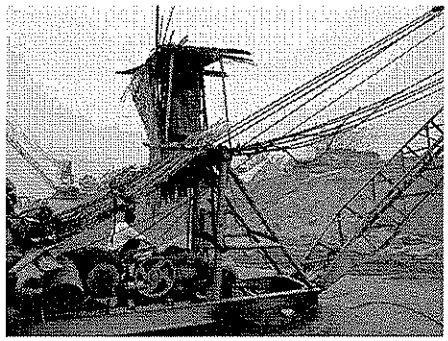
CRANES

Managing Risk

Jim Walter
Safety Director, Denver Operating Group
M.A. Mortenson Company

- Operating engineers
  - Apprenticeship
  - Journeyman
- 15 years operating cranes
  - Large lattice boom cranes
  - Small and large hydraulic cranes
  - Tower cranes
- NCCCO licensed
  - Alternate commissioner
  - Tower crane task force

For Rent



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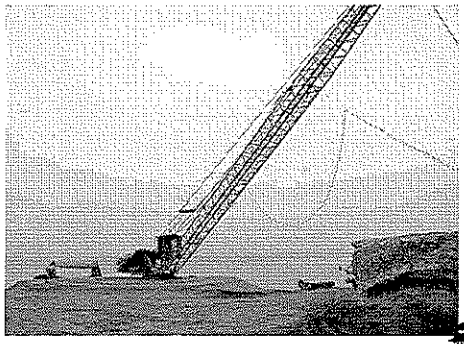
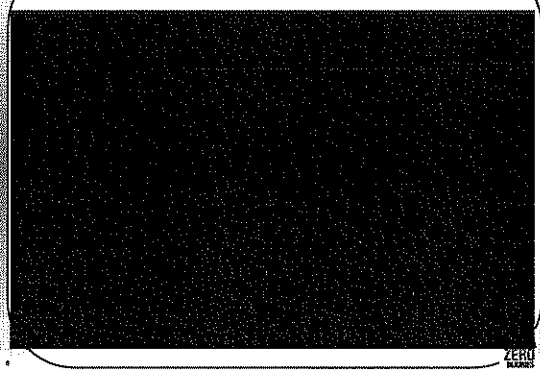


Cranes are the most unique, high profile piece of equipment on any jobsite

- A LOAD CANNOT BE LIFTED INTO THE AIR WITHOUT SOME DEGREE OF RISK AND DANGER.
- For this reason, it is critical that crane and rigging operations on projects be carefully managed and, if necessary, engineered to minimize this danger.

Disaster Can Happen in Seconds



Vendors / Owners

- Mandate that crane inspection data be supplied for the site supervisor prior to moving any crane onto a project.
  - Maintenance log books
  - Annual inspections
    - Documented repairs
  - Wire rope inspections
  - Daily inspections
- Build up cranes or lattice booms require an on-site inspection and load test before being put into service.
  - Independent 3rd party

Crane User

- Properly used by knowledgeable personnel.
  - Require CCO (or equivalent) certified crane operators.
  - Provide crane and rigging safety training for craft foremen.
  - Develop site specific hoisting plans for all hoisting activities.

Operating in a Safe Environment

- Evaluate crane foundation loadings prior to positioning a crane on a project.
- Establish and enforce formal lift planning procedures for all critical lifting operations on a project.
- Establish an ongoing rigging inspection and retirement program.
- Vigorously enforce safe lifting practices for every pick.

Rigger / Signal Person

- Proper rigging and signal person training.
- Sling angles.
- Softeners utilized.
- Inspection of shackles, hooks and slings.
- Load control mechanisms utilized (tag lines).

Site Supervision

- Includes project managers, superintendents, area supervisors, or craft foremen and have the overall responsibility for any lifting done with a crane.
  - Supervise all work involving the crane.
  - Crane operator receives orientation with site specific information including proximity to underground structures such as waterlines, sewers, or conduits and power lines are of particular importance.
  - Competent and trained riggers and signal persons.
  - Lifting planning with appropriate detail is developed, communicated, and understood by all involved in the operation.

Communication

- No single individual can ensure safe crane operation.
- Cooperation and communication between all team members is vital in achieving...
  - **Zero injuries**
  - **Zero property damage**

Insurance

- General liability coverage.
- Waiver and indemnity form or executed subcontract agreement-Any person or company who seeks to use company-owned equipment
- All leased equipment must be procured through execution of a Standard Equipment Lease Agreement, including the Service Addendum, if applicable.
- Subcontractors must carry equipment insurance in accordance with subcontract agreement.

Operators

- Certifications for crane operators
  - Mortenson
    - All Mortenson crane operators are required to be CCO certified within six (6) months of their date of hire, with re-certification required every five (5) years.
  - Subcontractors
    - CCO certified or equivalent
    - Equivalent =
      - American Crane Training
      - Crane Inspection & Certification Bureau
      - Crane Institute of America
      - North American Crane Bureau

Integrated Work Plans

(IWP)

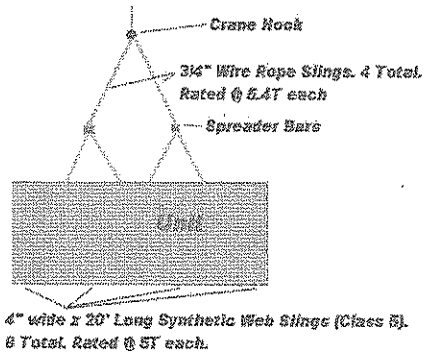
Planning

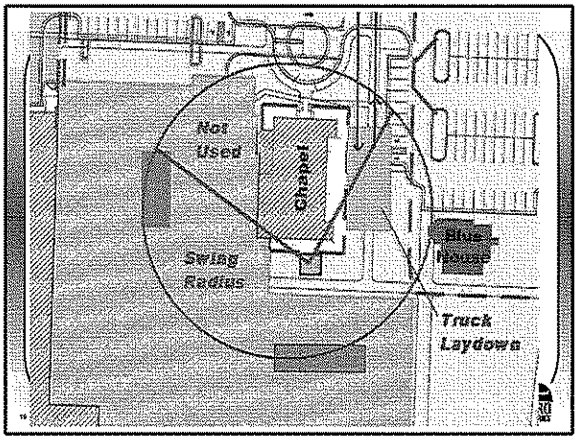
- Critical lifts
  - Gross load to be lifted is greater than 80% of rated capacity.
  - Load or boom will pass over an existing building during the lifting operation.
  - Gross load to be lifted is greater than 75% when erecting steel or hoisting concrete.

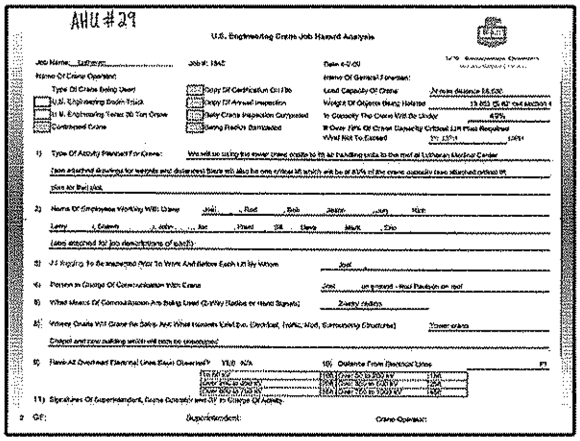
Planning

- Engineered lifts
  - Gross load is greater than 90% of rated capacity.
  - Load being lifted is an especially critical component.
  - Two or more cranes will be used.

Critical Pick

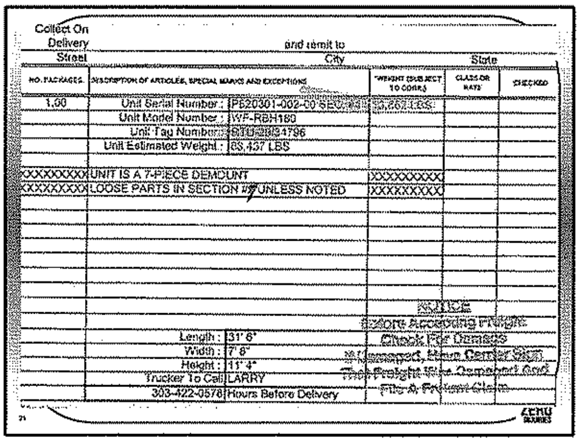





AHU #29

U.S. Engineering Crane Job Hazard Analysis

Type Of Crane Being Used
Copy Of Certification On File
Copy Of Annual Inspection
Contracted Crane
Load Capacity Of Crane
Weight Of Objects Being Hoisted
47%
1) Type Of Activity Planned For Crane:
2) Name Of Employees Working With Crane
(also attached for job descriptions of each)
11) Signatures Of Superintendent, Crane Operator and GF In Charge Of Activity
GF: Superintendent: Crane Operator:


Collect On Delivery and remit to

Street City State

NO. PACKAGES	DESCRIPTION OF ARTICLES, SPECIAL MARKS AND EXCEPTIONS		*WEIGHT (SUBJECT TO CORR.)	CLASS OR RATE	CHECKED
1.00	Unit Serial Number :	P620301-002-00 SEC [illegible]	[illegible] LBS		
	Unit Model Number :	WF-RBH180			
	Unit Tag Number :	[illegible]34796			
	Unit Estimated Weight :	85,437 LBS			
XXXXXXXX	UNIT IS A 7-PIECE DEMOUNT		XXXXXXXXX		
XXXXXXXX	LOOSE PARTS IN SECTION #7 UNLESS NOTED		XXXXXXXXX		
	Length :	31' 6"			
	Width :	7' 8"			
	Height :	11' 4"			
	Trucker To Call	LARRY			
	303-422-0578	Hours Before Delivery			

NOTICE
Before Accepting Freight
Check For Damage
If Damaged, Have Carrier Sign
That Freight Was Damaged And
File A Freight Claim

Project: Lutheran Medical Center

Date: 4-1-09

A. WEIGHT

E. RIGGING OF SLINGS

F. CRANE

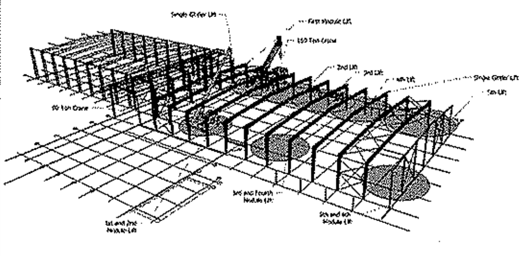
Total Weight

SPECIAL INSTRUCTIONS OR RESTRICTIONS FOR CRANE, RIGGING, LIFT, ETC.

DATE

DATE

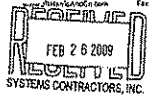
Engineered Pick



Engineered Pick

J.R. HARRIS & COMPANY
STRUCTURAL ENGINEERS
1775 Sherman Street, Suite 1525, Denver, CO 80203
303/860-9021 Fax 303/860-9237

24 February 2009



John
Systems Contractors, Inc.
8640 Welby Road
Thornton, CO 80229

Project #2373.02 - Structural Engineering Review of Crane Pick Plan for Unit 3 of Vestas Project, Brighton, Colorado

Dear John:

At your request, we have reviewed your plans for a two crane pick of the 166 ft long girders of Unit 3, at the Vestas project in Brighton, Colorado. We find that your two crane pick plan for the two girders module assembly with purlins and bracing installed is structural adequate with the limit of wind speeds below 10 mph. Enclosed documents you provided are the following:

- critical lift plan
- plan sketches
- sling capacities chart

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ZERO INJURIES

CRITICAL LIFT PLAN

Jobsite Name and Location: USA #2
General Contractor: Mortenson

Description and Sequence of Lift or Lifts: Module lift on the Shimoda building

Date of planned lift 4/6/09 to 5/25/09 ? Date today 2/20/09

1. A) Supervisor responsible for lift Jerry
   B) Designated Operator Jack and Kurt
2. A) Description of item to be lifted Shimoda roof modules
   B) Weight of item to be lifted Total 52,464.16 each half 26,232.08
   C) Was item weight estimated Yes ☒ No ☐ If yes, by whom? John
3. Major Hoisting Equipment to be used: 150 & 90 ton Link belt cranes.
   A) Unit Link belt 150 Lattice. Gross lift capacity 150 ton
   Link belt 90 Hydraulic 90 ton

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   B) Rigging to be used 1" four way spreader with 1" chokers
   C) Designated rigger or foreman Jerry to supervise all rigging and act as the lift director.
4. Inspection of Hoisting Equipment: Daily inspection of each crane.
   A) Lift unit inspector Jack & Kurt Date inspected Start of shift

   A) Area clear of personnel Controlled by S.C.I and Mortenson as necessary.
   B) Equipment inspection and operations performed? Daily
   By whom capable? Designated qualified person.
   C) Any discrepancies noted by operator or rigger Yes ☐ No ☒
   If so, what? [redacted] corrected before the start of the operation.
6. Is the item a freely suspended (free to move) load? Yes ☒ No ☐
   If not, complete item A.
   A) Describe restraining or holding forces involved (i.e. "Load must be lifted from trucks", "Load must be lifted off mounting bolts", etc.) N/A
   B) If eye bolts or similar attachments are used, have they been verified to be of sufficient size and capacity to handle the load? No eye bolt will be used.
   By whom? Baker Rigging book

ZERO INJURIES

8. What will be the boom configuration used?

Link belt 90 ton	100'		no		N/A
Link belt 150 ton	140'	ft. Jib	no	ft. Angle or offset	N/A

9. What will be the radius, boom angle, and capacity at the beginning and end of the lift?

Radius	Boom angle	Capacity
Link belt 90 ton 30'	68	42,200
Link belt 150 ton 40'	74.7	81,400

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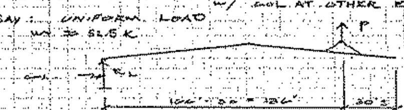
J.R. HARRIS & COMPANY
STRUCTURAL ENGINEERS
1775 Lincoln Street, Suite 1100
Denver, CO 80203-1000
303/860-9021 Fax: 303/860-9537
www.JRHarrisAndCo.com

Project No. 5875.02 By GES Date 4/__/09
Project Name CRANE PICK - VESTAS
Client SYSTEMS CONTRACTORS Checked ____ Date ____
Subject LOAD FOR CRANE W/ ONE END ON COLS. Sheet 1 of 1

SPAN 166' PICK AT 30' FROM END
W/ COL AT OTHER END
SAY: UNIFORM LOAD
W = 52.5 K



P = 52.5(166/2)/136 = 0.61(52.5) = 32 KIPS

CRANE LOAD = P = 32 K

90 TON CRANE AT 30' RADIUS CAPACITY = 42.2 K

CRANE = OK

2?

Boom Length (ft)	Load Radius (ft)	Boom Angle (degrees)	S + 0	'A' + 0	'AB' + 0	'AB' + 'A'	'ABC' + 0	'ABC' + 'A'	S + 0	'A' + 0	'AB' + 0	'AB' + 'A'	'ABC' + 0	'ABC' + 'A'
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Inspections

- Difficult to overstate the importance.
- Required by law.
- Will increase safety and reliability.
- Both ANSI (B 30.5) and OSHA (1926 and 1910) have requirements.

Inspections, con't

- Running rope removed from service if
  - 6 broken wires in 1 lay.
  - 3 broken wires in 1 strand in 1 lay.
  - 1/3 diameter wear on outside wires.
  - Kinking.
  - Crushing.
  - Bird caging.
  - Distortion.
  - Heat damage.

Inspections, con't

- Standing rope removed if:
  - More than 2 broken wires in 1 lay not at end.
  - More than 1 broken wire at end fitting.
  - Any reason for removing running rope.

Look here for broken wires /

removed from service

Testing

- Load testing after repairs or alterations
  - Must be written
  - Cannot exceed 110% of rated load

Site Review and Setup

- Supporting surfaces.
- Power lines.
- Access and usability.
- Working area.
- Work review and planning.
- Crane set up.

Supporting Surface

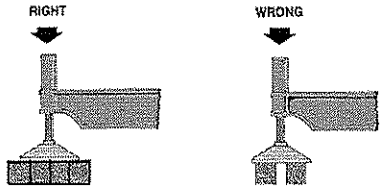
- Compressive strength of the soil.
  - Two methods to calculate the outrigger support area
    - 3 times the area of the float
    - Crane capacity divided by five (5)
- Site drainage.
- Spring or fall freeze / thaw considerations.
- Adjacent excavations or structures.

Supporting Surface, con't

- Blocking or cribbing
  - Transmit load.
  - Plywood vs. steel plate.
  - Minimum thickness.
  - Manufacturer's specifications.
  - Cable reel ends?

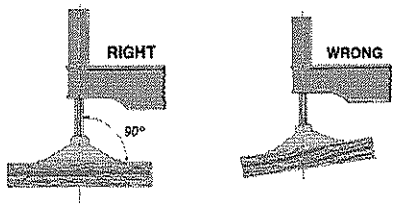
Supporting Surface, con't

- Proper placement
  - ANSI requirements.
  - No gaps between pieces.



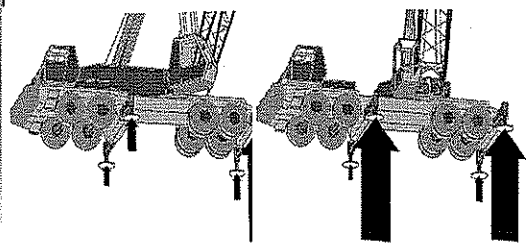
Supporting Surface, con't

- Level
  - Jack cylinder rod and float at 90 degrees.
  - On slope, will slide downhill.

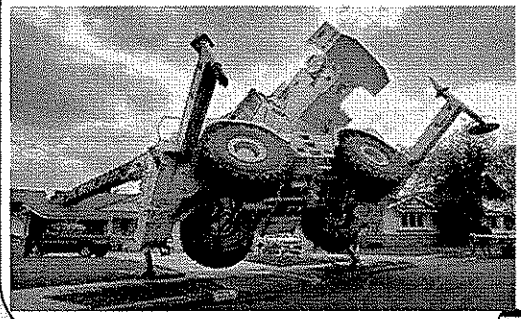


Supporting Surface, con't

- Loads applied by floats
  - Load changes every time crane swings, booms, telescopes, or hoists.

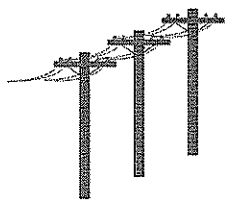


Short Sided Outriggers



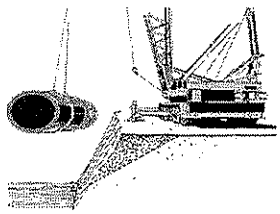
Visible and Hidden Hazards

- Often overlooked
- Sometimes noticed but not considered serious



Visible and Hidden Hazards, con't

- Setting up close to excavation
  - Soil type determines minimum distance.
- People in the excavation



Visible and Hidden Hazards, con't

- Crane selection
  - heaviest load weight(s) to be lifted.
  - boom length required.
  - greatest radius and height at which the load(s) must be handled.

A LIFT MUST **NEVER** BE PLANNED WHICH EXCEEDS THE PUBLISHED CAPACITY OF A CRANE!

Visible and Hidden Hazards, con't

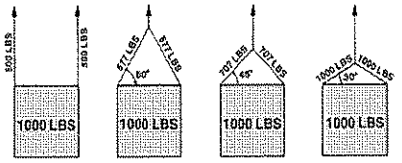
- Time and space considerations enter the picture when deciding whether a lattice boom or hydraulic crane will best serve the project's needs.
- Each type of machine has strong and weak points.
- A few important factors to keep in mind when assessing what type of crane will best serve the project are as follows:

Rigging

- Estimating Loads
  - Look at shipping ticket.
  - Look at shop drawings.
  - Calculate weight of load.

Sling Angles

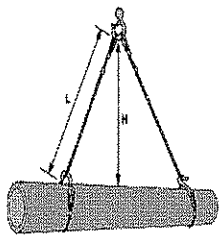
- Sling Angle: Position of sling relative to horizontal
  - Tension in sling increases as angle to horizontal decreases.
- Note changes from left to right
  - Sling tension doubles, weight remains the same.



Determining Sling Angle

- Determining Sling Tension
  - Riggers and Operators should know how to calculate sling angle factor

$\frac{L}{H}$ = Sling loading factor



Determine Sling Loading

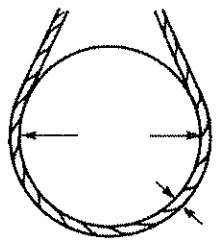
- To calculate sling tension: (2 legs)
  - Divide total weight by two (2).
  - Multiply by sling angle factor.

Types of Hitches

Determine Strength Reduction

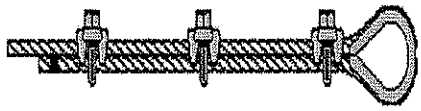
- D / d Ratio

D = Diameter of ben
d = Diameter of slin



Wire Rope Clamps

- OSHA requirements
- Proper torque



Not allowed for slings and bridles

Sling Removal Criteria

- Wire Rope Slings (con't)
  - Remove from service if:
    - 10 broken wires in 1 lay.
    - 5 broken wires in 1 strand, 1 lay.
    - Severe abrasion.
    - Distorted rope structure.
    - End attachments damaged or worn.
    - 1/3 wear of outside wire.
    - Heat damage.

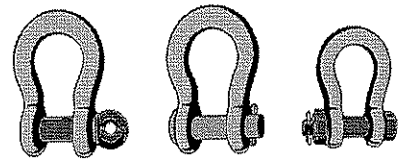
Nylon Sling Removal Criteria

- Synthetic web slings
  - Easy to use, lightest, less likely to damage load
  - Easily damaged
  - Use special fittings
  - Tags required
  - Safety yarn

Rigging Devices

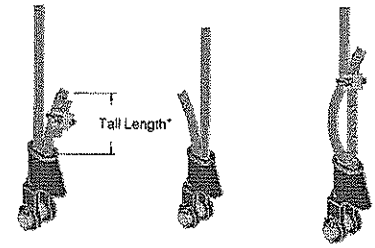
- Shackles
  - Recommended types:
    - Screw pin
    - Bolt

YES NO YES



Rigging Devices

YES NO NO



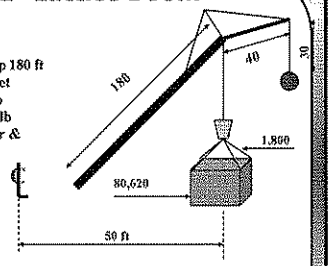
Crosby says tail is 6 rope diameters except for rotation resistant which is 20 rope diameters.

Rigging Equipment

- Must take damaged or defective equipment out of service
  - Do not overload.
  - Custom-made equipment.

Exercise 1- Lattice Boom

Crane: Manitowoc 4100 Series 2
Base: Crawlers Extended
Boom: No. 22C Open Throat Top 180 ft
Jib: No. 123 40 ft 10 Degree Offset
Block: 200 Ton w/4 Parts 4815 lb
Ball: 15 Ton 30 ft Below Jib 865 lb
Counterweight: 146,400 lb Upper & 60,000 lb Lower
Gantry: Raised



You must hoist a load that weighs 80,620 lb with rigging that weighs 1800 lb.
Before starting understand Reading & Using a Manitowoc Chart.
Note that on Manitowoc cranes all hoist rope below the boom and jib is part of the load. Calculate the gross load at 50 ft radius.

Solution on next slide

Exercise 1 - Lattice Boom

Solution

The full length in use is boom length times # of parts times weight per ft, or boom length plus jib length times # of parts times weight per ft. Full length not in use is 10 ft or as given.

Load	80,620 lb	
Rigging	1,800	
Block	4,815	
Ball	865	
Effective Jib	3,600	
Block Rope	1,685	4 x 180 x 2.34 = 1,684.8
Ball Rope	70	30 x 2.34 = 70.2
	93,455 lb	= Gross Load

Could the load be handled at a longer radius?

What are the minimum parts of line required for this lift?

Is this lift limited by tipping or strength?

Answers on next slide

Exercise 1 - Lattice Boom

No, the load can not be handled at a longer radius. The capacity at 55 ft radius is only 88,500 lb.

For minimum parts of line look at the chart titled Hoist Reeving For Main Load Block. Three parts would handle up to 97,500 lb and we are not lifting the jib, ball, or ball rope.

The lift is limited by tipping, because there is no asterisk beside capacity.

Capacity at 50' radius = 101,000 lbs

Capacity at 55' radius = 88,500 lbs

Contingency Planning

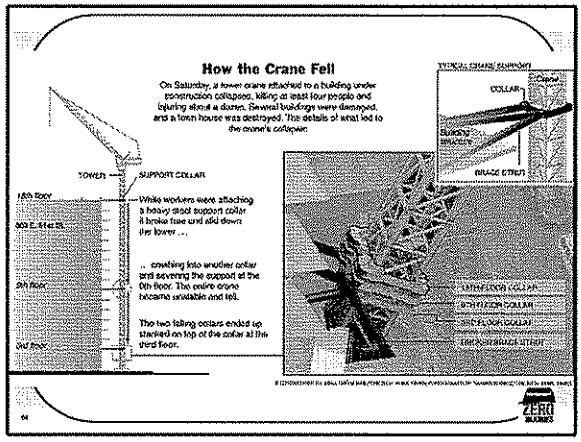
- Certain occurrences which may not necessarily come into play during a lifting operation must nonetheless be covered by planning.
- Emergency Response/Crisis Management - Action plans and phone numbers need to be clearly understood and readily accessible in the event a mishap should occur. This information must current and available on all projects but may need to be reviewed and re-emphasized in anticipation of especially critical procedures.

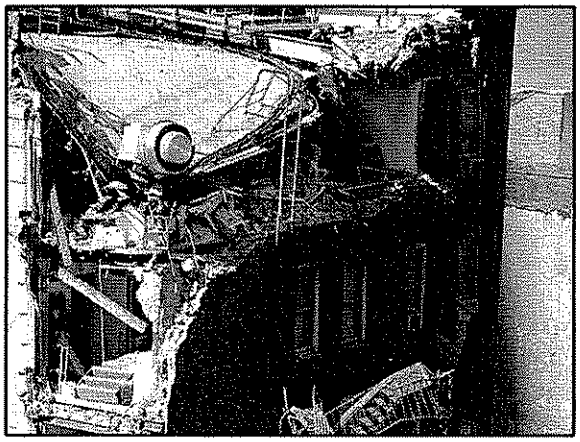
Contingency Planning, con't

- A weather envelope for critical lifting procedures should be established prior to starting. Wind is the most common factor which needs to be dealt with. Crane manufacturers generally provide some type of guidance in this area.
- However, load size, shape and elevation need to be considered in establishing limitations. 20-30 mph is generally viewed as a reasonable maximum wind speed for low level, small wind areas of operation.

Contingency Planning, con't

- Darkness - Procedural problems can occur which delay the best planned operation. Such delays can extend beyond daylight hours. Lift starting time limitations and artificial lighting alternatives are subjects worthy of consideration.
- Shift Changes - Delays can extend complex lifting operations beyond shift deadlines. Plans for such an occurrence may need to be put in place.
- Spectator Control - Rumors of any heavy lifting operation circulate quickly on a worksite, and the procedure draws much attention. The dangers inherent in this occurrence are twofold. First, unnecessary personnel in the immediate area of the lifting operation will be exposed to and possibly even cause a mishap. Second, workers performing unrelated tasks can easily be distracted and injured. Off-peak or non-standard work times may be worth considering for unique lift operations if this risk is judged to be excessive.


How the Crane Fell
On Saturday, a tower crane attached to a building under construction collapsed, killing at least four people and injuring about a dozen. Several buildings were damaged, and a town house was destroyed. The details of what led to the crane's collapse:
TOWER
SUPPORT COLLAR
While workers were attaching a heavy steel support collar it broke free and slid down the tower ...
... crashing into another collar and severing the support at the 6th floor. The entire crane became unstable and fell.
The two falling collars ended up stacked on top of the collar at the third floor.
COLLAR
BRACE STRUT
ZERO



Questions and Answers