the Monitoring Methods, Forms and Tools, used in US&R**

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Topics to be Discussed

- **Introduction to Structure Hazard Mitigation**
- **Methods to Monitor Structures**
  - **Planning**
  - **Record Keeping**
  - **Types of Monitoring Tools**
    - **Advantages & Disadvantages**
  - **Maintenance of Theodolite & Total Station**
  - **Monitor Tools Practice Stations**

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Introduction to Hazard Mitigation

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Mitigation Planning

- **Following Assessment, need to consider alternatives that will reduce Risk for Search & Rescue Operations**
  - **Need to have a written Plan that will become part of the Incident Action Plan (IAP)**
- **AHJ often asks FEMA US&R to provide a Prioritized Plan for Hazard Mitigation**
  - **Structure Hazards**
  - **Hazardous Materials, WMD**
- **AHJ normally does not have StS skills**

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Mitigation Planning

- **IST-StS may be directed to develop the Mitigation Plan**
  - **TF StSs should be asked to provide input**
  - **TF StS may be required to develop their own Mitigation Plan in Large Earthquake Incident**
- **Plan must be developed quickly**
  - **Rough Draft w/sketches in Hours not Days**
  - **Plan can be changed and improved**
  - **IST GIS can enhance the graphics when practical**

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Mitigation Planning

- **Plan is Essential Component of Risk vs Reward Analysis**
  - **Mitigation will normally be done in a series of steps**
  - **As Reward of finding Live Victims decreases, additional Mitigation should be Planned and implemented to further decrease the Risk to Rescuers**
  - **Mitigation may be Planned as a continuum that Reduces Risk, Step by Step**

Form MIT-1

US&R Struct. Haz. Mitigation Form - MIT-1 By: ______ Date: ______

STRUCTURE DESCRIPTION:
Bldg ID:
No. Stories: No. Basements:
MATERIALS: Wood Concrete Steel URM PC Concrete
TYPE OF COLLAPSE: Pancake Soft 1st Story Wall Failure O-turn Other

MITIGATION METHODS & ABBREVIATIONS

Avoid and Barracade	A&B	Horiz. Tieback	H-TB
Remove	Remo	Vert Tieback	V-TB
Minimize Exposure	Exp-M	Shield	Shld
Vertical Shore	V-Sho		
Horiz. Shore	H-Sho	Monitor	Mon
Raker Shore	R-Sho	(GoTo Monitor Form)	
Daigonal Brace	DB	Other (specify)	

LIST OF POSSIBLE HAZARDS	HAZ LOCATOR (Use Circled No. & locate on Sketch)	MIT METHOD (Use abbrev. indicated above)	PRIORITY (From 1 to 9, may be several of ea.)	TIME REQD (Est. to complete reqd mitigation)	COMMENT
FALLING HAZARD TYPE					
Glass, Light Bldg Facing					
Bldg Contents, H'vy inc Safe					
Brick Veneer					
Rock Veneer Panels					
P.C. Panels					
HVAC Units					
Ducts, Elec Conduit					
Structure Element - Loose					
Str Elmt, Hanging & Attached					
Other					
LOCAL COLLAPSE HAZARD					
Leaning Wall					
Damaged Column					
Damaged Floor					
Un-braced Column					
Punching Shear Potential					
Debris Overload-Floor					
ResQ Equip Overload					
Rain & Clogged Roof Drains					
Damaged Retaining Wall					
Other					
GLOBAL COLLAPSE HAZARD					
Leaning Building					
Multi Floor Collapse					
Multi Column Collapse					
Other					

SKETCH:

Form Mit-Log

US&R Struct. Mitigation Log - MIT-Log By: ______ Sht ___ of ___

STRUCTURE I.D.

DATE	TIME	HAZARD LOCATOR	MIT METHOD	COMMENT
Example mm / dd / yy	1100 hr	4	R-Shore	

Risk vs Reward

- **Most Operations in US&R involve Risk**
  - **Many Mitigation Options involve Risk during installation**
  - **Need to consider the Mitigation Installation Risk in the Plan**
  - **Lowest Risk Mitigation should be considered First**
  - **Example**
    - ◆**Avoid**
    - ◆**Removal**
    - ◆**Spot Shoring**

Survival time vs time to do Mitigation

- **What Mitigation requires the least time to complete?**
  - **What is minimum level of Risk Reduction?**
  - **Need to offer as many alternatives as possible**
    - ◆**Each alternative should be accompanied by estimate of required time to complete**
  - **Is there a combination of simple measures that will suffice?**
  - **Need to remember victim survival may depend on rapid extrication**
    - ◆**We are there to Save Lives, but not create new Victims – Difficult Choices!**

Simple Hazard Mitigation

- **Avoid**
  - **Need effective barrier system**
  - **Needs to be part of the IAP**
  - **May be Lowest Risk Option**
- **Removal**
  - **Lift off, push over, pull down**
  - **Operation may require Site Evacuation**
  - **Needs to be part of the IAP**
  - **May pose some Risk to Hidden Victims**

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What if you can't remove-it?

- **Build a Shield**
  - Some type of "Catch System"
  - Needs to be strong and limber
    - Consider Aluminum or Micro-Lam Wood
  - Soft – Impact absorbing surface
    - Multi-Layered

Aluma beams & Plywd in Puerto Rico

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Simple Hazard Mitigation

- **Exposure reduction**
  - How long do we need to be in the area?
  - Risk is a function of severity and exposure
  - Limit time exposed to hazard
  - Limit number of personnel exposed
  - Needs to be part of the IAP
  - Probably a short term, High Risk Option
- **Similar to Time, Distance, & Shielding Rule used in Hazmat**

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Other Hazard Mitigation

- **Monitor Structure Hazard**
  - Later in this section
- **Recognize & Refer Hazard (Hazmat)**
  - US&R TFs may be equipped and asked to perform Offensive Ops in WMD Incident
    - Rescue TF members + few other victims
    - StS need to be prepared to operate in Contaminated Environment

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Short & Long Term Rescue??

- **Short Term Rescue**
  - Assumes one or two Live Rescues
  - Up to Two Hours
  - Does not involve complicated mitigation
  - Usually involves minimum exposure
- **Long Term Rescue/Recovery**
  - Assumes one or more live rescues and possibly body recovery
  - May last from 2 hrs to several Days
  - Involves shoring, bracing, etc
  - Mitigation should continue to further Reduce Risk as rescue proceeds

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Longer Term Hazard Mitigation

- **Vertical & Lateral Shoring**
  - Place Shoring in Sequence (long term rescue)
    - Progressively Reduce Risk
  - Class 1, Spot Shores
  - Class 2, Two-dimensional Shores
  - Interconnect pairs of Class 2 to form Class 3, Three dimensional Shores
- **Systems w/ predictable Failure Mode**
  - Wood system with slow failure mode
  - Struts, Pipes w/ buckling Failure Mode are less desirable
    - Short Term, Class 1 solution

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Class 1 – Class 2 – Class 3

T Shore – 2 Post Vertical – Laced Post

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Other longer term Hazard Mitigation

- Lateral Bracing
  - Use to reduce Buckling Risk of Column left after Collapsed Floors
    - Choices are Brace for 2% load, Remove much Load, or Sister Column
    - Bracing often most efficient choice
  - System of Spot Shores against leaning building
- Lateral Tieback
  - When shoring isn't practical
  - Need Adequate Anchors
    - May need new concrete Dead Men, etc

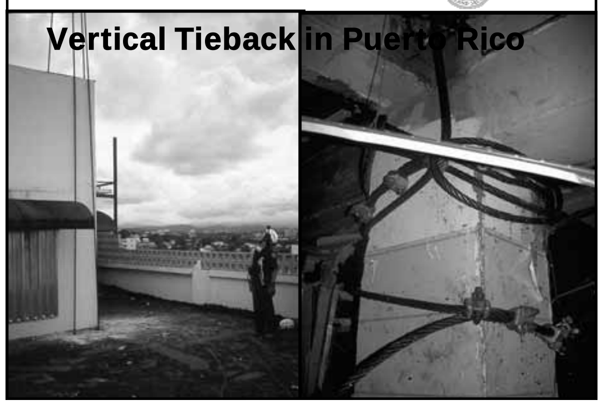
Lateral Bracing

Column Bracing Building Bracing

Other longer term Hazard Mitigation

- Vertical Tieback
  - Use cable to hang structure from above
  - Failure Mode may be Brittle
  - Connection to and developing the Load may be difficult
  - May use Crane or Excavator to temporarily hang structure
    - De-rate Load Chart to increase Safety Factor from 1.2 to 2.4

Vertical Tieback in Puerto Rico



Mitigation Summary

- Start with a Plan
  - AHJ needs Prioritized Plan
  - Start w/ rough sketches goto IAP w/GIS
- Risk vs Reward
  - Identify Risks for installing the Mitigation
  - Increase Mitigation as Reward is reduced
- Do most Simple Mitigation First
  - Some simple may present High Risk
- Place most appropriate Shoring/Bracing
  - Don't be Limited by what was done elsewhere

Methods to Monitor Stability of Structures

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Elements of Monitoring

- Monitoring Plan
- Record Keeping
- Emergency Communication Plan
- Monitoring Tools
- Properly Trained Personnel

Monitoring Plan

- Where and how
- Control/Reference Points
- Directions of movement
- Caution vs Alarm
- Record Keeping
- Report Info in Incident Action Plan
  - Info gets to those who need it

Where, How & Direction

- Visualize Failure Mode
  - Must be Ductile
- What tools will best detect movement
  - Measure Angular Rotation
  - Measure Translation
  - Measure Vertical Deflection
- What is most likely direction of movement
- Where to place monitoring devices on structure

Control / Reference Points

- Essential to establish Repeatability
  - Establish Credibility
  - Avoid False Alerts/Alarms
- Selected for Stability
  - Not affected by :
    - Wind
    - Temperature
    - Changes from Debris Removal
    - Changes in Sight Lines

Caution vs Alarm

- Need to know what is “Reasonable” or “Normal” Movement
  - Due to light winds
  - Due to change in Sun Angle
- Only valid is Failure Mode is Ductile
  - Otherwise, No Warning Time
- Levels may change
  - Based on incident’s observation history
- Need Effective Warning System
  - See Emergency Comm Plan to follow

Story Drift

Compare Angle Rotation to Story Displacement – in one 12ft story

Angle (deg)	.01	.05	.10	.15	.20	.40	.60	.80
Drift (inch)	.025	.126	.251	.337	.502	1.0	1.51	2.01

Story Drift = Lateral Displacement in 1 Story

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Data Interpretation

- Most Challenging Aspect
  - No simple Rules
  - Consider overall context of Bldg & Incident
- Key Factors to Consider
  - Initial Conditions
  - Movement Magnitude & Rate
  - Movement Trend –Cyclic, Monotonic, Step
  - External Influences
- All movement must be considered "In Context"
  - Murrah Bldg – "Normal" was 5/8" in 10 stories

Reference Movements - Bldgs

- The 1, 2, 3 Rule – Normal "Noise"/ Story
  - Concrete = 1/16" (0.025 deg)
  - Steel = 2/16" (0.05 deg)
  - Wood = 3/16" (0.075 deg)
- Rough estimates only
  - Caused by change in sun angle
  - Caused by light winds
  - Day- night transition

Reference Movements - Devices

- Plumb bob – Vulnerable to wind
- Crack Gage – Parallax may be an issue
- Smart Level – Resolution is 0.20 deg
- Laser Level – Diameter of Beam
- Total Sta/Theodolite – Depends on quality and stiffness of Tripod Set-up
- WBMS – Resolution is 0.05 deg
  - Software displays to 0.01 deg

Record Keeping

- Written Records need to be kept of all Monitoring Devices
  - All Monitoring Devices, inc Crack Monitor
  - See next slide for suggested intervals
- Recording System could be setup and kept by IST Structure Spec Staff
  - Each TF Structure Spec should keep own Unit Log (ICS 214) including Monitoring Data
  - Need to share data at every shift change, assuming no significant movement (Hand-off)
  - Report Info in IAP, OAP and/or TAP
    - Depends on incident & IST

Recording Data, Intervals

- Periodically
  - Initially Hourly – Later at longer interval
  - Electronically and/or MON-1 & MON-Log
- Discussion at Shift Change
- Following Significant Events
  - Aftershocks
  - Windstorms
  - Shifting of Debris
  - Heavy Equipment – load collisions, etc

Communication Protocols

- Need to strike a balance between Rapid Notification and Avoidance of False Alarms
  - Alert Threshold must be greater than "Normal", but less than Impending Collapse
- Must be able to Effectively Communicate any Alarm to Leadership
- A pre-determined "Alarm Level" should be discussed & established with Leaders, so Rapid Response is Facilitated

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FEMA Monitor Forms - 2009

- Landscape forms have been developed for better use w/Total Station
  - MON-1, MON-2, CP Log and MON-Log in Landscape format
- The Landscape forms may be used for less complicated monitoring devices
  - Mon-1 and Mon-Log in landscape
  - MON-Log is also provided in portrait, since it will all for the recording of more measurements on 1 sheet
- All Monitoring Forms would be used to hand-off information to the on-coming shifts
  - They should become part of the OAP or TAP

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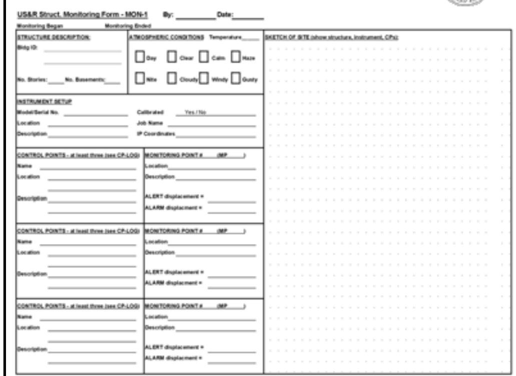
US&R Struct. Monitoring Form - MON-1

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US&R Struct. Monitoring Form - MON-2

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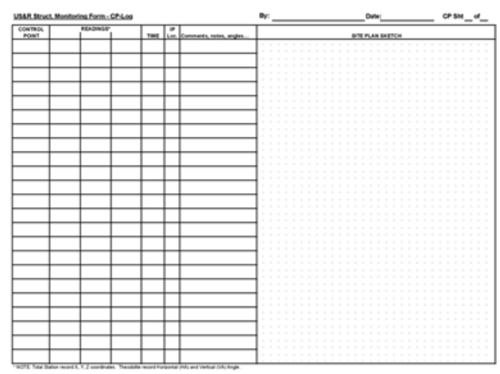
US&R Struct. Monitoring Form - CP-Log

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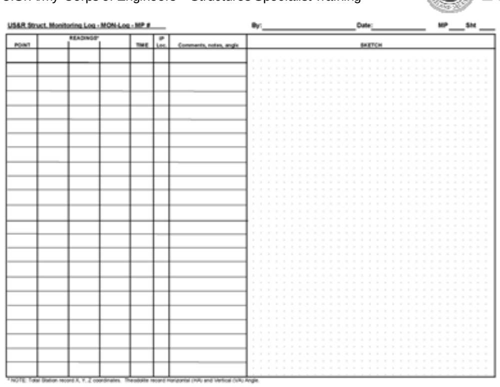
US&R Struct. Monitoring Log - MON-Log - MP #

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Monitoring Log – Portrait

- This forms is intended for use with simple monitoring devices
  - Theodolite
  - Electronic and Laser Levels
  - Wireless Bldg Monitoring System
    - It creates its own Log File on a SD Card
  - Plumb-bob & Crack Monitors
- MON-Log is used to record the data every time a monitoring point is checked
  - Number of these forms depends on how many monitoring points
    - If only a few points, may use one form per day
    - May use one form per monitoring point per day
    - Use as many as appropriate

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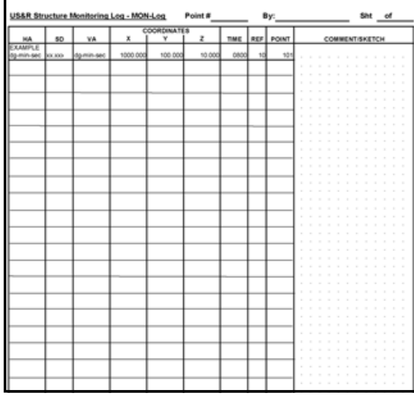

US&R Structure Monitoring Log - MON-Log Point # ______ By: ______ Sht __ of __

HA	SD	VA	COORDINATES X	Y	Z	TIME	REF	POINT	COMMENT/SKETCH
EXAMPLE dg-min-sec	xx.xxx	dg-min-sec	1000.000	100.000	10.000	0800	10	101	

Form MON-Log
8 ½ x 11

Emergency Comm. Plan

- **Effective Warning System**
  - **For Caution and Alarm Warnings**
- **Involves Coordination**
  - **FEMA Task Force Leaders**
  - **FEMA Incident Support Team**
  - **Incident Command**
- **All must understand, and be able to Hear Warning Signals**
- **All must know their Evacuation Routes, and to Whom they Report**

US&R Monitoring Devices

- **Theodolite and Total Station**
  - **Reflectorless Total Station**
- **Electronic Tilt Meter**
- **Electronic Level**
  - **SmartLevel & SmartTool**
- **Laser Levels**
- **Plumb bob**
- **Crack measuring devices**
- **Wind Speed Measuring Devices**

Use of Devices
Theodolite/Total Station

- **Theodolite/Total Station may be used to detect small movement in remote structures**
  - **Method 1 - Establish a vertical line that will compare a point on a dangerous building to a point on the ground to detect additional tilt / movement**
  - **Method 2 - Use a Reference Point on an adjacent building, and turn an angle to several locations of potential movement on a questionable structure**
  - **Method 3 - Just do a spot check on an individual point on a damaged structure, such as Falling or Collapse Hazards (Total Station could measure X, Y, & Z)**

Use of Devices -Theodolite/Total Station

- **Advantages**
  - **Observation w/o contacting structure**
  - **Make Distant Observations**
  - **Ability to Zoom - In on structure**
  - **Observe many points from One Location**
- **Disadvantages**
  - **Cost of instrument**
    - **20sec Theodolite = $2000**
    - **5sec Reflectorless Total Sta = $6500**
  - **Need Trained Operators**
  - **Readings not Intuitive**
  - **Need stable Reference/Control points**
    - **Difficult establishing aftershock control?**
  - **Can't Use w/Face Mask**

Use of Devices Theodolite / Total Station

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Use of Devices - Theodolite/Total Station

- **Theodolite have often been used Poorly and without Reference/Control**
- **False Movements have been reported at several major incidents**
  - **Most often as a result of someone inadvertently bumping the tripod, without having an adequate Reference/Control mark system**
  - **This can lead to a lack of confidence in this very important system**
- **This is a very effective device that must be used properly**

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Use of Devices – WBMS

- **Wireless Building Monitoring Sys (WBMS)**
  - **System uses up to 4 Sensors, placed structure(s), to measure & transmit movement as an angle change.**
    - **Measures angle change of 0.05 degree (repeatable)**
  - **Signal is sent to 900mh Spread Spectrum Receiver**
    - **Range is up to 1000 ft. (clear sight)**
    - **Not as far thru Heavy Concrete & Metal Structures**
  - **Receiver is linked to MS Pocket PC PDA or a Laptop by wireless, blue-tooth connection**
    - **PDA software polls sensors at 10 to 15 sec interval**
    - **PDA chirps for each coherent signal received**
    - **May set software to alarm for any amount of angle change**
  - **Available at IST, FEMA & USACE systems**
    - **Use special mounting hardware**

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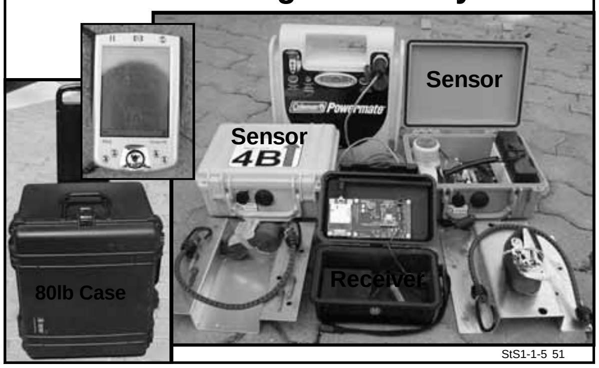
Wireless Building Monitor Sys



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Use of Devices – WBMS

- **Advantages**
  - **Monitor 4 or more locations at once**
  - **Very accurate and can set Alarm for any amount of movement**
  - **Portable Receiving/Alarm System**
  - **Remote Observation (up to 1000 ft)**
  - **Can Use w/Face Mask**
- **Disadvantages**
  - **High cost ($18,000 per full-system, 2005)**
  - **Need Qualified, Techno-Operator**
  - **Need planned, periodic battery recharge system**
  - **Need to place Sensors on Structure**
    - **They have remote, 7-day, 12v batteries**

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Use of Devices – Electronic Levels

- **Electronic Levels should be placed in pairs on structure to measure change in any angle (Vertical or Horizontal)**
  - **Measures angle change of 0.2 degrees**
  - **Cost is in $100 range, each**
  - **Must be continually read (no alarm)**
    - **New lower cost model cannot be set on zero when placed in vertical position**
  - **Use binoculars for remote reading**
  - **Must alter device to turn battery saver off**
  - **Mount on steel angle using a C-clamp**

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Use of Devices – Electronic Levels

- **Advantages**
  - **Low cost**
  - **Long battery life (about 40 hours)**
  - **Easy to read**
- **Disadvantages**
  - **Not as accurate as WBMS**
  - **Need to place on structure**
  - **Need to place 2 in each location to measure angle change in N-S + E-W direction**
  - **Someone needs to read them – line of sight**
  - **Need to modify Battery Saver Function**

Use of Devices – Laser Levels

- **Laser Levels - placed on structure to indicate movement by changed position of the light beam on a specified target**
  - **May measure angle change or lateral/vertical movement**
    - **Accuracy depends on setup – maybe 0.2 degrees,**
    - **1/8"Must be continually read (no alarm)**
    - **Target should be set in safe area**
  - **RoboToolz Laser Level**
    - **Low cost, but less useful**
  - **Hilti Laser Level - PMP-34 – In Cache 2009**
  - **Moderate cost w/ lots of extras**

RoboToolz Laser Levels

- **Cost is $100 each for tri-axial laser**
- **Battery life is about 14 hours (AAA batteries)**
- **Mount on steel angle, since device has magnets**

Tri-axial

Single

Hilti PMP-34 Laser Level

- **GSA cost is $460 each for tri-axial laser**
- **Battery life is about 40 hours (AA batteries)**
- **Comes w/ case and several mounting devices**
- **Self leveling, and has several modes of operation**
  - **Single, Double, Triple, Self level off, Battery save off**
  - **2009 Cache**

Use of Devices – Laser Levels

- **Advantages**
  - **Low cost**
  - **Easy to read**
- **Disadvantages**
  - **Not as accurate as WBMS**
  - **Need to place on structure**
  - **Need to place 2 targets for each location to measure angle change in N-S + E-W direction**
  - **Someone to read them – line of sight**
  - **Need to replace batteries**
    - **Every 12 hrs for RoboToolz**
    - **Every 40 hrs for Hilti**

Use of Devices – Plumb Bob

- **Use a Plumb bob hung from small structure to compare to a point on the ground/pavement**
  - **Allows one to observe change in a leaning structure**
- **Advantages**
  - **inexpensive, easy to use, no special skills (a rock on a string will suffice)**
- **Disadvantages**
  - **Requires one to attach to structure, constant observation, not too accurate**

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Crack Monitoring

- Draw or sawcut 'x' centered on crack
- Use inexpensive ($15) plastic strain gage can be placed at crack
- Spray paint cracked area
- Place shims/cards in cracks
- Inexpensive, easy to read change, but need to be checked (up close) periodically

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Monitor Wind Speed

- Low cost, hand-held devices
  - Kestrel = $100

  - Brunton = $60

- Weather Station w/ remote sensors
  - $150

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Method to Monitor Disaster Site

- P vs S wave - time delay
  - P wave travels faster than S waves
  - If distance from Fault to Site is more than 50km there is opportunity to warn of Aftershocks
- Seismic Trigger deployed at Disaster Site
  - Warns when P wave arrives
  - Destructive S wave arrives later
- Pager System
  - Pagers at disaster site are signaled from sensors at fault that measure Aftershocks

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Trained Monitoring Personnel

- Need properly trained individuals
- TF Struct Spec may be needed elsewhere
- Monitoring help is Function of IST StS
  - Pre-scripted Mission Assignment, USACE
  - Local Land Surveyors
  - Other Local Assets
- Proper Training
  - Understand US&R
  - Know what to do with observations
  - Detach from Rescue Operations

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Key Learning Points

- Structure Mitigation requires initially rapid and then continuing Prioritization & Planning
  - Creative Alternatives are what is needed
- Monitoring needs careful planning & the reporting of reliable information
  - The StS must become familiar with the Operation and Care of all Monitoring Tools in the Task Force Cache

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Practical Use of Monitoring Equipment

6Jun05

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Section 1-5 Intro to Hazard Assessment and Monitoring Tools

Topics to Discuss

- Total Station/Theodolite use
- Instrument handling
- Maintenance & Storage
- Tripod Setup & Adjustment
- Setting Benchmarks & Control Points

Theodolite / Total Station Use

- When to use
  - When movement is a concern
  - When a hazard can not be totally mitigated.
  - When prolonged exposure to a hazard is expected
  - How long is prolonged - judgment required
  - When it is feasible

Theodolite / Total Station Use

- Equipment for efficient setup
  - Transit or Theodolite
  - Tripod
  - Plumb bob for establishing equipment location
  - Caution marking tape to cordon off the equipment
  - Reference point

Theodolite / Total Station Use

- Equipment for efficient setup, continued
  - Documentation supplies
  - Method of anchoring into position
  - Lighting for night operations
  - Marking tools
  - Permanent marker
  - Paint

Theodolite / Total Station Use

- Techniques
  - Checking building tilt
  - Checking height of Falling Hazard
  - Estimating distances using a transit
  - Finding accurate distance with Total Station
    - Using Reflector Prism
    - Using Reflector-less - Pulse Laser
  - Estimating distance using laser rangefinder binoculars

Theodolite / Total Station Use

- Documentation
  - Need for documentation
  - Establish a routine
  - Shift change
  - Sharing Documentation
    - With IST
    - With AHJ & IC
      - As part of the Incident Action Plan

Section 1-5 Intro to Hazard Assessment and Monitoring Tools

Theodolite / Total Station Use

- Accuracy
  - May require judgment
  - Affected by
    - Site activities
    - Wind
    - Temperature
    - Human condition

Instrument Handling

- Always carry the instrument in its case
- Never place the instrument on the ground.
- Do not hold the two standards to carry the instrument around a job site.
- When leaving the instrument set up
  - Place the lens cap on and cover the whole instrument with the vinyl cover.

Instrument Handling

- Protect the instrument against the elements
  - Rain
  - Strong direct sunlight, etc.
- During transportation
  - Always place accessories in their correct position
  - To prevent displacement.

Instrument Handling

- Drying a wet instrument
  - Wipe the instrument carefully, remove the foam inserts and let them dry out completely.
  - When everything is completely dry you may place the instrument back in its container.

Maintenance & Storage

- Instrument can be affected by moisture.
  - During surveying ops, wipe rain off with clean cotton cloth.
- Clean Instrument before returning it to case.
  - Brush off the lenses, breathe on them
    - never touching lenses with fingers
    - wipe them clean with a cotton cloth or tissue.
  - Never use liquids such as oil, benzene, water, or detergents.

Maintenance & Storage

- After constant use, regularly check the tripod for any loose or defective parts.
- Contact the manufacturer or instrument sales immediately if:
  - There is condensation or mold on any of the internal surfaces of the telescope.
  - There is any foreign matter clogging threaded or movable components
  - If the instrument has been dropped.
    - Do not force any motion as this may cause further damage.

Section 1-5 Intro to Hazard Assessment and Monitoring Tools

Maintenance & Storage

- Remove the instrument from container so that air can circulate
  - This helps to prevent mildew and fungus.
  - Storage area should be dustproof, have good air circulation and low humidity.
  - In extreme cold, don't take the instruments indoors during non-working periods but leave them in a protected place at outside temperature, this prevents condensation.

Tripod Setup & Adjust

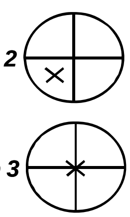
- Setting up Tripod
  - Loosen quick clamps or twist locks on legs
  - With tripod closed, raise the tripod head to about chin level. Tighten leg locks.
  - Spread the tripod legs so that the three shoes form an equilateral triangle and are fixed firmly in the ground
    - Adjust so that tripod head is approximately level and positioned directly over the surveying point.

Centering the Instrument by adjusting the Leg Length

Optical plummet

Step 2

Step 3



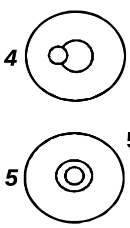
1. Mount the instrument on the tripod head. Tighten the tripod's centering screw.
2. If the instrument has an optical plummet, turn its eyepiece to focus on the reticle. Then push or pull the eyepiece to focus on the surveying point.
3. Turn the foot screws to center the surveying point in the reticle.

Centering the Instrument by adjusting the Leg Length

Circular vial

Step 4

Step 5



4. Now look at the circular vial. Observe the off-center direction of the bubble. Shorten a leg nearest to the direction, or extend a leg farthest from the direction. Generally, two legs have to be adjusted to center the bubble.
5. Final leveling can be completed by adjusting legs and/or turning the leveling screws to complete centering of vial.

Centering the Instrument by adjusting the Leg Length

6. Look through the optical plummet again. If the surveying point is off-center, loosen (tripod) centering screw and move the 80-2158-00 to center the surveying point on the reticle. Tighten the center screw. Recheck leveling of the vial.

Setting Benchmarks & Control Points

- After Leveling, hang the plumb bob from the instrument
  - Mark its location on the ground.
  - Call this IP-1
  - If you have more than one instrument the next one is IP-2, and so on

Section 1-5 Intro to Hazard Assessment and Monitoring Tools

National Urban Search & Rescue Response System
U.S. Army Corps of Engineers – Structures Specialist Training

Control Points for Horizontal Angle

- Define at least two "bomb-proof" control point location
  - Send someone to each, set target, and record the horizontal angle
  - Call these CP1-1, CP1-2, CP2-1, CP2-2, and so on.
  - Identify point or points on structure or structures that you need to monitor and set or find precise target
    - If target structure is badly damaged, it may not be safe to set a target

StS1-1-5 85

National Urban Search & Rescue Response System
U.S. Army Corps of Engineers – Structures Specialist Training

Control Points for Vertical Angle

- In addition to the two "bomb-proof" CP locations, one may run Vertical Angle Checks
  - Find/Establish a stable point on the ground or on the base of a building that is on a plumb line with the point on the structure that you wish to monitor
    - Mark this point with a large nail, paint mark, etc
    - Call this CP1-1V and so on
  - One can also periodically run a vertical angle check up and down the side of a structure to monitor change in tilt

StS1-1-5 86

National Urban Search & Rescue Response System
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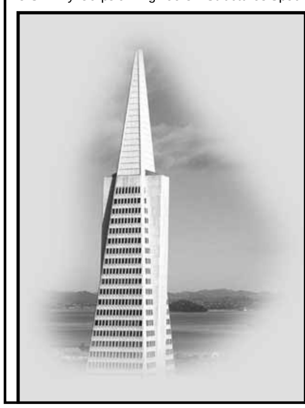

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National Urban Search & Rescue Response System
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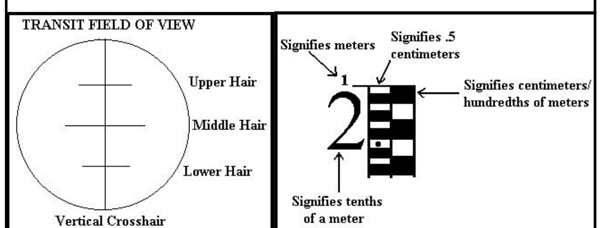

StS1-1-5 88

National Urban Search & Rescue Response System
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Key Learning Points

- Total Station is more accurate and useful than Theodolite
  - One needs to practice and handle it correctly
- WBMS is accurate but sensitive to how it is mounted
- Other – Low-Tech devices have limitations, but usefulness
- Distance measuring devices may be very useful, and continue to improve

StS1-1-5 89

National Urban Search & Rescue Response System
U.S. Army Corps of Engineers – Structures Specialist Training

3 - Station Setup

- Total Station/Theodolite Stations – 2 Sta
  - Setup and establish control points
- Building Tilt Sensors
  - WBMS Half System w/connections
  - Smartlevel, Smarttool, connections
  - Laser Levels & Tripod
  - Plumb bob
- Height and Distance Measuring
  - Laser Rangefinders
    - Binoculars & Handheld EDM
  - Clinometer

StS1-1-5 90

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

INTRODUCTION

The objectives of this section are listed in the adjacent slide
The Topics that will be included are:

- Introduction to Structure Hazard Mitigation
- Methods to Monitor Structures, inc Planning & Record Keeping
- Introduction to Mitigation and Monitoring Forms
- Types of Monitoring Tools, inc Advantages & Disadvantages
- Maintenance of Theodolite & Total Station

Terminal Objectives

- **The Student shall understand the Basic, US&R Approach to Mitigating Damaged Structures, including use of forms**
- **The Student shall familiar with the Monitoring Methods, Forms and Tools, used in US&R**

STRUCTURE / HAZARD MITIGATION

STRUCTURE MITIGATION PLANNING

Following assessment, US&R forces need to consider the alternatives that will reduce risk for Search & Rescue Ops.

- Eventually a written plan will be developed, that will become part of the Incident Action Plan (IAP)
  - The Authority Having Jurisdiction (AH) may ask FEMA US&R to provide or at least contribute to a Prioritized Plan for Hazard Mitigation.
  - This Plan my contain sections for Structure Hazard Mitigation as well as HazMat and/or WMD Mitigation.
  - We will discuss only Structure Hazard Mitigation here.
  - The AHJ often does not have engineers that are trained to efficiently provide US&R (Rescue) Engineering judgments.
- The IST StS has often been directed in the past to develop the structure portion of the Mitigation Plan.
  - The IST StS may ask several TF StS to provide input.
  - In the case of a US&R response to a large earthquake, each Task Force may be required to operate as the only FEMA US&R resource at an isolated site, and , therefore the TF StS may be required to develop their own Mitigation Plan.
  - In any case a Structure Mitigation Plan must be developed very quickly. Within the first few hours. It may start as nothing more than rough sketches, and transition into something much more descriptive.
  - The plan can be changed and improved as the incident progresses. For incidents that continue for more than a few days, the IST Geographical Information Systems Unit will probably be deployed, and detailed plans and maps will be produced that can greatly enhance the mitigation planning process

Mitigation Planning

- **Following Assessment, need to consider alternatives that will reduce Risk for Search & Rescue Operations**
  - **Need to have a written Plan that will become part of the Incident Action Plan (IAP)**
- **AHJ often asks FEMA US&R to provide a Prioritized Plan for Hazard Mitigation**
  - **Structure Hazards**
  - **Hazardous Materials, WMD**
- **AHJ normally does not have StS skills**

Mitigation Planning

- **IST-StS may be directed to develop the Mitigation Plan**
  - **TF StSs should be asked to provide input**
  - **TF StS may be required to develop their own Mitigation Plan in Large Earthquake Incident**
- **Plan must be developed quickly**
  - **Rough Draft w/sketches in Hours not Days**
  - **Plan can be changed and improved**
  - **IST GIS can enhance the graphics when practical**

Mitigation Planning

- **Plan is Essential Component of Risk vs Reward Analysis**
  - **Mitigation will normally be done in a series of steps**
  - **As Reward of finding Live Victims decreases, additional Mitigation should be Planned and implemented to further decrease the Risk to Rescuers**
  - **Mitigation may be Planned as a continuum that Reduces Risk, Step by Step**

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

STRUCTURE MITIGATION FORM

The Mitigation, Checklist Form has been developed, and may be used to efficiently develop and communicate mitigation methods and locations. This form works like a Termite Report Form, with pre-determined abbreviations for mitigation methods and space for a location map. It is shown here

US&R Struct. Haz. Mitigation Form - MIT-1 **BY:** ______________ **DATE:** ________

Where required, circle all the information or items that apply. NOTE: AFTERSHOCKS MAY CAUSE ADDITIONAL DAMAGE OTHER THAN NOTED.

STRUCTURE DESCRIPTION:

Bldg ID: ______________

No. Stories: **No. Basements:**

MATERIALS:
Wood **Concrete** **Steel** **URM** **PC Concrete**

TYPE OF COLLAPSE:
Pancake **Soft 1st Story** **Wall Failure** **O-turn** **Other**

MITIGATION METHODS & ABBREVIATIONS

Avoid and Barracade	**A&B**	**Horiz. Tieback**	**H-TB**
Remove	**Remo**	**Vert Tieback**	**V-TB**
Minimize Exposure	**Exp-M**	**Shield**	**Shld**
Vertical Shore	**V-Sho**		
Horiz. Shore	**H-Sho**	**Monitor**	**Mon**
Raker Shore	**R-Sho**	(GoTo Monitor Form)	
Daigonal Brace	**DB**	**Other** (specify)	

LIST OF POSSIBLE HAZARDS	**HAZ LOCATOR** (Use Circled No. & locate on Sketch)	**MIT METHOD** (Use abbrev. indicated above)	**PRIORITY** (From 1 to 9, may be several of ea.)	**TIME REQD** (Est. to complete reqd mitigation)	**COMMENT**
FALLING HAZARD TYPE					
Glass, Light Bldg Facing					
Bldg Contents, H'vy inc Safe					
Brick Veneer					
Rock Veneer Panels					
P.C. Panels					
HVAC Units					
Ducts, Elec Conduit					
Structure Element - Loose					
Str Elmt, Hanging & Attached					
Other					
LOCAL COLLAPSE HAZARD					
Leaning Wall					
Damaged Column					
Damaged Floor					
Un-braced Column					
Punching Shear Potential					
Debris Overload-Floor					
ResQ Equip Overload					
Rain & Clogged Roof Drains					
Damaged Retaining Wall					
Other					
GLOBAL COLLAPSE HAZARD					
Leaning Building					
Multi Floor Collapse					
Multi Column Collapse					
Other					

SKETCH:

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

STRUCTURE MITIGATION LOG

A Mitigation Log has also been developed, to keep track of the progress of on-going mitigation. It is intended to become part of the Incident Action Plan and also act as a Hand-Off document (to inform on-coming shift of the progress in deploying the mitigation

US&R Struct. Mitigation Log - MIT-Log **BY:** ______________ **SHT** ___ **OF** ___

STRUCTURE I.D.

DATE	TIME	HAZARD LOCATOR	MIT METHOD	COMMENT
Example mm / dd / yy	1100 hrs	4	R-Shore	

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

STRUCTURE / HAZARD MITIGATION (continued)

STRUCTURE MITIGATION PLANNING (continued)

- A Plan is an essential component of US&R, Structure Mitigation. It is essential to be considered in the context of Risk vs Reward Analysis.
  - As the Probability of finding Live Victims decreases, additional Mitigation should be implemented, from the Plan, in order to further reduce the risk to Rescuers
  - Mitigation should be planned as a series of well-defined steps.

Mitigation Planning
- Plan is Essential Component of Risk vs Reward Analysis
  - Mitigation will normally be done in a series of steps
  - As Reward of finding Live Victims decreases, additional Mitigation should be Planned and implemented to further decrease the Risk to Rescuers
  - Mitigation may be Planned as a continuum that Reduces Risk, Step by Step

RISK vs REWARD

- Some Risk is involved in most all US&R Operations. In addition many of the most viable Mitigation Options involve Risk, during their installation.
  - One must consider and clearly state the Mitigation Installation Risk in the Mitigation Plan
  - Obviously, the least risk mitigation should be considered first. These usually include the mitigation options that require the least time to install or institute such as

Risk vs Reward
- Most Operations in US&R involve Risk
  - Many Mitigation Options involve Risk during installation
  - Need to consider the Mitigation Installation Risk in the Plan
  - Lowest Risk Mitigation should be considered First
  - Example
    - Avoid
    - Removal
    - Spot Shoring

SURVIVAL TIME CONSIDERATIONS

- If live victims are found, their survival may depend on the speed with which they are removed. There may not be time to construct well braced shoring systems, or other complicated mitigation
  - Therefore, the amount of Risk Reduction may have to be minimized, and/or mitigation methods that are quickly accomplished must be adopted.
  - The Structures Spec must be as creative as possible, in order to find a balance between the desired Risk Reduction and the time it takes to accomplish it
  - When victim survival is at stake, a larger risk will probably be taken by Rescuers, and the StS must find a way to reduce this risk

Survival time vs time to do Mitigation
- What Mitigation requires the least time to complete?
  - What is minimum level of Risk Reduction?
  - Need to offer as many alternatives as possible
    - Each alternative should be accompanied by estimate of required time to complete
  - Is there a combination of simple measures that will suffice?
  - Need to remember victim survival may depend on rapid extrication
    - We are there to Save Lives, but not create new Victims – Difficult Choices!

SIMPLE HAZARD MITIGATION

- **AVOID** Plan direction of SAR activities as far away as possible from hazard and its effects. Access of badly collapsed structure should start from the top, rather than from the edge (between layers), or than by tunneling. The use of mining techniques of tunneling and shoring with individual vertical posts has lead to aftershock caused shore failures. Consider alternatives, consult with others, and be as resourceful as possible.

Simple Hazard Mitigation
- Avoid
  - Need effective barrier system
  - Needs to be part of the IAP
  - May be Lowest Risk Option
- Removal
  - Lift off, push over, pull down
  - Operation may require Site Evacuation
  - Needs to be part of the IAP
  - May pose some Risk to Hidden Victims

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

STRUCTURE / HAZARD MITIGATION (continued)

SIMPLE HAZARD MITIGATION (continued)

- **REMOVAL** May be more efficient than shoring. Parts of URM walls may be removed by hand, using aerial ladders for upper portions, or in larger pieces using crane and clamshell. Precast concrete sections are more easily removed by small cranes or other concrete removal machines, due to their moderate size and lack of interconnections compared to cast in place concrete. If at all possible - Lift Off, Push Over, or Pull Down (safely of course) as a first choice

- **SHIELDS** If Falling Hazards cannot be quickly removed, perhaps some sort of "Catch Structure" can be built. These structures should be Strong and Limber. One should consider Aluminum or High – Strength, Micro-Lam Timber. Aluminum is three times as limber as Steel, but can develop similar bending strength (if properly heat treated). Micro-Lam can develop twice the strength of structural sawn lumber and is very resistant to impact loading. One can build the "Catch Surfaces of these structures in layers to further increase the flexibility and provide redundancy

What if you can't remove-it?
- Build a Shield
  - Some type of "Catch System"
  - Needs to be strong and limber
    - Consider Aluminum or Micro-Lam Wood
  - Soft – Impact absorbing surface
    - Multi-Layered

Aluma beams & Plywd in Puerto Rico

- **EXPOSURE REDUCTION** One of the most efficient methods of hazard reduction is to limit the time of exposure, and to limit the number rescuers that are being exposed to a potentially dangerous situation. Because of the natural tendency of rescuers to be helpful and be **Part of the Action**, one will often find more than the minimum required number in a confined space especially when a live rescue in nearing completion. Risk is a function of both severity and exposure. In addition to Exposure Reduction, one should add a well padded Escape Route

Simple Hazard Mitigation
- Exposure reduction
  - How long do we need to be in the area?
  - Risk is a function of severity and exposure
  - Limit time exposed to hazard
  - Limit number of personnel exposed
  - Needs to be part of the IAP
  - Probably a short term, High Risk Option
- Similar to Time, Distance, & Shielding Rule used in Hazmat

- **MONITOR** as discussed previously, methods including the use of crack measuring devices, Theodolites and other tilt measuring devices (Change in Tilt) are used to monitor damaged structures. To be effective these devices must be continually read and accompanied by an effective alarm system that activates an efficient evacuation plan. Monitoring will be discussed in detail, later in this section

- **RECOGNIZE** and refer hazardous materials to Hazmat Specialist. Eliminate/Shut off all possible fire hazards.

Other Hazard Mitigation
- Monitor Structure Hazard
  - Later in this section
- Recognize & Refer Hazard (Hazmat)
  - US&R TFs may be equipped and asked to perform Offensive Ops in WMD Incident
    - Rescue TF members + few other victims
    - StS need to be prepared to operate in Contaminated Environment

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

STRUCTURE HAZARD MITIGATION (continued)

SHORT or LONG TERM RESCUE

- Short Term would normally be considered as a rescue that took a few hours and therefore, would not involve complicated mitigation.
  - The mitigation that would be appropriate are the "Simple " methods that we have just discussed
- Long Term Rescue and/or Recovery would involve more than one live victims and/or possibly body recovery. It could last for many days, and could eventually be transitioned into the Recovery Phase when all hope of finding live victims had gone.
  - The mitigation for Long Term Rescue would be more complicated and should be considered as a series of steps that produce an increasing amount of Risk Reduction.
  - Shoring, Bracing and Tiebacks are the type of mitigation that should be considered, and they will be briefly be discussed here and more extensively in following Sections.
- **SHORING** Provide both vertical and lateral support, build safe haven areas. This will be discussed in detail in its own section, with special emphasis on slow/forgiving failure modes. Shoring should be planned as a series of progressively more stable installations.
  - Initially, spot shores could be quickly installed. They are one dimensional, Class 1 Shores
  - These would be followed with multi-post, two dimensional, Class 2 Shores
  - Lastly if two-post , Class 2 Shores are built, they can be converted to three dimensional, Class 3 Shores
- **LATERAL BRACING** Lateral bracing of damaged columns, beams, leaning walls and entire leaning buildings may be required. This bracing is best constructed using wood or steel diagonal compression members, or Raker Shores. The lateral braces should be constructed in pairs or greater numbers with adequate lateral bracing.
- **LATERAL AND VERTICAL TIEBACKS** Tension tieback bracing can also be effective for holding walls, and cranes have been used to temporally suspend parts of damaged buildings. The design of any system using Wire Rope Tiebacks in tension, must account for considerable elongation of the system.
- **IN SUMMARY** a comprehensive Plan is essential to efficient, well conceived Mitigation, where the Risk vs. Reward ratio is clearly articulated and understood

Short & Long Term Rescue??
- Short Term Rescue
  - Assumes one or two Live Rescues
  - Up to Two Hours
  - Does not involve complicated mitigation
  - Usually involves minimum exposure
- Long Term Rescue/Recovery
  - Assumes one or more live rescues and possibly body recovery
  - May last from 2 hrs to several Days
  - Involves shoring, bracing, etc
  - Mitigation should continue to further Reduce Risk as rescue proceeds

Longer Term Hazard Mitigation
- Vertical & Lateral Shoring
  - Place Shoring in Sequence (long term rescue)
    - Progressively Reduce Risk
  - Class 1, Spot Shores
  - Class 2, Two-dimensional Shores
  - Interconnect pairs of Class 2 to form Class 3, Three dimensional Shores
- Systems w/ predictable Failure Mode
  - Wood system with slow failure mode
  - Struts, Pipes w/ buckling Failure Mode are less desirable
    - Short Term, Class 1 solution

Other longer term Hazard Mitigation
- Lateral Bracing
  - Use to reduce Buckling Risk of Column left after Collapsed Floors
    - Choices are Brace for 2% load, Remove much Load, or Sister Column
    - Bracing often most efficient choice
  - System of Spot Shores against leaning building
- Lateral Tieback
  - When shoring isn't practical
  - Need Adequate Anchors
    - May need new concrete Dead Men, etc

Other longer term Hazard Mitigation
- Vertical Tieback
  - Use cable to hang structure from above
  - Failure Mode may be Brittle
  - Connection to and developing the Load may be difficult
  - May use Crane or Excavator to temporarily hang structure
    - De-rate Load Chart to increase Safety Factor from 1.2 to 2.4

Mitigation Summary
- Start with a Plan
  - AHJ needs Prioritized Plan
  - Start w/ rough sketches goto IAP w/GIS
- Risk vs Reward
  - Identify Risks for installing the Mitigation
  - Increase Mitigation as Reward is reduced
- Do most Simple Mitigation First
  - Some simple may present High Risk
- Place most appropriate Shoring/Bracing
  - Don't be Limited by what was done elsewhere

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

METHODS TO MONITOR STABILITY

The fundamentals of structural monitoring for SAR include: a **Monitoring Plan**; effective **Emergency Communication Plan**; **Monitoring Tools, & Trained Monitoring Personnel**.

MONITORING PLAN: Similar to a design performance memorandum, the monitoring plan establishes the expected performance levels for the structure being monitored.

- **Where, How & Direction**
  - Identifies what structure or component is being monitored, why, and for how long monitoring should continue.
  - One needs to visualize the failure mode. If it is not ductile, there probably will not be adequate time for a warning, so Monitoring would not be a viable method of Mitigation
    - What is the direction of the expected movement?
  - One must determine which of the available monitoring tools will best determine the expected movement.
    - Angular rotation can be measured using several tools
    - The accurate measurement of lateral and vertical translation need to be carefully planned.
  - Safety and sightlines will probably influence the location of the monitoring devices on the structure
  - Identifying survey targets on a damaged structure may not be possible so finding appropriate targets that will telegraph incipient movement is critical.
- **Control / Reference Points**
  - The establishing of control and reference points will help ensure the accuracy of the monitoring.
    - Control points should be visible in various conditions and from at least two monitoring locations (to observe movements in X, Y and Z directions
    - Control points should be checked often in order to eliminate false reading. False reporting will destroy the Credibility of the entire Monitoring Program
  - Control Points need to be selected for stability. The effect of the following need to be anticipated and understood:
    - Wind and Temperature
    - Changes caused by debris removal
    - Changes in sight lines

Elements of Monitoring
- Monitoring Plan
- Record Keeping
- Emergency Communication Plan
- Monitoring Tools
- Properly Trained Personnel

Monitoring Plan
- Where and how
- Control/Reference Points
- Directions of movement
- Caution vs Alarm
- Record Keeping
- Report Info in Incident Action Plan
  - Info gets to those who need it

Where, How & Direction
- Visualize Failure Mode
  - Must be Ductile
- What tools will best detect movement
  - Measure Angular Rotation
  - Measure Translation
  - Measure Vertical Deflection
- What is most likely direction of movement
- Where to place monitoring devices on structure

Control / Reference Points
- Essential to establish Repeatability
  - Establish Credibility
  - Avoid False Alerts/Alarms
- Selected for Stability
  - Not affected by :
    - Wind
    - Temperature
    - Changes from Debris Removal
    - Changes in Sight Lines

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

METHODS TO MONITOR STABILITY (continued)

MONITORING PLAN (continued)

- **Caution vs. Alarm**
  - Must establish the tolerances, which create a "**CAUTION**" or an "**ALARM"** notification.
    - **Caution** levels might include movements that are out of the expected, but not large enough to warrant evacuation.
    - **Alarm** levels would include movements that telegraph impending collapse and evacuating rescue personnel is appropriate.
    - NOTE: Expected movements due to thermal expansion/contraction shouldn't initiate a "CAUTION".
    - The adjacent slide shows the comparison between Story Drift and Angle Rotation. Since some of the US&R monitoring devices measure only rotation, one must have an idea of what amount of story drift is "Normal" and convert that to rotation
  - An effective emergency communication system used to inform command of changing site conditions and the potential for site evacuation, must be initiated- to be discussed.
- **Data Interpretation**
  - In order to know what any finite movement means, one must consider the following important factors:
    - What was the initial condition of the building? However, in many cases US&R StS will have little data, and will need to assume a plumb structure .
    - What is the magnitude of the movement, as well as its rate? Most buildings oscillate daily as the sun moves from one side to the other. However, even gradual movement, all in one direction, would require careful and serious consideration.
    - What are the external influences? Are afternoon winds a normal phenomenon? It there mass transit trains nearby that cause vibrations
  - The adjacent slide presents the 1, 2, 3 Rule for "Normal Story Drift" that should be expected under somewhat windy conditions and sun angle change
  - Monitoring devices are subject to various types of movement factors as listed on the adjacent slide. The device's resolution must be considered. That is one of the reasons for favoring the use of the Total Station

Caution vs Alarm
- Need to know what is "Reasonable" or "Normal" Movement
  - Due to light winds
  - Due to change in Sun Angle
- Only valid is Failure Mode is Ductile
  - Otherwise, No Warning Time
- Levels may change
  - Based on incident's observation history
- Need Effective Warning System
  - See Emergency Comm Plan to follow

Story Drift
Compare Angle Rotation to Story Displacement – in one 12ft story

Angle (deg)	.01	.05	.10	.15	.20	.40	.60	.80
Drift (inch)	.025	.126	.251	.337	.502	1.0	1.51	2.01

Story Drift = Lateral Displacement in 1 Story

Data Interpretation
- Most Challenging Aspect
  - No simple Rules
  - Consider overall context of Bldg & Incident
- Key Factors to Consider
  - Initial Conditions
  - Movement Magnitude & Rate
  - Movement Trend –Cyclic, Monotonic, Step
  - External Influences
- All movement must be considered "In Context"
  - Murrah Bldg – "Normal" was 5/8" in 10 stories

Reference Movements - Bldgs
- The 1, 2, 3 Rule – Normal "Noise"/ Story
  - Concrete = 1/16" (0.025 deg)
  - Steel = 2/16" (0.05 deg)
  - Wood = 3/16" (0.075 deg)
- Rough estimates only
  - Caused by change in sun angle
  - Caused by light winds
  - Day- night transition

Reference Movements - Devices
- Plumb bob – Vulnerable to wind
- Crack Gage – Parallax may be an issue
- Smart Level – Resolution is 0.20 deg
- Laser Level – Diameter of Beam
- Total Sta/Theodolite – Depends on quality and stiffness of Tripod Set-up
- WBMS – Resolution is 0.05 deg
  - Software displays to 0.01 deg

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

Communication Protocols

- There is a critical balance that needs to be assessed: The need for rapid notification vs. the need to avoid false alarms. If there are movements observed in a critical element, one must quickly decide of they could lead to a collapse. This will be very difficult.
  - To facilitate this process a meeting with appropriate leadership should be held in order to determine;

  What is the communication chain

  At what level of movement will trigger the alarm.

  Who has authority to sound the alarm

  What is the plan for responding to the alarm

Recording Data

- Monitoring data should be recorded periodically, depending on the level of risk the monitoring point presents to rescuers. It also should be done following the significant events that could cause changes in stability. Each incident will be different, but the following are suggested as typical:
  - Initially the periodic reading could be made as often as every few minutes, especially when attempting to determine how the structure is responding.
  - After in initial performance has been established, readings should be made at least hourly for all critical structures, and at two or three hour intervals for others.
  - Readings should also be done following significant events such as: Aftershocks; windstorms exceeding 25 mph; shifting of debris. impacts cased by objects being moved by heavy equipment.
- The history of monitoring reading and activities needs to be communicated to the on-coming StS at each shift change. The Monitoring Forms that will be discussed next, provide a standard method for doing this.

Record Keeping

- The StS must document all readings, expected direction of movement(s), potential failure-modes and effects, observations, and readings.
  - An effective record keeping system needs to be well organized and keeps the Incident Command, Incident Support Team (IST), and Task Force Leaders, informed of site conditions.
  - The Task Force StS would normally keep the his/her Safety Officer and Rescue Team Manager informed of the monitoring activities.

Communication Protocols
- Need to strike a balance between Rapid Notification and Avoidance of False Alarms
  - Alert Threshold must be greater than "Normal", but less than Impending Collapse
- Must be able to Effectively Communicate any Alarm to Leadership
- A pre-determined "Alarm Level" should be discussed & established with Leaders, so Rapid Response is Facilitated

Recording Data, Intervals
- Periodically
  - Initially Hourly – Later at longer interval
  - Electronically and/or MON-1 & MON-Log
- Discussion at Shift Change
- Following Significant Events
  - Aftershocks
  - Windstorms
  - Shifting of Debris
  - Heavy Equipment – load collisions, etc

Record Keeping
- Written Records need to be kept of all Monitoring Devices
  - All Monitoring Devices, inc Crack Monitor
  - See next slide for suggested intervals
- Recording System could be setup and kept by IST Structure Spec Staff
  - Each TF Structure Spec should keep own Unit Log (ICS 214) including Monitoring Data
  - Need to share data at every shift change, assuming no significant movement (Hand-off)
  - Report Info in IAP, OAP and/or TAP
    - Depends on incident & IST

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

- **Record Keeping (continued)**
  - Depending on incident specifics, the TF StS may be asked to coordinate all monitoring with the IST StS at every shift change, and when appropriate
  - The documentation may be included in the Operational Action Plan (OAP), generated by the IST and/or the Incident Action Plan, generated by the Incident Command Staff
- **Monitoring Forms**
  - These forms were revised in 2008 in order to accommodate the data needed for operation of the Total Station
  - Previous to 2007 there were only two monitor forms, and both were formatted as **Portrait.**
    - MON–1 was the initial form, to be used to record the conditions of the instrument setup, control points (CP) & monitoring points (MP). Its use has been discontinued in favor of the new, landscape version that will be discussed next.
    - MON-Log was used to record the data every time a monitoring point was checked. Its use is still recommended, even though a landscape MON-Log is also provided, since more readings may be recorded on one sheet. It is also assumed that this form would be used with simple monitor devices.
  - The **Landscape** forms: MON-1, MON-2, CP-Log and MON-Log have been developed for use with the Total Station by the Structures Spec**.** They may also be used with the other, less complicated, monitoring devises.
    - MON–1 is the initial form, to be used to record the conditions of the instrument setup, control points (CP) & monitoring points (MP). It provides space for a sketch
    - MON-2 is intended for additional setups, CP & MP
    - CP-Log is to be used to log the data every time the control points are checked, and or when the instrument is moved (for whatever reason) and re-established.
    - Mon-Log is used to record the data every time a MP is checked. There would be as many MON-Logs are there are MPs.
    - All these forms can serve as part of the Shift Change hand-off documentation, and as previously mentioned may become part of the OAP

Samples of these forms are on following pages

Recording Data, Intervals
- Periodically
  - Initially Hourly – Later at longer interval
  - Electronically and/or MON-1 & MON-Log
- Discussion at Shift Change
- Following Significant Events
  - Aftershocks
  - Windstorms
  - Shifting of Debris
  - Heavy Equipment – load collisions, etc

FEMA Monitor Forms - 2009
- Landscape forms have been developed for better use w/Total Station
  - MON-1, MON-2, CP Log and MON-Log in Landscape format
- The Landscape forms may be used for less complicated monitoring devices
  - Mon-1 and Mon-Log in landscape
  - MON-Log is also provided in portrait, since it will all for the recording of more measurements on 1 sheet
- All Monitoring Forms would be used to hand-off information to the on-coming shifts
  - They should become part of the OAP or TAP

Monitoring Log – Portrait
- This forms is intended for use with simple monitoring devices
  - Theodolite
  - Electronic and Laser Levels
  - Wireless Bldg Monitoring System
    - It creates its own Log File on a SD Card
  - Plumb-bob & Crack Monitors
- MON-Log is used to record the data every time a monitoring point is checked
  - Number of these forms depends on how many monitoring points
    - If only a few points, may use one form per day
    - May use one form per monitoring point per day
    - Use as many as appropriate

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

US&R Struct. Monitoring Form - MON-1 By: ____________ Date: __________

Monitoring Began Monitoring Ended

STRUCTURE DESCRIPTION:

Bldg ID: ______________________
____

No. Stories: _____ No. Basements: _____

ATMOSPHERIC CONDITIONS Temperature_____

☐ Day ☐ Clear ☐ Calm ☐ Haze
☐ Nite ☐ Cloudy ☐ Windy ☐ Gusty

SKETCH OF SITE (show structure, instrument, CPs):

INSTRUMENT SETUP

Model/Serial No. ________________ Calibrated Yes / No
Location ________________ Job Name ________________
Description ________________ IP Coordinates ________________

CONTROL POINTS - at least three (see CP-LOG)

Name ________________
Location ________________
____
Description ________________
____

MONITORING POINT # (MP)

Location ________________
Description ________________
ALERT displacement = ________
ALARM displacment = ________

CONTROL POINTS - at least three (see CP-LOG)

Name ________________
Location ________________
____
Description ________________
____

MONITORING POINT # (MP)

Location ________________
Description ________________
ALERT displacement = ________
ALARM displacment = ________

CONTROL POINTS - at least three (see CP-LOG)

Name ________________
Location ________________
____
Description ________________
____

MONITORING POINT # (MP)

Location ________________
Description ________________
ALERT displacement = ________
ALARM displacment = ________

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

US&R Struct. Monitoring Form - MON-2 By: ________ Date: ________ Mon-2 Sht ____ of ____

Monitoring Began Monitoring Ended

ADDITIONAL INSTRUMENT SETUP LOCATIONS		SKETCH OF SITE (show structure, instrument, CPs):
Location ________	Job Name ________	
Description ________	IP Coordinates ________	
CONTROL POINTS - at least three (see CP-LOG) Name ________ Location ________ ________ Description ________ ________	MONITORING POINT # (MP ____) Location ________ Description ________ ALERT displacement = ________ ALARM displacment = ________	
CONTROL POINTS - at least three (see CP-LOG) Name ________ Location ________ ________ Description ________ ________	MONITORING POINT # (MP ____) Location ________ Description ________ ALERT displacement = ________ ALARM displacment = ________	
CONTROL POINTS - at least three (see CP-LOG) Name ________ Location ________ ________ Description ________ ________	MONITORING POINT # (MP ____) Location ________ Description ________ ALERT displacement = ________ ALARM displacment = ________	
CONTROL POINTS - at least three (see CP-LOG) Name ________ Location ________ ________ Description ________ ________	MONITORING POINT # (MP ____) Location ________ Description ________ ALERT displacement = ________ ALARM displacment = ________	

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

US&R Struct. Monitoring Form - CP-Log

By: ______ Date: ______ CP Sht __ of __

SITE PLAN SKETCH

CONTROL POINT	READINGS*			TIME	IP Loc.	Comments, notes, angles...

* NOTE: Total Station record X, Y, Z coordinates. Theodolite record Horizontal (HA) and Vertical (VA) Angle.

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

US&R Struct. Monitoring Log - MON-Log - MP # ____ By: ____________ Date: ________ MP ____ Sht ____

POINT	READINGS*			TIME	IP Loc.	Comments, notes, angle	SKETCH

* NOTE: Total Station record X, Y, Z coordinates. Theodolite record Horizontal (HA) and Vertical (VA) Angle.

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

US&R Structure Monitoring Log - MON-Log-P **By:** __________ **Sht** ___ **of** ___

DATE	TIME	REF (Control) POINT	MONITORING POINT	COMMENT
Example				
mm / dd / yy	1000 Hrs	RP1-1 actual reading		Temp = 77F, establish control #1
	1000 Hrs	RP1-2 actual reading		Establish control #2
	1005 Hrs		MP1-1 initial reading	Establish monitoring point #1
	1015 Hrs		MP1-1 reading	No change from previous reading.

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

METHODS TO MONITOR STABILITY (continued)

- **Emergency Communication Plan**: Effective monitoring must utilize an effective **warning system** that informs Incident Command of potential structural movement (CAUTION) and includes a signal system to communicate **site evacuation** (e.g. three long horn blasts).

  - The FEMA Incident Support Team and Task Force Leader(s) must persuade the Local Incident Command to integrate the local monitoring plan into the overall site safety plan.
  - All rescue personnel must understand and be able to hear the warning device.
  - All must know their evacuation route, and to whom they are to report –Accountability

- **Monitoring Tools** - The following indicators have been used to monitor damaged structures in an attempt to warn of change in stability:

  - Engineers Theodolite or Total Station.
  - Electronic Tilt-meter Systems
  - Electronic Levels
    - SmartTool and SmartLevel
  - Laser pointers or Level
  - Plumb bob.
  - Crack measuring device

- **Theodolites and Total Stations** have been successfully used to monitor damaged structures, including Falling and Collapse Hazards.

  - They are capable of very remote sightings on damaged structures that allow the observer to operate without significant risk.
  - Also it is not required that the monitoring point be able to be physically accessed (only clearly observed).
  - For reliable and repeatable results it is necessary to establish control points, such as back sight lines, that allow for re-setup of the instrument.
    - This may be problematical following earthquake **Aftershocks** when many structures and ground surfaces have been moved and possibly disrupted.

Emergency Comm. Plan

- **Effective Warning System**
  - **For Caution and Alarm Warnings**
- **Involves Coordination**
  - **FEMA Task Force Leaders**
  - **FEMA Incident Support Team**
  - **Incident Command**
- **All must understand, and be able to Hear Warning Signals**
- **All must know their Evacuation Routs, and to Whom they Report**

US&R Monitoring Devices

- **Theodolite and Total Station**
  - **Reflectorless Total Station**
- **Electronic Tilt Meter**
- **Electronic Level**
  - **SmartLevel & SmartTool**
- **Laser Levels**
- **Plumb bob**
- **Crack measuring devices**
- **Wind Speed Measuring Devices**

Use of Devices

Theodolite/Total Station

- **Theodolite/Total Station may be used to detect small movement in remote structures**
  - **Method 1 - Establish a vertical line that will compare a point on a dangerous building to a point on the ground to detect additional tilt / movement**
  - **Method 2 - Use a Reference Point on an adjacent building, and turn an angle to several locations of potential movement on a questionable structure**
  - **Method 3 - Just do a spot check on an individual point on a damaged structure, such as Falling or Collapse Hazards (Total Station could measure X, Y, & Z)**

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

METHODS TO MONITOR STABILITY (continued)

- **Theodolite/Total Station Surveying Methods**: There are at least three methods that may be used when operating a Theodolite

  - **Method One** is to establish a vertical control line that will compare a point on the structure to a fixed point on the ground, in order to monitor any changes in a leaning column or wall.

    - This method is simple and provides reliable control and repeatability – **Especially post Aftershock**

  - **Method Two** is to use the Theodolite is to establish a reference point on an adjacent, stable structure, and then turn a series of horizontal angles to locations of interest on the damaged structure.

    - In this case we may be limited by the angular accuracy of the Theodolite.
    - This method requires the additional step of crosschecking the reference point, to assure that an observed movement has been accurately measured.

  - **Method Three**, the Theodolite may be used to spot check a single point on a structure, measuring any movement using the telescope crosshairs.

    - This method is inefficient, not repeatable, and not normally recommended.
    -
    - There may be instances where quick, short term monitoring of this type is all that is required, based on short term risk

- **Theodolite/Total Station Advantages and Disadvantages**

  Advantages: Allows for observation w/o making contact w/structure, and very distant observation with ability to zoom in on structure

  Disadvantages: Expense, Need well trained personnel, subject to false readings when instrument is accidentally bumped, reading are not as intuitive to unfamiliar personnel

Use of Devices
Theodolite/Total Station
- **Theodolite/Total Station may be used to detect small movement in remote structures**
  - **Method 1 - Establish a vertical line that will compare a point on a dangerous building to a point on the ground to detect additional tilt / movement**
  - **Method 2 - Use a Reference Point on an adjacent building, and turn an angle to several locations of potential movement on a questionable structure**
  - **Method 3 - Just do a spot check on an individual point on a damaged structure, such as Falling or Collapse Hazards (Total Station could measure X, Y, & Z)**

Use of Devices -Theodolite/Total Station
- **Advantages**
  - **Observation w/o contacting structure**
  - **Make Distant Observations**
  - **Ability to Zoom - In on structure**
  - **Observe many points from One Location**
- **Disadvantages**
  - **Cost of instrument**
    - **20sec Theodolite = $2000**
    - **5sec Reflectorless Total Sta = $6500**
  - **Need Trained Operators**
  - **Readings not Intuitive**
  - **Need stable Reference/Control points**
    - **Difficult establishing aftershock control?**
  - **Can't Use w/Face Mask**

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

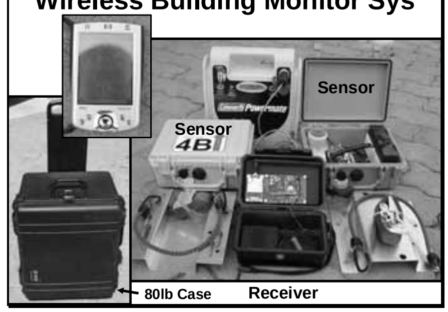
METHODS TO MONITOR STABILITY (continued)

- **Theodolites** have been often been used poorly and without reference marks, as well as proper records and warning systems.
  - As a result erroneous readings have caused false alarms to be sounded.
  - This is, obviously, an intolerable condition that can undermine the creditability of a monitoring system
  - The most common cause of false readings is inadvertent moving of the tripod.
    - One needs to establish effective barrier systems around Theodolite monitoring stations.
    - Previously established, back sights and reference points can minimize these problems.
    - At earthquake caused incidents, one must also plan for Aftershocks by setting up the instrument and the reference points properly
- **A Wireless Biaxial Tiltmeter System** is available from: Exponent Technology Development - Wireless Building Monitoring System (602) 206-4126 www. Exponent.com
  - A full-system consists of four, bi-directional sensors that can be read by either one of two iPAQ Pocket PC (or a laptop computer) A full-system has 2 spread spectrum receivers.
  - Receivers have range to 1000ft with clear sight line, but less if signal is obstructed be heavy or metal structures.
  - The software will poll each sensors at 10 sec intervals. It checks the signal for interference, and a audible ping is heard as each sensor "reports" good data
    - A lower frequency "clunk" is heard if a sensor is not operation properly or turned off
  - The software can be set to trigger an alarm at any preset angle change (alarm can be sounded through an earpiece)
  - Tilt meters are sensitive to angle change of .05 deg.
  - WBMS units are in Pelican Cases, each having:
    - Two Sensors with 7 day, 12v. batteries & cables
    - One Receiver w/ Blue Tooth communication
    - One PDA w/ Pocket PC 03 or Mobile 5 Op System
    - Software, Manuals & connecting hardware
  - In 2005, FEMA purchased, 2 full systems for each IST (Four Pelican Cases + small case w/drill-driver, etc)
  - Advantages and Disadvantages show in adjacent slide

Use of Devices - Theodolite/Total Station
- Theodolite have often been used Poorly and without Reference/Control
- False Movements have been reported at several major incidents
  - Most often as a result of someone inadvertently bumping the tripod, without having an adequate Reference/Control mark system
  - This can lead to a lack of confidence in this very important system
- This is a very effective device that must be used properly

Use of Devices – WBMS
- Wireless Building Monitoring Sys (WBMS)
  - System uses up to 4 Sensors, placed structure(s), to measure & transmit movement as an angle change.
    - Measures angle change of 0.05 degree (repeatable)
  - Signal is sent to 900mh Spread Spectrum Receiver
    - Range is up to 1000 ft. (clear sight)
    - Not as far thru Heavy Concrete & Metal Structures
  - Receiver is linked to MS Pocket PC PDA or a Laptop by wireless, blue-tooth connection
    - PDA software polls sensors at 10 to 15 sec interval
    - PDA chirps for each coherent signal received
    - May set software to alarm for any amount of angle change
  - Available at IST, FEMA & USACE systems
    - Use special mounting hardware

Wireless Building Monitor Sys



Use of Devices – WBMS
- Advantages
  - Monitor 4 or more locations at once
  - Very accurate and can set Alarm for any amount of movement
  - Portable Receiving/Alarm System
  - Remote Observation (up to 1000 ft)
  - Can Use w/Face Mask
- Disadvantages
  - High cost ($18,000 per full-system, 2005)
  - Need Qualified, Techno-Operator
  - Need planned, periodic battery recharge system
  - Need to place Sensors on Structure
    - They have remote, 7-day, 12v batteries

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

METHODS TO MONITOR STABILITY (continued)

- **Electronic levels,** sensitive to an angle change of 0.1 degree, with digital read-out, can be purchased at Home Depot type stores and on-line for about $100 (2005).
  - They can be mounted on a structure, the angle recorded, and any subsequent change would then need to be read by a TF member.
  - In order to mount the SmartTool on a concrete structure, one may do the following:
    - Place a 1 x1x1/8 x 0'-9" steel angle that has been attached to the structure with putty type epoxy or 1/4" concrete screws placed thru 5/16" holes that have been drilled in the angle
    - One may use a 2 ½" C-clamp in addition to the tape or as another type of removable, but positive connection
  - They are supplied with a battery saver feature that turns them off in 5 min. if no change in angle is sensed.
    - This feature can be defeated by a modification: write D. Hammond at djhammond@sbcglobal.net

    Made by MACKLANBURG-DUNCAN
    TOOL CRIB CATALOG (# 92288) 1-800-635-5140
    www.amazon.com\toolcrib
    SEARS TOOLS sells Crastsman SmartTool
    (#30758) 1-800-377-4717

- **Laser Levels**, may also be used to measure an angle change of about 0.1 degrees. An inexpensive one may be purchased at Home Depot for less than $100 (RoboToolz) in a 3-beam or single beam configuration, and come with magnets embedded in their bottom surface. Hilti makes a more accurate and useful Laser Level Kit PMP-34, which is self leveling and includes mounting devices
  - Both may be mounted on a structure using the same steel angles and screws as for the SmartTool
  - One would then need to place a target within 75ft of the device with an **X** on it to observe the structure's movement
  - One could use the 3-beam laser level with 2 targets to observe movement in two directions. Otherwise it would require that two single beam lasers be mounted in a mutually perpendicular orientation (same as SmartTools)
  - Battery life is an issue with the RoboToolz laser, since it only has 12 hours of operation on its AAA batteries. The Hilti PMP-34 uses 9v. batteries (about 40 hours)

Use of Devices – Electronic Levels

- **Electronic Levels should be placed in pairs on structure to measure change in any angle (Vertical or Horizontal)**
  - **Measures angle change of 0.2 degrees**
  - **Cost is in $100 range, each**
  - **Must be continually read (no alarm)**
    - **New lower cost model cannot be set on zero when placed in vertical position**
  - **Use binoculars for remote reading**
  - **Must alter device to turn battery saver off**
  - **Mount on steel angle using a C-clamp**

Use of Devices – Electronic Levels

- **Advantages**
  - **Low cost**
  - **Long battery life (about 40 hours)**
  - **Easy to read**
- **Disadvantages**
  - **Not as accurate as WBMS**
  - **Need to place on structure**
  - **Need to place 2 in each location to measure angle change in N-S + E-W direction**
  - **Someone needs to read them – line of sight**
  - **Need to modify Battery Saver Function**

Use of Devices – Laser Levels

- **Laser Levels - placed on structure to indicate movement by changed position of the light beam on a specified target**
  - **May measure angle change or lateral/vertical movement**
    - **Accuracy depends on setup – maybe 0.2 degrees,**
    - **1/8"Must be continually read (no alarm)**
    - **Target should be set in safe area**
  - **RoboToolz Laser Level**
    - **Low cost, but less useful**
  - **Hilti Laser Level - PMP-34 – In Cache 2009**
  - **Moderate cost w/ lots of extras**

Hilti PMP-34 Laser Level

- **GSA cost is $460 each for tri-axial laser**
- **Battery life is about 40 hours (AA batteries)**
- **Comes w/ case and several mounting devices**
- **Self leveling, and has several modes of operation**
  - **Single, Double, Triple, Self level off, Battery save off**
  - **2009 Cache**

Use of Laser Levels

- **Advantages**
  - **Low cost**
  - **Easy to read**
- **Disadvantages**
  - **Not as accurate as WBMS**
  - **Need to place on structure**
  - **Need to place 2 targets for each location to measure angle change in N-S + E-W direction**
  - **Someone to read them – line of sight**
  - **Need to replace batteries**
    - **Every 12 hrs for RoboToolz**
    - **Every 40 hrs for Hilti**

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

METHODS TO MONITOR STABILITY (continued)

- A simple **Plumb Bob** and string can be used for small to moderate structures to determine changes in position of one story from another, between a story and the ground, or between an upper part of the wall and the ground.
  - This can allow one to measure & record the changes in a leaning structure when other device is available.
  - A rock on a string will suffice

  Benefits: inexpensive and simple to use. No special skills are required

  Disadvantages: Personnel must attach plumb bob to structure and constantly observe it

Use of Devices – Plumb Bob
- **Use a Plumb bob hung from small structure to compare to a point on the ground/pavement**
  - **Allows one to observe change in a leaning structure**
- **Advantages**
  - **inexpensive, easy to use, no special skills (a rock on a string will suffice)**
- **Disadvantages**
  - **Requires one to attach to structure, constant observation, not too accurate**

CRACK MEASURING DEVICES

Cracks in concrete or masonry shearwalls or concrete moment frame beams can be monitored in several ways. Obviously, it is important to know if the cracks in a damaged building are of a constant width or enlarging. Methods that have been used include:

- Marking an "**X**" across the crack with the center on the crack. Lateral movement changes can be observed.
- Placing folded paper in cracks or use automobile thickness gages (.004" to .025") in a specific location.
- Adhesive or other tape may be placed across the joint to measure change, but dusty conditions may prevent tape from adhering. (Need to be prepared to clean surfaces if this is only option that is available.)
- Two parallel sticks (rulers) can be taped across a crack with a perpendicular line being drawn across both of them (or existing lines on two rulers can be aligned). If the crack changes width, then the originally straight line will be offset.
- Plastic Strain gages may be placed across cracks to indicate change. (mount with quick set epoxy or screws)

  Made by: Avongard, (www.avongard.com)

  (inexpensive glass slides used with microscopes may, also be used in this way
- Note that if a structure has significant changes in temperature, the cracks will change width, due to the temperature change. The larger the structure the larger the change.

Crack Monitoring
- **Draw or sawcut 'x' centered on crack**
- **Use inexpensive ($15) plastic strain gage can be placed at crack**
- **Spray paint cracked area**
- **Place shims/cards in cracks**
- **Inexpensive, easy to read change, but need to be checked (up close) periodically**

WIND SPEED MONITORS

As shown in the adjacent slide, inexpensive, pocket devises may be used to monitor the wind speed. One is included in the FEMA US&R StS Cache

Monitor Wind Speed
- **Low cost, hand-held devices**
  - **Kestrel = $100**
  - **Brunton = $60**

- **Weather Station w/ remote sensors**
  - **$150**

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

METHOD TO MONITOR DISASTER SITE

SEISMIC TRIGGER DEVICE

This can be installed at the site to sense the initial **P** waves of strong aftershocks. Since the P waves travel at 5 km/sec max. and the damaging **S** waves follow at approx. 3 km/sec, a warning signal could be triggered at a building site prior to the damaging effects of the **S** wave.

- The device comes in a portable carrying case and would need to be bolted to a solid slab/foundation, etc. somewhere near a damaged building.
- For sites within 10 km of the aftershock origin there would not be enough warning to be useful.
- For sites over 50 km away there would be would be time to escape to cover etc. (seven seconds +)
- A device of this type was used at a site after the Loma Prieta Earthquake. The current cost of the device is approximately $6000.00 and is manufactured by:

  Earthquake Safety Systems
  2064 Eastman Ave., Ste 102 Ventura, CA 93003
  (805) 650-5952

AFTERSHOCK WARNING SYSTEM

The U.S.G.S., and others, have discussed making an aftershock warning system available to US&R Task Forces during the first week after an earthquake.

- The system uses an array of sensors near the fault to detect aftershocks.
- A warning signal is relayed by repeaters to individual pagers that will be given to each task force that is involved in rescue operations.
- For sites that are about 10 km from the active fault, there will be only 3 seconds warning.
- For sites that are 50 km away there will be 12 seconds warning (proportionally greater warning for greater distance from aftershock origin).

Method to Monitor Disaster Site

- **P vs S wave - time delay**
  - **P wave travels faster than S waves**
  - **If distance from Fault to Site is more than 50km there is opportunity to warn of Aftershocks**
- **Seismic Trigger deployed at Disaster Site**
  - **Warns when P wave arrives**
  - **Destructive S wave arrives later**
- **Pager System**
  - **Pagers at disaster site are signaled from sensors at fault that measure Aftershocks**

SECTION 1.5 INTRO to MITIGATION & MONITORING TOOLS

TRAINED MONITORING PERSONNEL

- Personnel that are adequately trained to implement the monitoring plan are critical to an effective plan.
- In most cases the Task Force, Structures Specialists need to focus their attention on other tasks, such as assessment, providing aid to the rescue efforts, mitigation design, etc.
  - A Structure Specialist may even need to leave the site as part of a Search and Recon Team
- In past incidents, the Incident Support Team (IST) Structure Specialist has been able to provide Monitoring Support to the Task Forces.
  - Trained individuals from the U.S. Army Corps of Engineers will normally be available, as part of the IST staff, to provide Monitoring as well as other support to individual Task Forces
  - It is unlikely that local, Professional Land Surveyors would be able to help due to liability issues.
- As a minimum, monitoring personnel should:
  - Be thoroughly trained in the use of monitoring tools and equipment.
  - Be able to translate observed conditions into appropriate action.
  - Be able to detach themselves from the rescue operations for long periods of time.

Trained Monitoring Personnel

- Need properly trained individuals
- TF Struct Spec may be needed elsewhere
- Monitoring help is Function of IST StS
  - Pre-scripted Mission Assignment, USACE
  - Local Land Surveyors
  - Other Local Assets
- Proper Training
  - Understand US&R
  - Know what to do with observations
  - Detach from Rescue Operations

SUMMARY

- Structure Mitigation is one of the most important tasks for the StS. It requires a creative, progressive approach, that needs continual Planning and Prioritization
- Structure Monitoring needs careful planning and coordination.
- The StS needs to become familiar with all the monitoring tools in the US&R Cache, and know the advantages/disadvantages of each
  - Special forms have been created to record the data from the monitoring equipment. The StS needs to become familiar with the use of these forms, prior to any deployment
- Monitoring Tools need to be operated by trained individuals, and the Task Force StS may need help from outside the Task Force to operate some of these tools
  - A StS Tool Check List has been developed that should be completed by each StS every two years. See next page and Disasterengineer.org, Library

Key Learning Points

- Structure Mitigation requires initially rapid and then continuing Prioritization & Planning
  - Creative Alternatives are what is needed
- Monitoring needs careful planning & the reporting of reliable information
  - The StS must become familiar with the Operation and Care of all Monitoring Tools in the Task Force Cache

TASK FORCE StS TOOL CACHE OPERATING SKILLS

Task Force StS Tool Cache – Practical Check List

Student ______________________________ Agency____________________________

Date & Location of Course (if applicable): ____

Instructor: Under Column "Date Performed or Observed". Instructor or student must put both the date and skill, and either a "P" for performed or an "O" for observed. Student must then initial the appropriate column to the right. If the instructor believes that although the student has performed the skill he/she s still inadequate because of lack of skill or practice, he/she should indicate under "Remarks" after discussion with the student. Both must sign and date the bottom of the record in order to make it valid.

Skills for the StS Tool Cache	**Date Performed Observed (P/O)**	**Student**	**Instructor**
Determine height of structure using Range Finding Binoculars and Clinometer			
Determine distance to & height of structure using Hilti PD-32			
Attach and setup Avongard Strain Gage across crack in concrete. (may use 2 pieces of plywood to simulate)			
Check Smart-Tool and/or Smart-Level to see if the Battery Saver feature has been set to off (will not automatically shut off after sitting idle for more than 5 minutes)			
Set Smart-Tool to read zero deg. on a nearly level surface			
Set Smart-Tool to read ninety deg. on a nearly vert. surface			
Set Smart-Level to read zero deg on a vertical surface (Only reqd is TF has a Smart Level in Cache)			
Use Zircon Metal detector to locate rebar in a concrete slab			
Mount laser level to a concrete surface using the steel angles and setup to measure the movement of a point			
Measure wind speed using the pocket wind meter			

The student and instructor/qualified StS agree that the below-signed student adequately completed skills practice and/or review: or has observed all the above skills.

Instructor/Qualified StS Signature ___________________________________Date:___________

Remarks:____

____

____

____

Student Signature:____Date:____________

Remarks:____

____