Crane Rental Accidents

-Preventable or Not-

Jim D. Wiethorn, P.E.
Principal/Chairman
Haag Engineering Co.

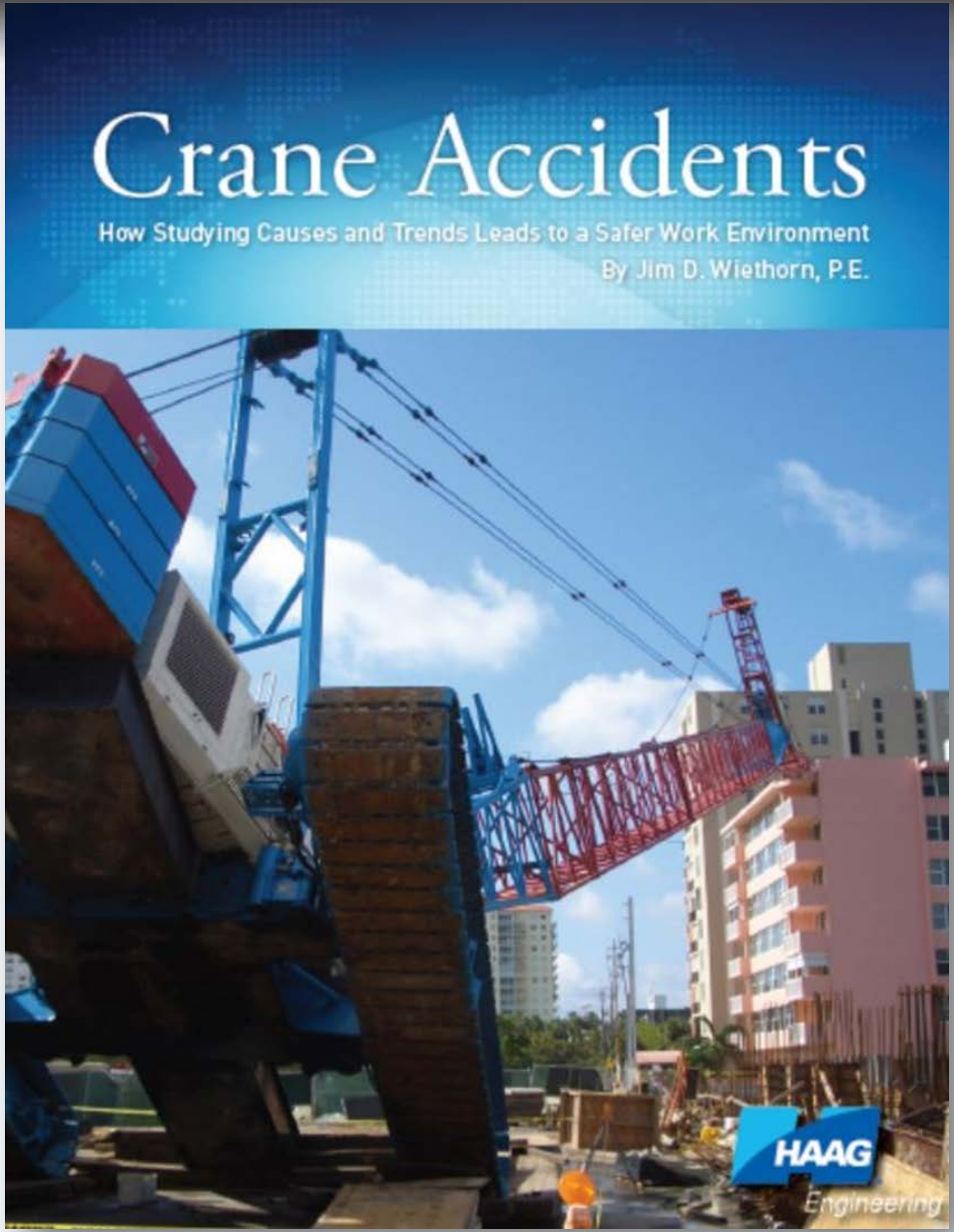
CRANE RENTAL
ASSOCIATION OF CANADA

HAAG
Engineering

PUBLISHED 2014

HAAG Engineering

www.haagglobal.com



CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

-Preventable or Not-

Study Results Tidbits

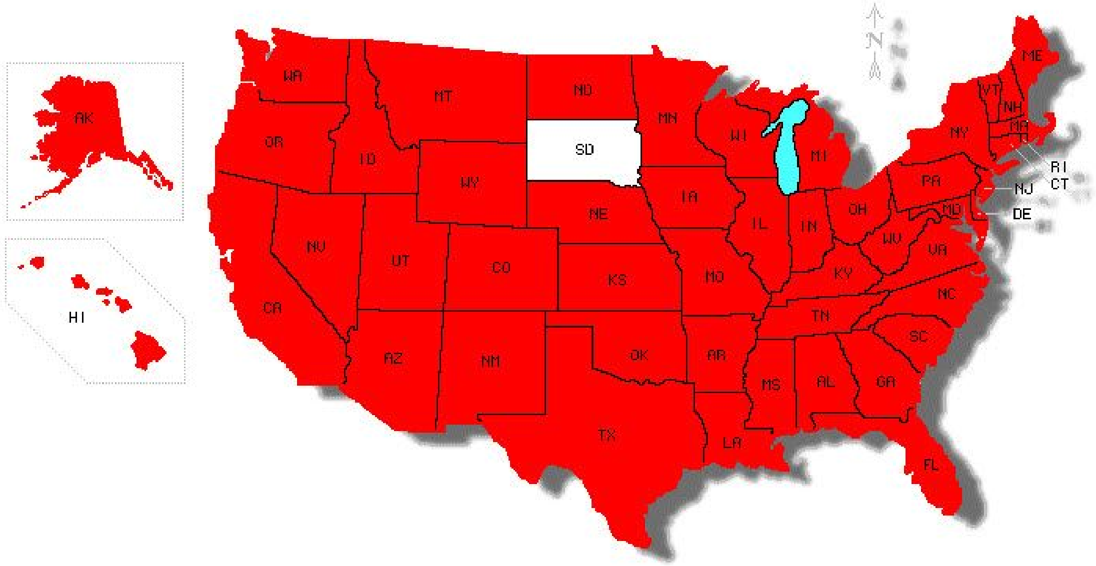
- 94% of crane accidents examined occurred as a result of some type of error due to human decision making
- More fatalities of Other Field Personnel (OFP) as a result of crane accidents than of those actually involved in the lift
- 48.5% of all overturns (stability) occurred as a result of overloading the crane
  - 17.4% of those were associated with operational aid turned off or disconnected
- 29.8% of all crane accidents had no load on the hook
- 56.7% of all rigging failures occurred as a result of lack of softeners

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Data Bank

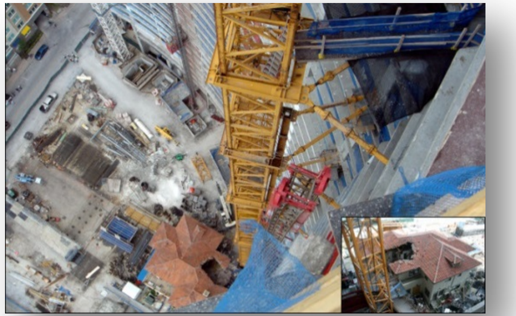
- **1983-2013: 716 crane accidents-507 Categorized**
- **Crane accidents in 49 of 50 States and Internationally-South Africa-Brazil-Canada-Puerto Rico-Turks & Caicos-Virgin Islands, Grand Bahama Island**
- Crane Types
  - **Tower**
  - **Mobile**
  - **Bridge**
  - **Hydraulic**
  - **Cableway**
  - **Derrick**
  - **Pedestal**
  - **Gantry**
  - **MEGA**
  - **Launching Girders**
  - **Other**



CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

10 - Crane Study Categories



- **Commercial Construction**
  - **Work with multiple users on a site**
  - **Almost Exclusive use of tower cranes**
  - **Consistent lifting but with different loads/radii**
  - **Lifts are often made in tight quarters-multiple workers**
  - **Multiple ranges of lifts: General, Production & Critical**
- **Highway/Road & Bridge Construction**
  - **Often lifts have to be done at night**
  - **More critical lifts-dual crane picks**
  - **Unprepared crane ways-continuous crane movement-native soil**
  - **Tight fits-complicated**
  - **Multiple Random Power Lines Over Roads**

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Crane Study Categories

- **Industrial/Manufacturing**
  - **Greatest number of "certified" operators**
    - **First to controls gets to operate the crane**
  - **Continuous use 24/7-maintenance is problematic**
  - **Usually consistent or identical lifts**
    - **Moving product from one point to another**
  - **Irregular or complicated center-of-gravity calculations/lifting-piping**
- **Residential Construction**
  - **No qualified riggers – lack of rigging/lifting experience**
  - **Operator is often brought into the lift-held to a higher standard**
  - **Workers Do Not Understand Load Drift**
  - **Lack of Tag Lines**

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Crane Study Categories

- **Marine Industry**
  - **24-Hour operations**
  - **Multiple blind lifts during operations**
  - **General idea of weights but not known until lifted**
  - **Lifting off barges and ships**

- **Mining Industry**
  - **Maintenance-Potential chemical exposure**
  - **Unknown ability of riggers**
  - **Equipment can remain idle for a long period of time between uses**
  - **Multiple Shifts/Operators of a Single Unit**

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Crane Study Categories

- **Arborists/Logging Industry**
  - **Follows different standard-ANSI Z133**
  - **Unknown weights and control of load**
  - **Unknown rigging ability of climber who is also the Lift Director**
  - **Logging-24/7 repetitive operations**
- **Agriculture Industry**
  - **No qualified riggers – lack of rigging/lifting experience**
  - **Weight of load seldom known**
  - **Site obstructions-power lines**
  - **Creative uses of rigging**

Crane Study Categories

- **Oilfield-Land Base Industry**
  - Maintenance Issues-Remote areas
  - Availability of qualified operators
  - Multiple types of lifts with multiple companies
  - 24-Hour operations

- **Oilfield-Offshore Industry**
  - Maintenance/Exposure Issues
  - Equipment idle for long periods of time
  - Sufficiently trained riggers
  - Dynamic loading and offloading boats
  - 24-Hour operations

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Crane Study Basis-Cases/Category

- **1983 - 2013**
- **716 Crane Accidents**
- **507 Accidents Categorized**

	CASES	%
• Commercial Construction -	192	37.9
• Industrial/Manufacturing -	141	27.8
• Highway Construction -	57	11.2
• Residential Construction -	19	3.7
• Marine Industry -	33	6.5
• Mining Industry -	9	1.8
• Arborist/Logging -	7	1.4
• Oilfield-Land Base Industry -	31	6.1
• Oilfield-Offshore Industry -	17	3.4
• Agriculture Industry -	1	0.2
TOTAL	507	

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Breakdown by Crane Types

Mobile-Hydraulic	164	32.4	%
Track Lattice	95	18.8	%
Tower Crane	58	11.5	%
Mobile-Lattice	55	10.9	%
Mobile RT	42	8.3	%
Boom Truck	30	5.9	%
Overhead	24	4.7	%
Track Hydraulic	7	1.4	%
Special Crane	7	1.4	%
Gantry	5	1.0	%
MEGA	5	1.0	%
Straddle Crane	5	1.0	%

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Accident Types

Crane Overturn	18.5 %
Boom Collapse	18.5 %
Crane Travel/De-Railed	15.8 %
Unstable/Dropped/Lost Load	10.1 %
Rigging Failure	5.9 %
Power Line Contact	4.1 %
Boom/Jib Dropped	3.9 %
Assembly/Disassembly	3.4 %
Landed Load Stability	2.4 %
Two Block	1.8 %
Trip/Slip/Fall/Jump From Crane	1.6 %
Signaling	1.4 %
Personnel Basket Failure	0.8 %
Slewing Assembly Failure	0.6 %
***Worker Contact	33.9 %

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Crane Stability Causes

- Additional Load Suddenly Applied 4%
- Crane Out Of Level 4%
- Wrong Weight-Operator 8%
- Crane Struck By Other Equipment 1%
- Foundation Failure 3%
- Improper A/D Procedures 6%
- Insufficient-Removed CW 4%
- Lifting Device Failed 1%
- Lost Load-Stability 3%
- Maintenance Issue 1%
- Manufacturing Defect 3%
- No Out-Boom Extended-No Load 2%
- Op/Aid Turned Off/Disconnected 3%
- Outrigger Failure-Soil 1%
- Outrigger Failure-Structural 4%
- Outriggers Not Extended 10%
- Overload 49%
- Pulling A Load-Lateral Load At Tip 2%

- Soil Failure/Trench/Slope 7%
- Signals 3%
- Swing-Dynamic Loading 4%
- Traveling The Crane-Drive/Rail 6%
- Traveling w/Suspended Load 2%
- Wind 6%
- Wrong Set-Up-Mode-A2B 4%
- Wrong Weight-By Others 9%
- Wrong Weight-Not Known 6%
- Mat Displacement 2%
- Overriden-A2B 7%
- Structural Failure 2%
- Upper Not Locked-Rotates 3%
- Use By An Unauthorized Person 1%
- Wrong Weight-Demolition 4%
- Wrong Wt-Fluids/Matls in Load 3%
- Altered Or Damaged A2B 1%
- Stuck Load 1%

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Boom Collapse Causes

- Boom Impact 9.3%
- Dynamic Loading 7.0%
- Foundation Design 1.2%
- High Boom-Into Backstops 9.3%
- Maintenance Issue 7.0%
- Manufacturing Defect 9.3%
- Operational Aid Turned Off/Disc 17.4%
- Overload 29.1%
- Overridden LMI or A2B 7.0%
- Prior Damage/Repair To Boom/Jib 10.5%
- Side Loaded 18.6%
- Structural Failure 11.6%
- Stuck Load 5.8%
- Wind Loading-Boom/Tower 14.0%

- Wrong Weight - Demolition 4.7%
- Abuse-Lack of Maint. 3.5%
- Additional Load is Suddenly Applied 1.2%
- Altered Or Damaged A2B 1.2%
- Crane Was Rigged Improperly 1.2%
- Dynamic Loading 7.0%
- Failure at Landed Load 1.2%
- Tie-In Design 2.3%
- Wrong Setup-Mode - LMI 2.3%
- Wrong Weight - By Others 4.7%
- Wrong Weight - Not Known 2.3%
- Wrong Weight - Operator 2.3%
- Wrong Weight - Fluids/Mats In Load 1.2%
- Wind Loading-Load 1.2%

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Load vs No Load On-The-Hook

- **Load On-The-Hook**
  - **356 Incidents 70.2%**
- **No Load On-The-Hook**
  - **151 Incidents 29.8%**

Injuries & Deaths

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Crane Study Basis-Deaths/Category

• 507 Accidents Categorized	# Deaths
• Commercial Construction -	55
• Highway Construction -	32
• Industrial/Manufacturing-	29
• Oilfield-Land Base Industry -	11
• Marine Industry -	10
• Residential Construction -	3
• Mining Industry -	3
• Arborist/Logging -	2
• Oilfield-Offshore Industry -	2
• Agriculture Industry -	0
TOTAL	147

Crane Study Basis-Deaths/Trade

507 Accidents Categorized	# Deaths
Other Field Personnel -	51
Operator -	38
Ironworker -	24
Rigger -	20
Management -	10
Pedestrian/Bystander -	3
Oiler -	1
Signal Person -	0
TOTAL	147

Crane Study Basis-Injuries/Category

- **507 Accidents Categorized**

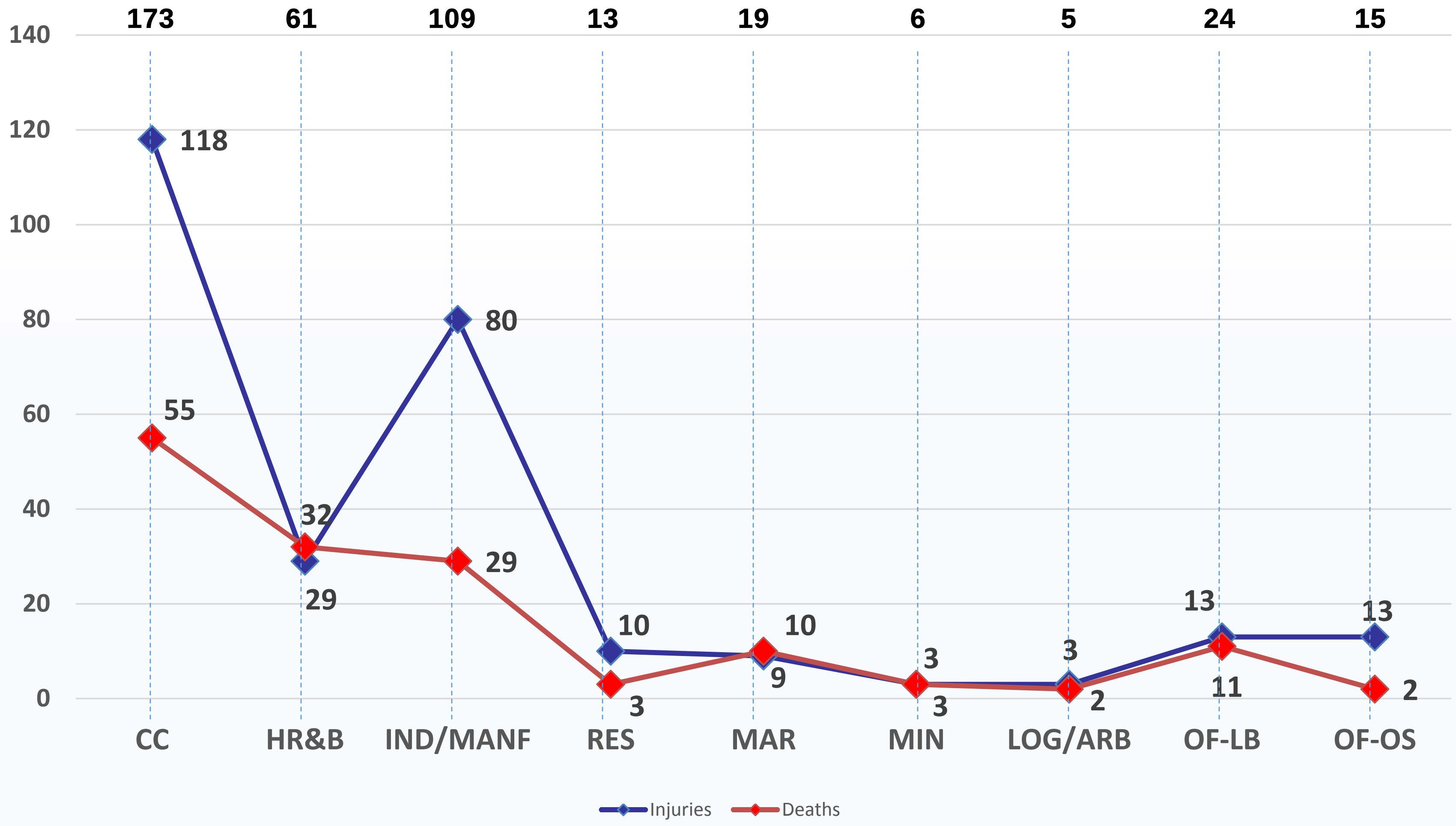
	# Injuries
Commercial Construction -	118
Industrial/Manufacturing -	80
Highway Construction -	29
Oilfield-Land Base Industry -	13
Oilfield-Offshore Industry -	13
Residential Construction -	10
Marine Industry -	9
Mining Industry -	3
Arborist/Logging -	3
Agriculture Industry -	0
TOTAL	281

Crane Study Basis-Injuries/Trade

- **507 Accidents Categorized**

	# Injuries
Rigger -	91
Other Field Personnel -	82
Ironworker -	50
Operator -	29
Pedestrian/Bystander -	14
Signal Person -	9
Management -	5
Oiler -	1
TOTAL	281

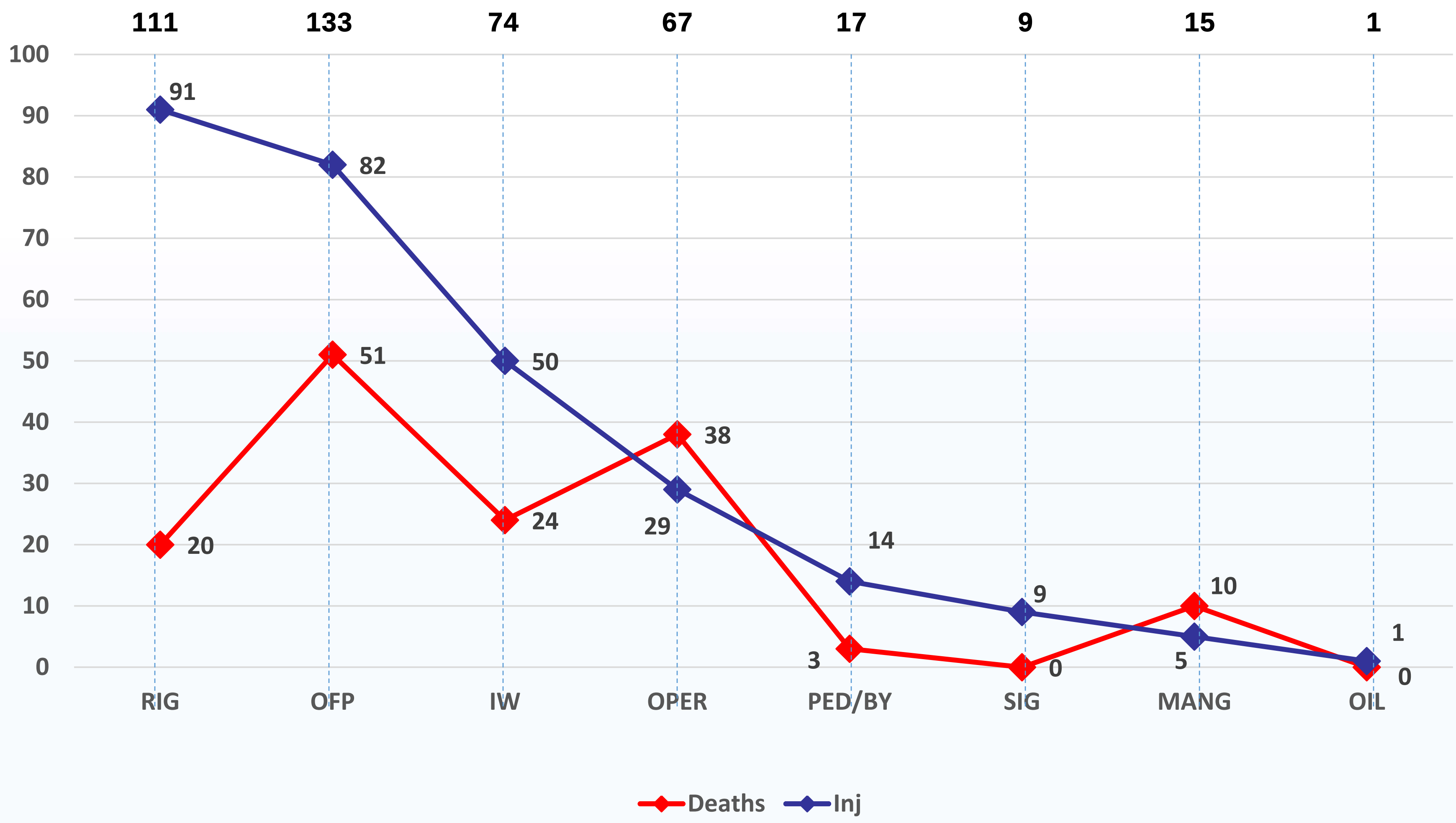
Total Deaths/Injuries By Industry



CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Total Deaths/Injuries By Trade



CRANE RENTAL
ASSOCIATION OF CANADA

HAAG Engineering

Type of Crane Operations

Type of Crane Operations
(507 Accidents)

• Bare Lease/Operated	20.3%
• Borrowed/Unauthorized Use	6.0%
• Owned/Operated by User	18.2%
• Service Provider-Operator	42.6%
• (Crane Rental Companies)	

Bare Lease/Operated
(103 Accidents)

• Boom/Jib Collapse	28.2% - 29
• Crane Overturn	20.4% - 21
• Worker Contact/Load-No Accident	8.7% - 9
• Assembly/Disassembly	5.8% - 6

Owned/Operated by User

(182 Accidents)

• Boom/Jib Collapse	21.4% - 39
• Crane Overturn	17.6% - 32
• Boom/Jib Dropped	8.2% - 15
• Worker Contact/Load-No Accident	6.6% - 12

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Service Provider-Operator
(216 Accidents)

• Crane Overturn	17.6% - 38
• Worker Contact/Load-No Accident	15.3% - 33
• Unstable/Dropped/Lost Load	13.4% - 29
• Boom/Jib Collapsed	11.1% - 24

Responsibilities of Parties

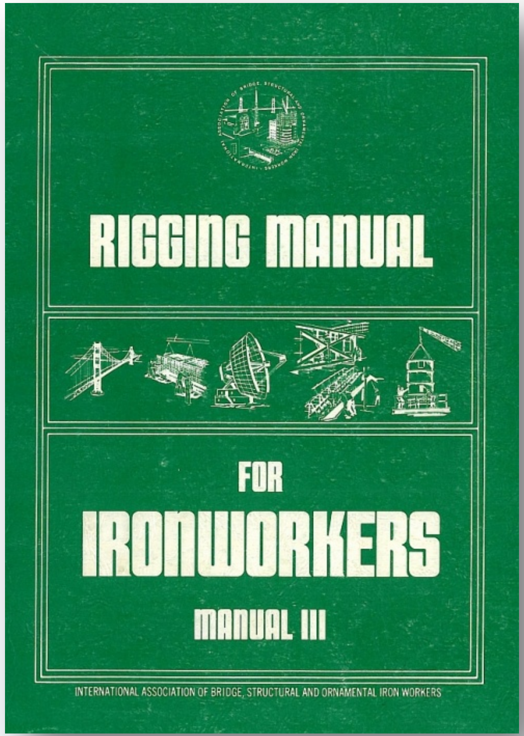
CRANE RENTAL ASSOCIATION OF CANADA

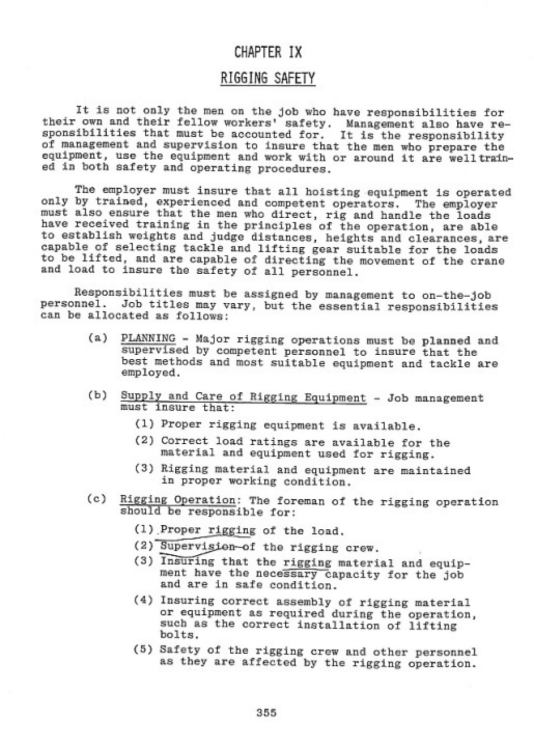
HAAG Engineering

Duties & Responsibilities

-Where It Began-

- **Iron Workers – 1960's**
  - **International Association of Bridge, Structural and Ornamental Iron Workers**





CHAPTER IX

RIGGING SAFETY

It is not only the men on the job who have responsibilities for their own and their fellow workers' safety. Management also have responsibilities that must be accounted for. It is the responsibility of management and supervision to insure that the men who prepare the equipment, use the equipment and work with or around it are well trained in both safety and operating procedures.

The employer must insure that all hoisting equipment is operated only by trained, experienced and competent operators. The employer must also ensure that the men who direct, rig and handle the loads have received training in the principles of the operation, are able to establish weights and judge distances, heights and clearances, are capable of selecting tackle and lifting gear suitable for the loads to be lifted, and are capable of directing the movement of the crane and load to insure the safety of all personnel.

Responsibilities must be assigned by management to on-the-job personnel. Job titles may vary, but the essential responsibilities can be allocated as follows:

(a) PLANNING - Major rigging operations must be planned and supervised by competent personnel to insure that the best methods and most suitable equipment and tackle are employed.

(b) Supply and Care of Rigging Equipment - Job management must insure that:

(1) Proper rigging equipment is available.

(2) Correct load ratings are available for the material and equipment used for rigging.

(3) Rigging material and equipment are maintained in proper working condition.

(c) Rigging Operation: The foreman of the rigging operation should be responsible for:

(1) Proper rigging of the load.

(2) Supervision of the rigging crew.

(3) Insuring that the rigging material and equipment have the necessary capacity for the job and are in safe condition.

(4) Insuring correct assembly of rigging material or equipment as required during the operation, such as the correct installation of lifting bolts.

(5) Safety of the rigging crew and other personnel as they are affected by the rigging operation.

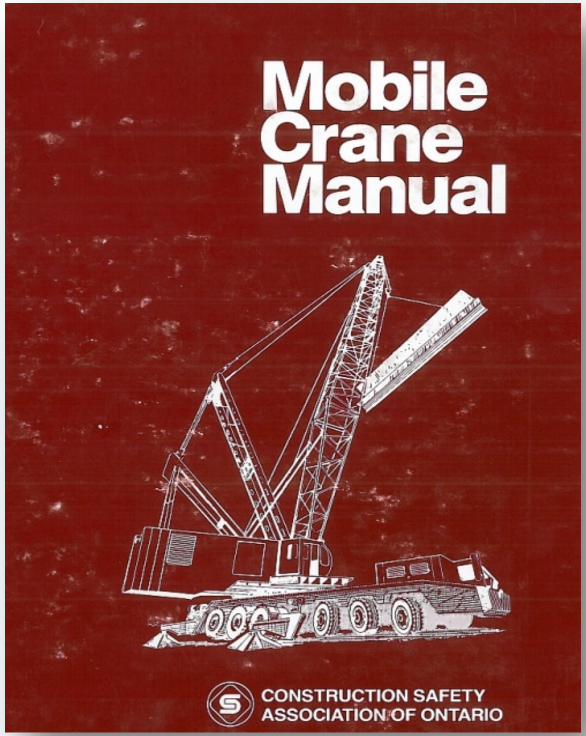
355

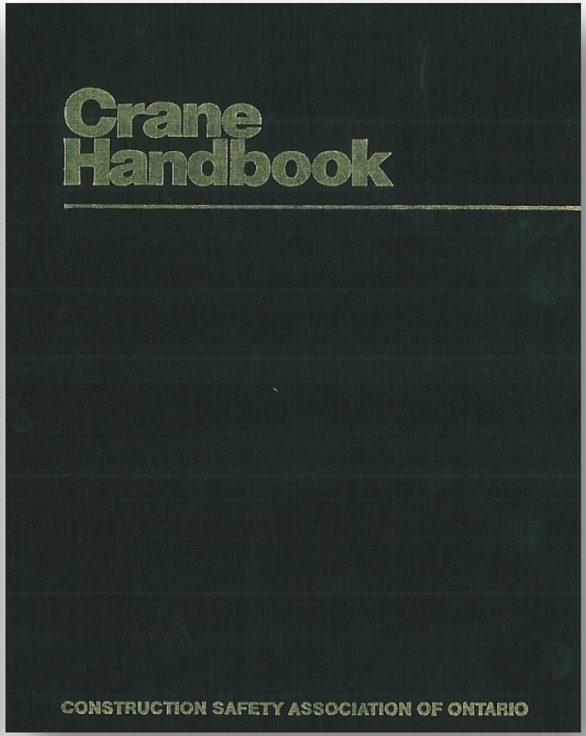
CRANE RENTAL ASSOCIATION OF CANADA

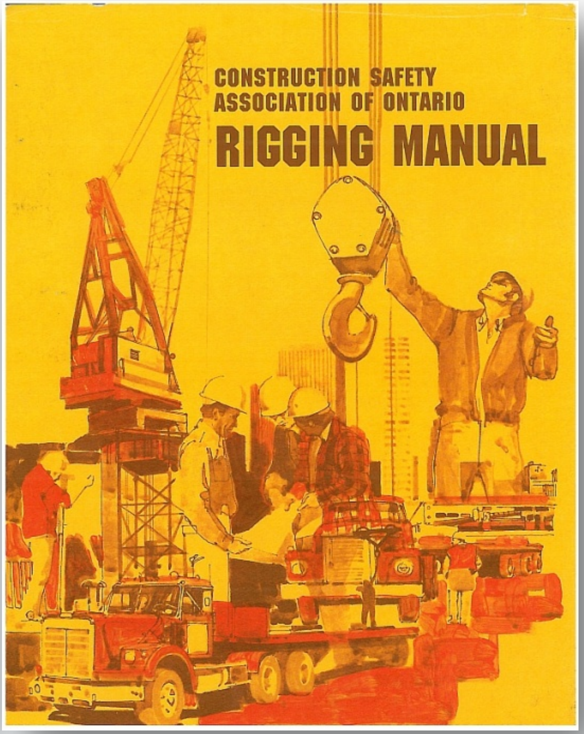
HAAG Engineering

Publications by Don Dickie

- **Don Dickie - 1970 - 1998**

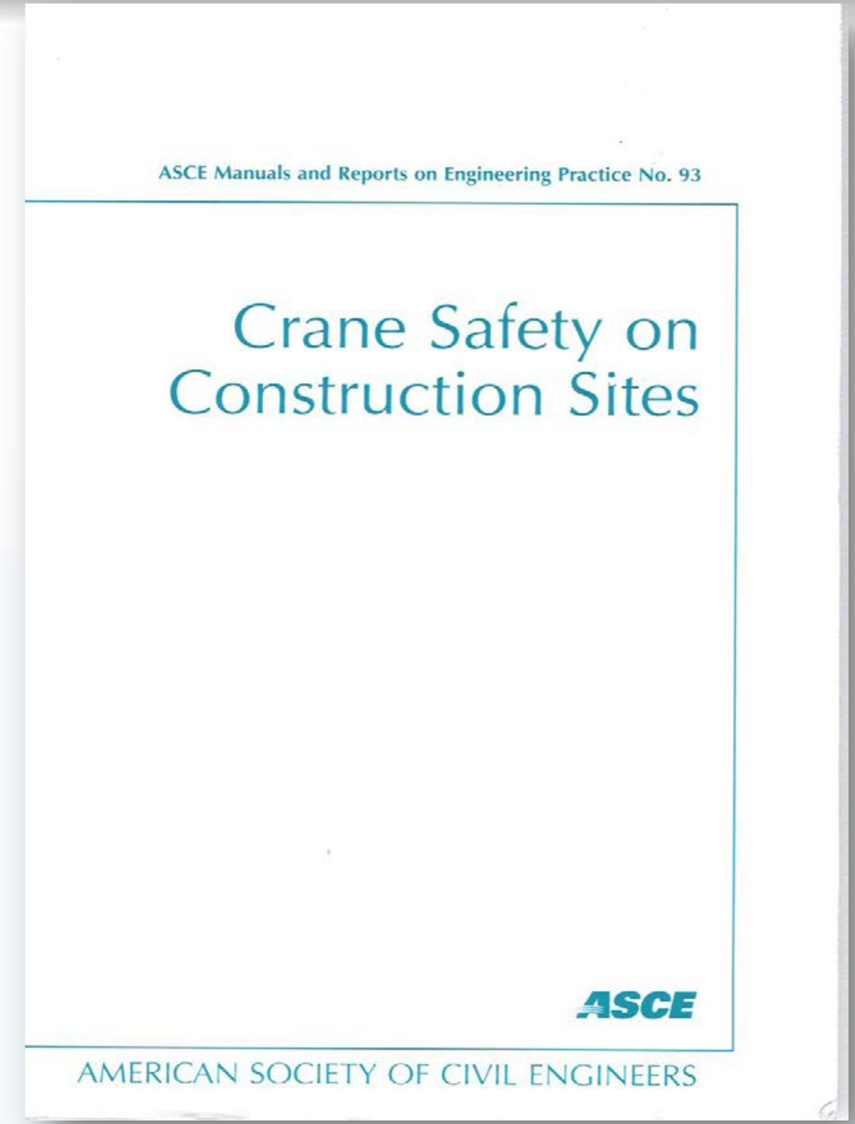






CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering



First Publication in the United States Specifically Dealing with Duties & Responsibilities

ASCE Manuals and Reports on Engineering Practice No. 93

Published: 1998

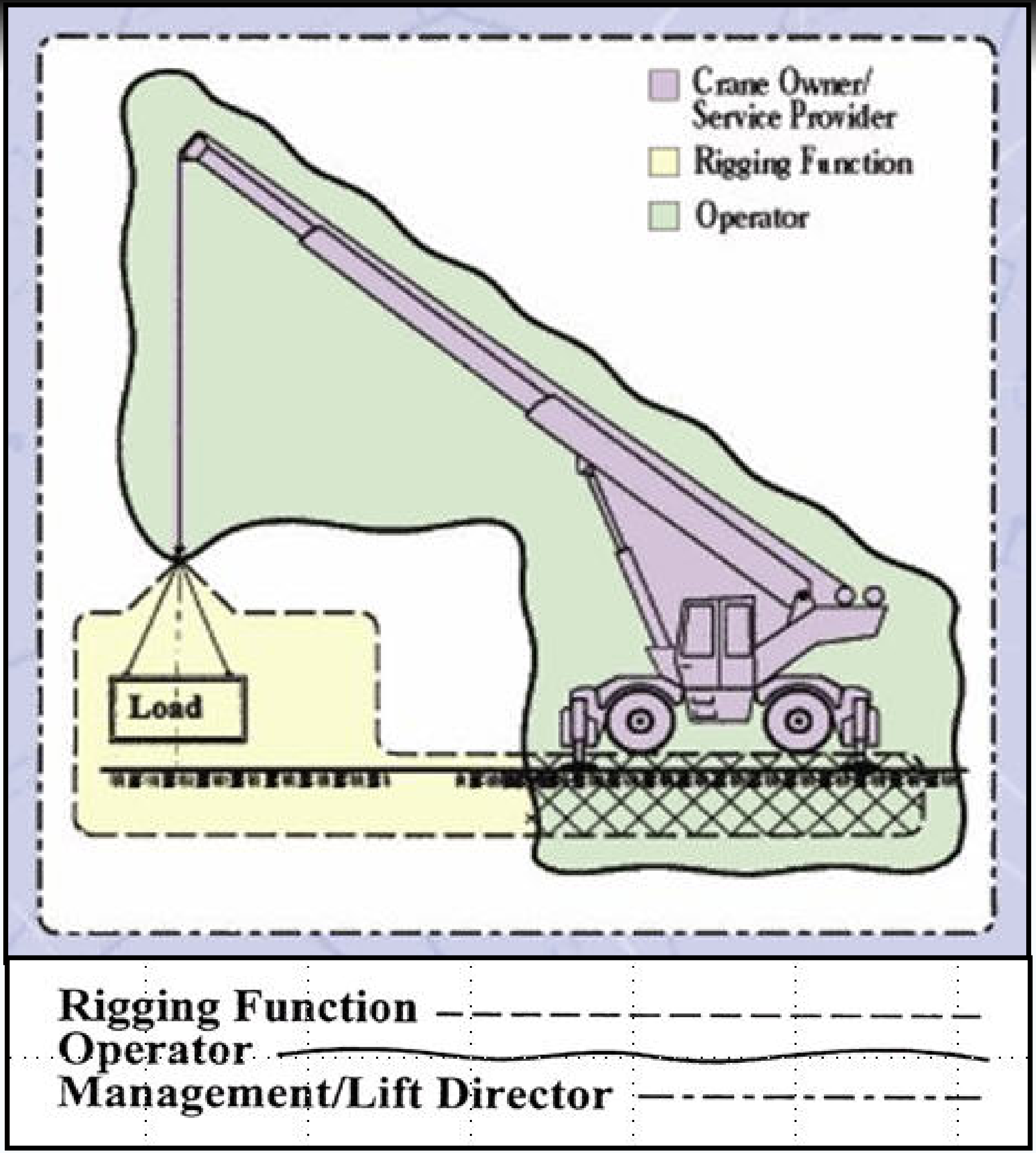
1998 - 2007

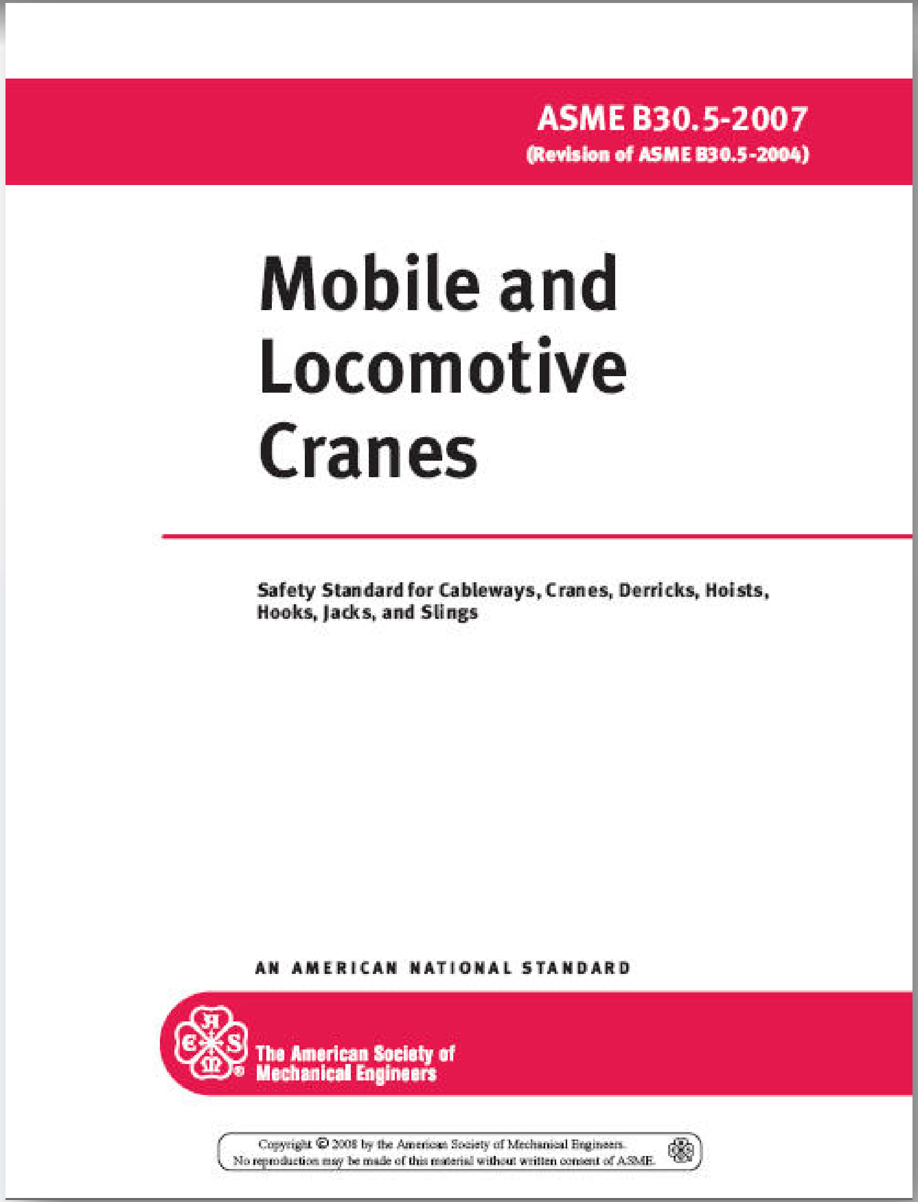
CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Primary Parties

ASCE 93 Zones Of Responsibilities




ASME B30.5-2007
(Revision of ASME B30.5-2004)

Mobile and Locomotive Cranes

Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

Current National Consensus Standard

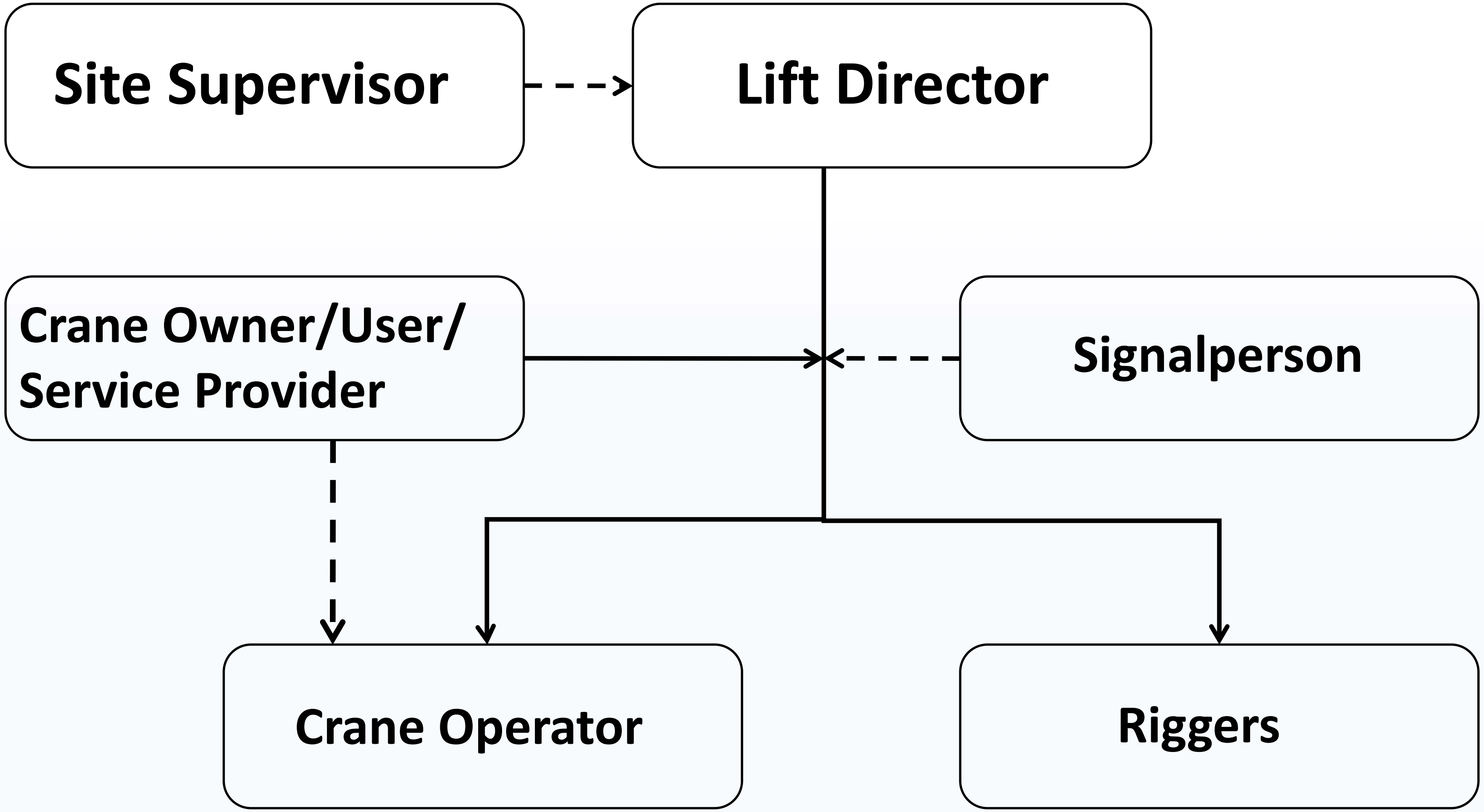
ASME B30.5-2007
Duties & Responsibilities

2007
-
Present

CRANE RENTAL
ASSOCIATION OF CANADA

HAAG Engineering

Responsibility Flow Chart



CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Parties Involved With Lifts

- Site Supervisor
- Lift Director
- Rigger
- Operator
- Service Provider
- Owner/User
- Signal Person
- Other
- Crane Manufacturer
- Manufacturer of Load
- Maintenance/Inspection Personnel

Quantifying Contribution to Incident

- The responsible parties were categorized as either "primary" or "secondary".

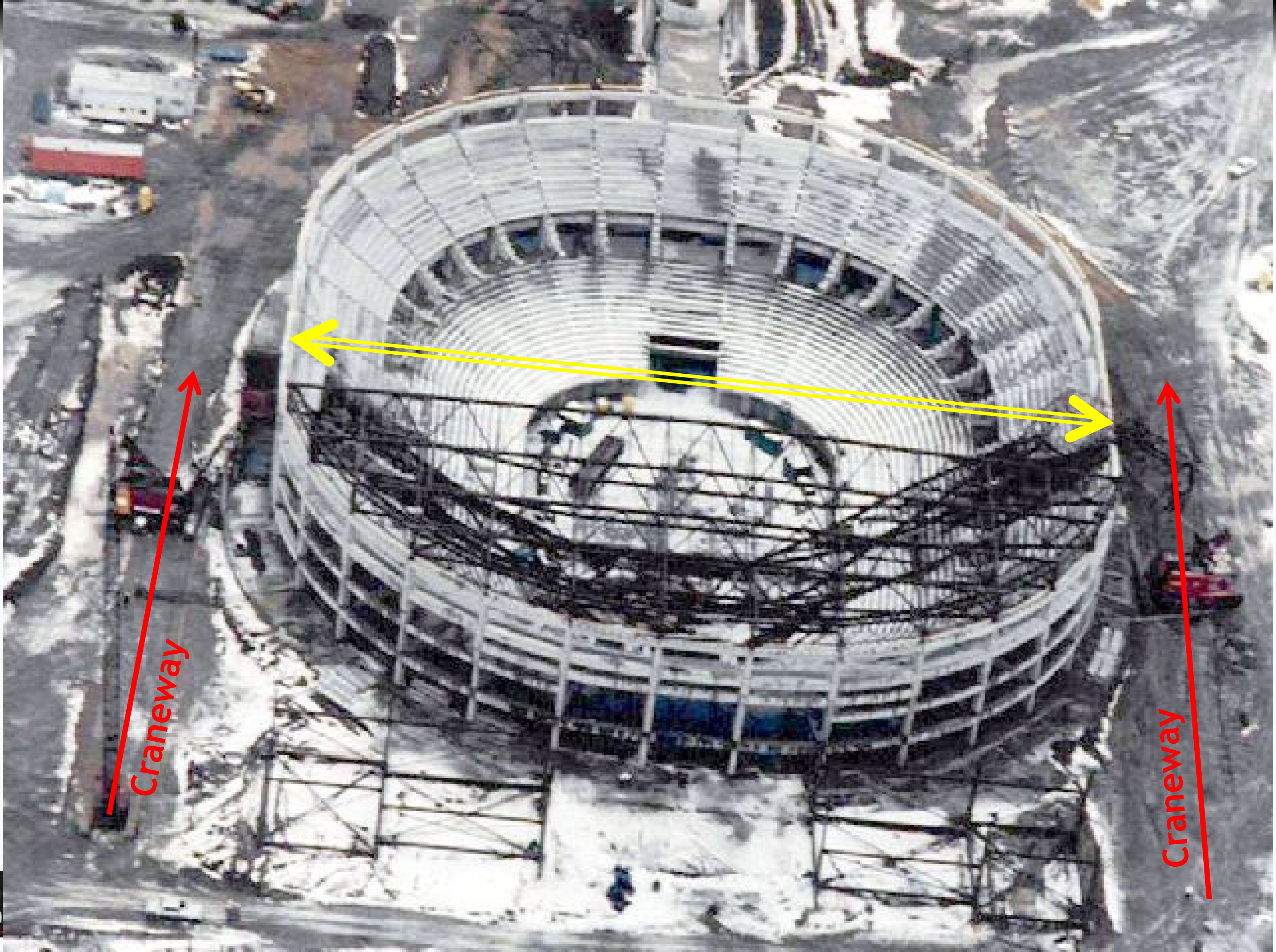
- A primarily responsible party has been defined as a party who failed in their responsibility in such a way that, without their breach of responsibility, the accident would not have occurred.

- A secondarily responsible party has been defined as a party whose breach of responsibility exacerbated the accident, but it would have occurred regardless due to other factors; or, the person in some form was aware of a potentially unsafe condition but did nothing.

Typical Responsibility Assessment

CRANE
ASSOCIATIO

HAAG
Engineering

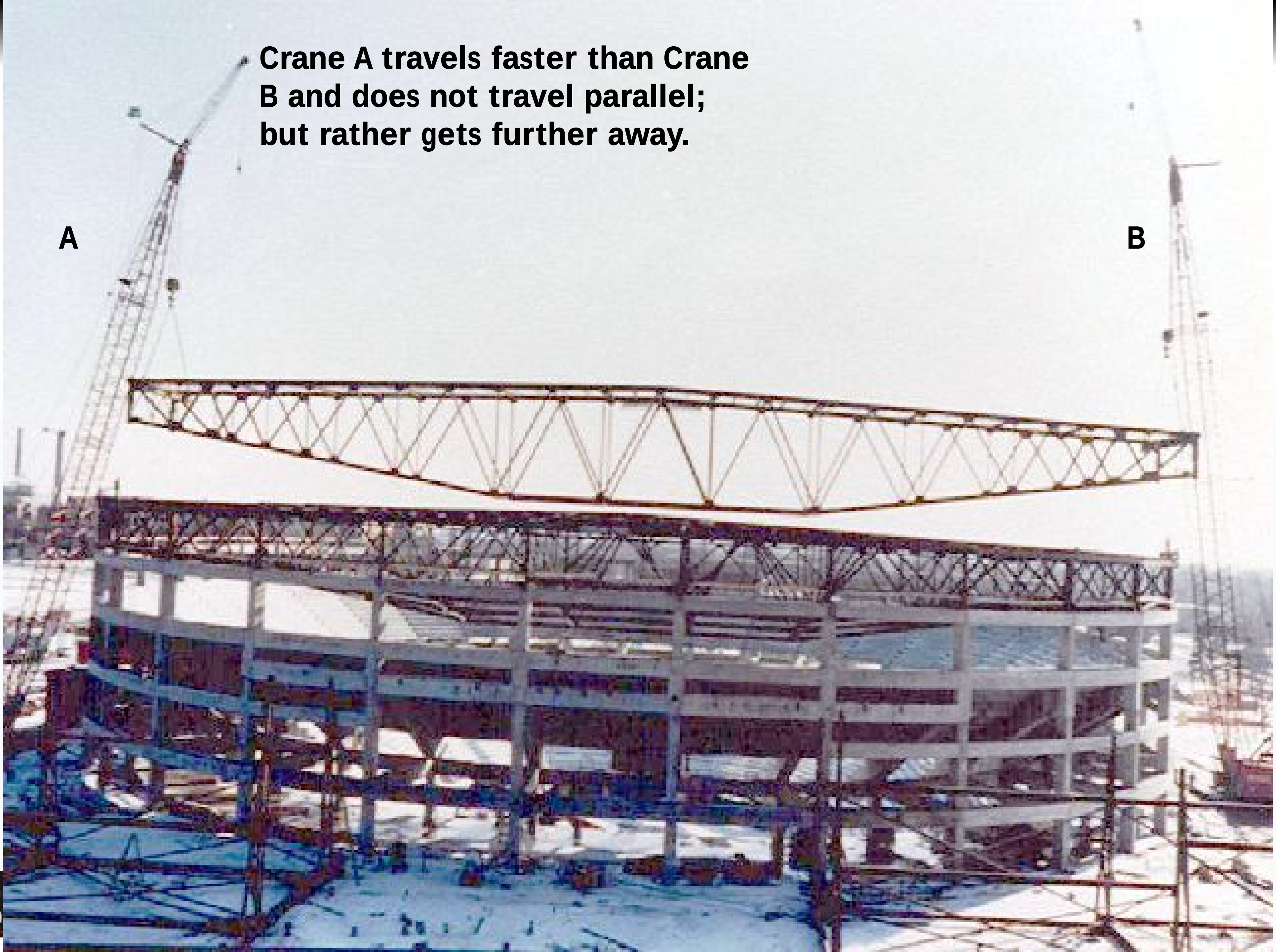

Craneway
Craneway

Breslin Area

- Dual pick and carry with a load using 2-4100’s
- Operators would pick up the long span truss and travel to its designated location for placement.
- Hand signals were used rather than radios. One person gave the signal to the operator and the spotter on the roof; who in turn transfer the signal to the opposite side of the stadium to the other spotter; who then signaled the crane operator on the other side of the stadium
- There was no directional guidance or speed control for the operators to follow

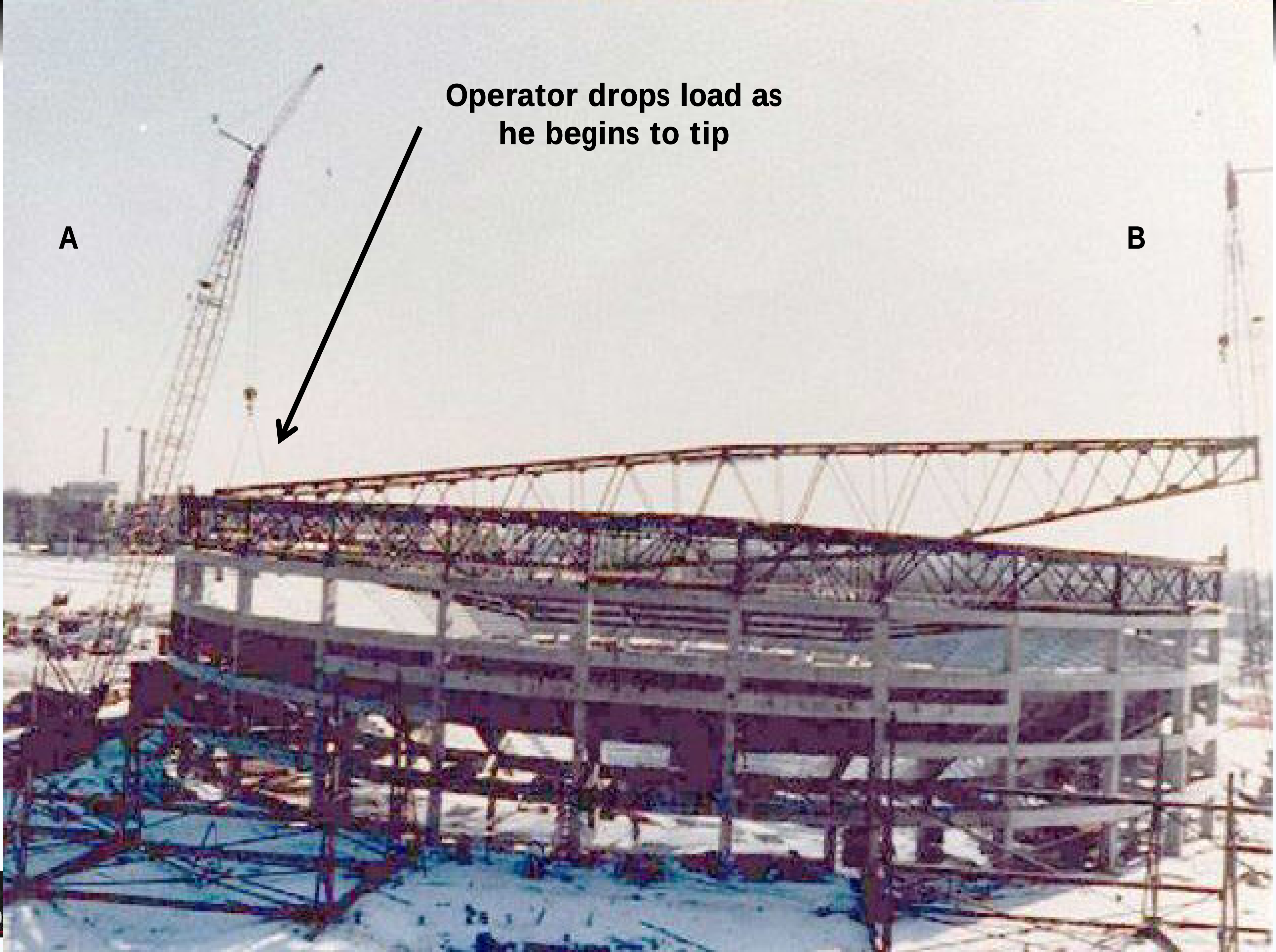
CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

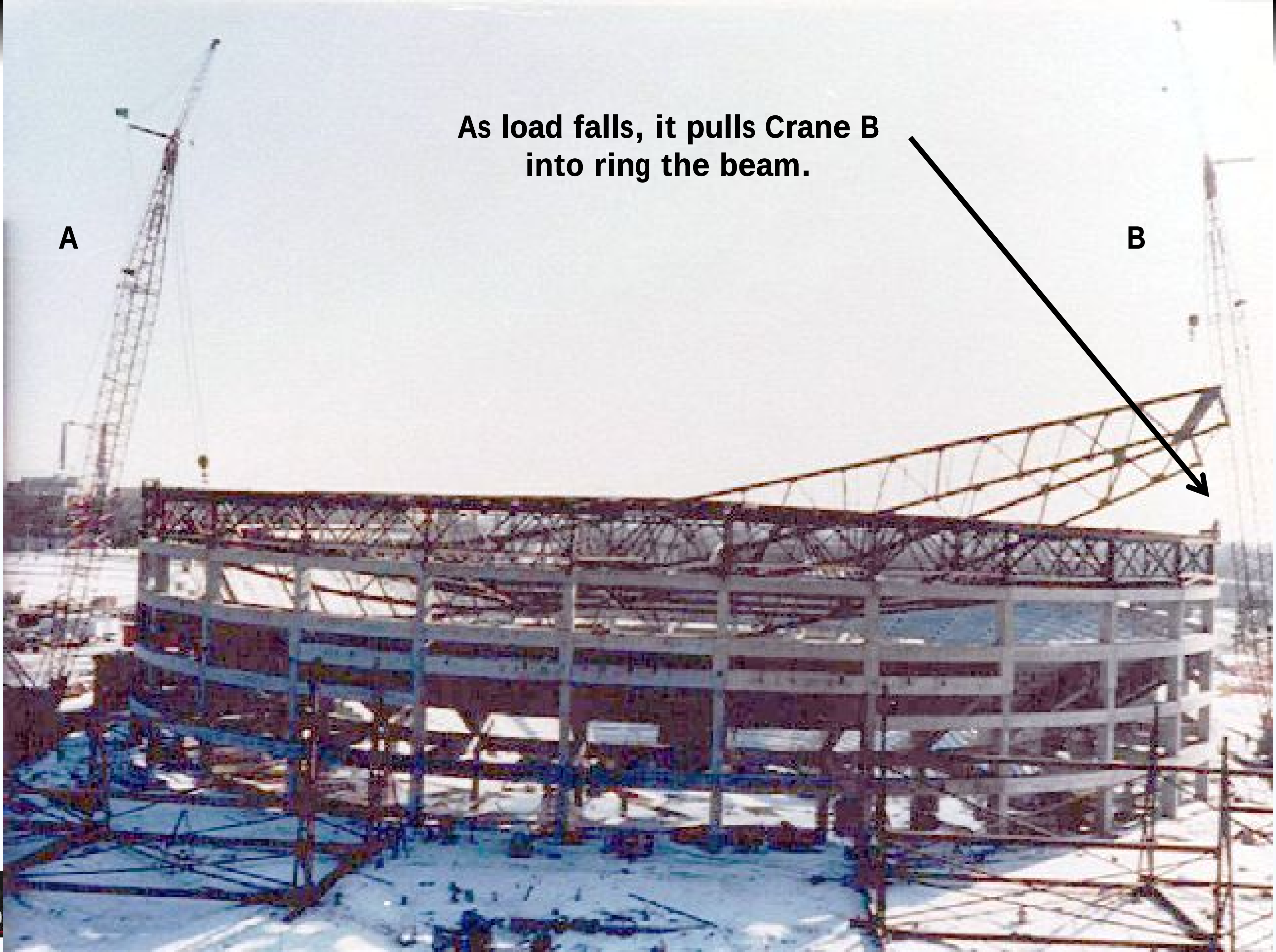


CRANE
ASSOCIATIO

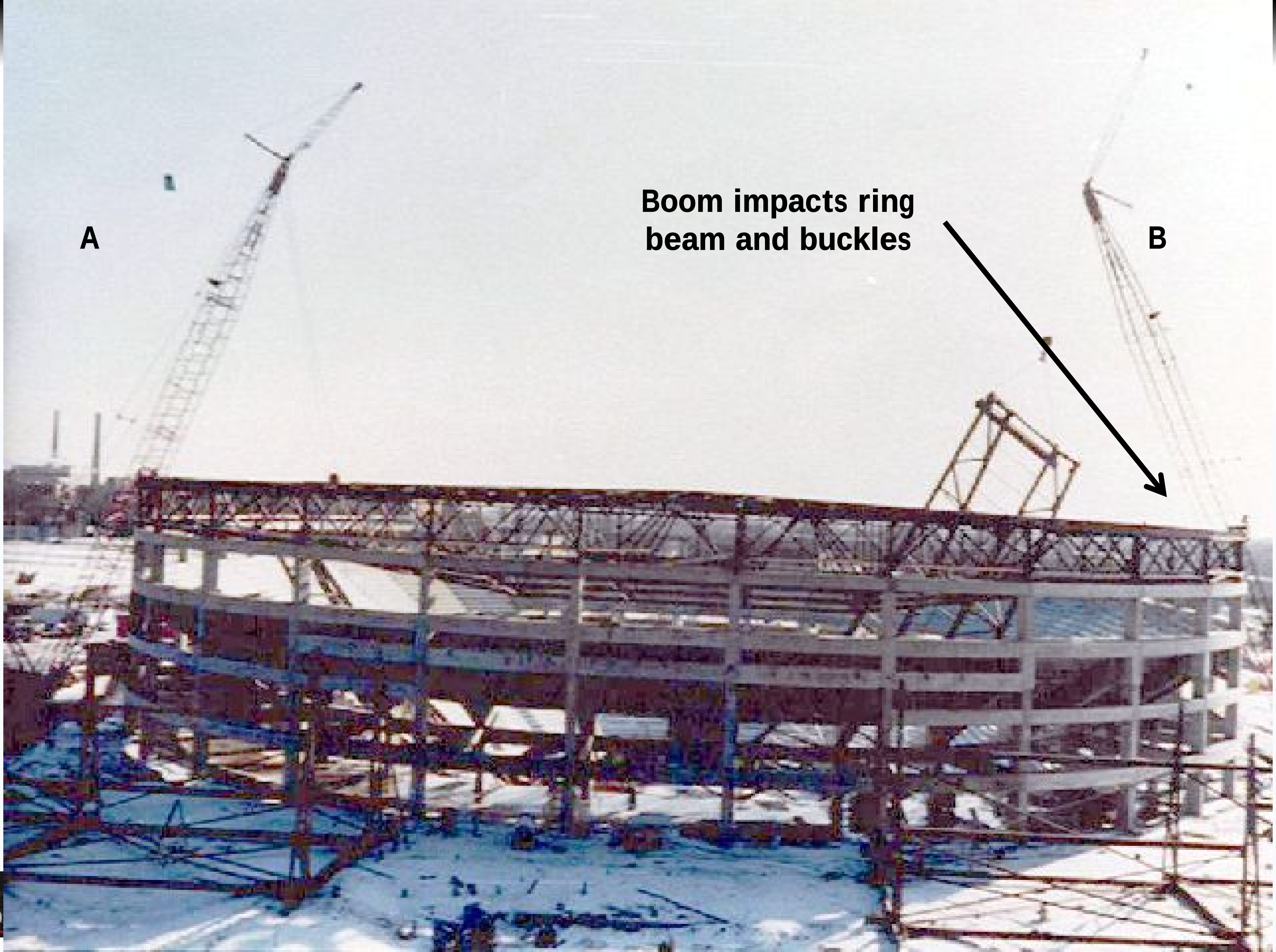
HAAG
Engineering


Operator drops load as
he begins to tip
A
B


A
B
Load strikes seating;
Crane A boom rebounds


As load falls, it pulls Crane B
into ring the beam.
A
B


A
B

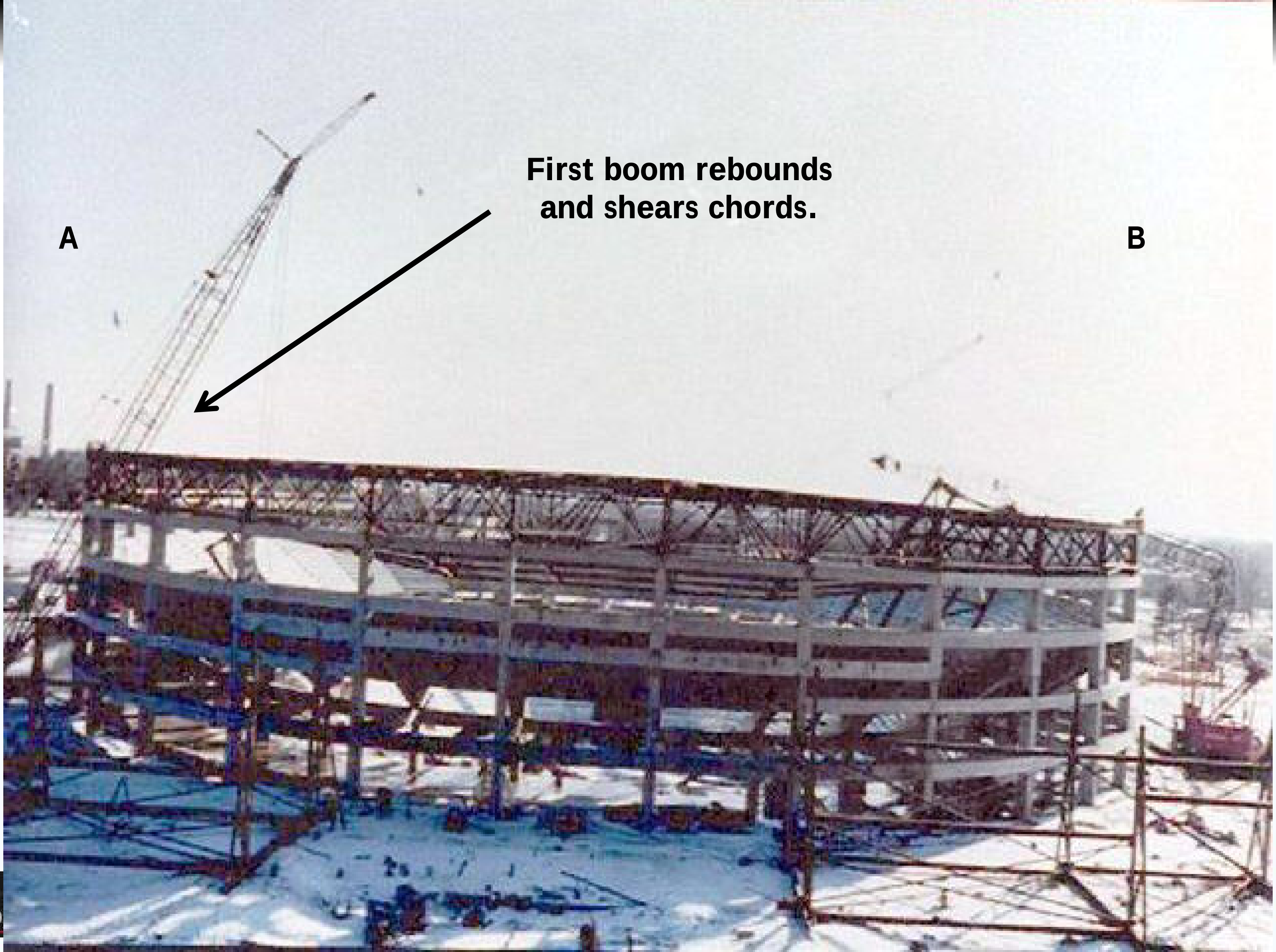


CRANE ASSOCIATIO

HAAG Engineering

CRANE ASSOCIATIO

HAAG Engineering



CRANE ASSOCIATIO

HAAG Engineering


A
B


A
B

CRANE ASSOCIATIO

HAAG Engineering

Breslin Center - *Dual Pick*

Michigan State University

Type of Lift/Operation: Critical

Noted Deficiencies:

- Lack of control line for parallel dual crane travel.
- Lack of station markers for uniform travel control.
- Lack of hardwired communication between operators.
- Lack of compacted crane-way for level travel.

Responsibilities: Primary: Lift Director

Secondary: Operator

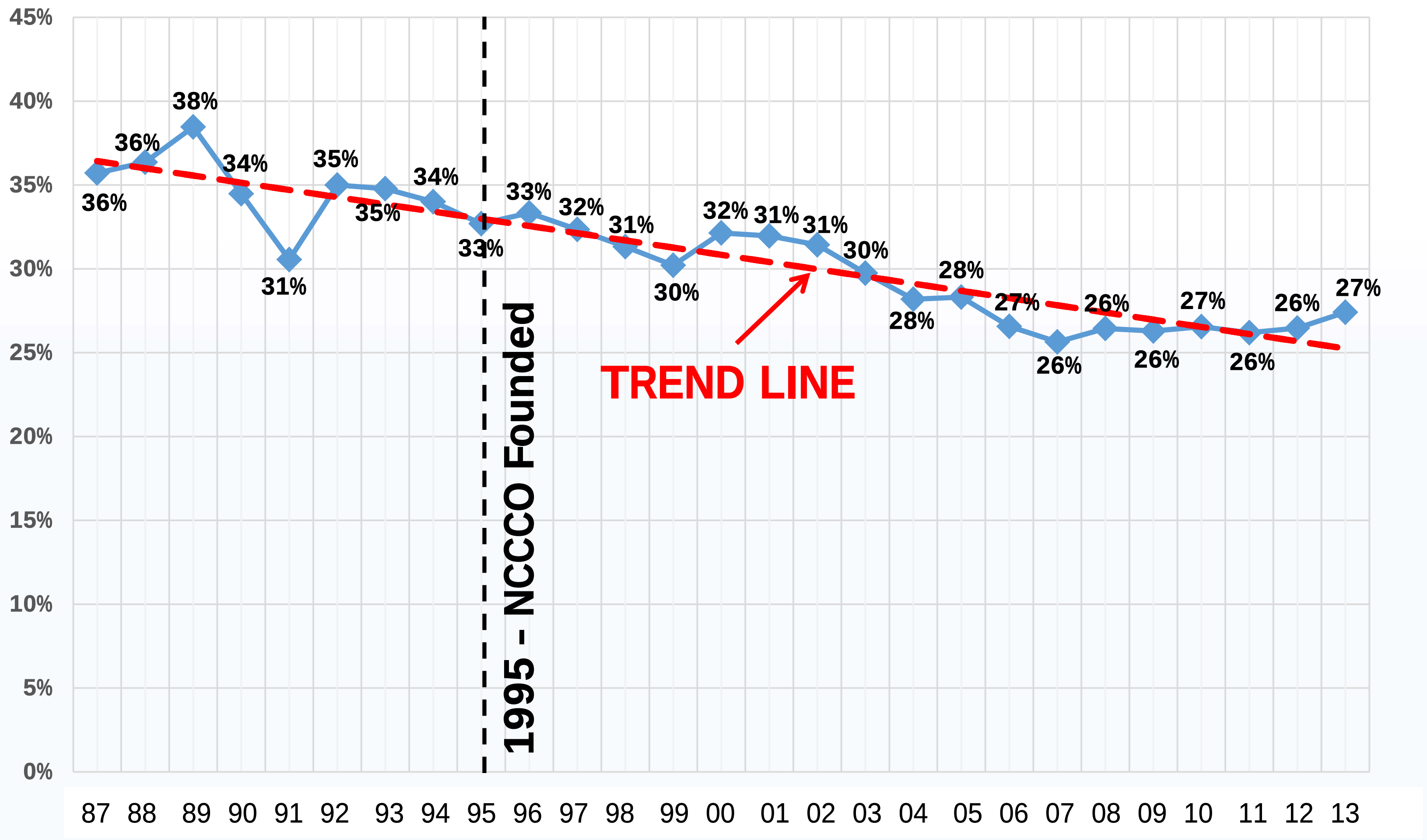
CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Primarily Responsible (All Incidents)

• Operator	27.4	%
• Lift Director	24.9	%
• Rigger	21.3	%
• Site Supervisor	16.8	%
• Mechanical/Maintenance	6.1	%
• Crane Manufacturer	5.7	%
• Owner/User	4.1	%
• Other	4.1	%
• Manufacturer of Load	2.2	%
• Signal Person	1.9	%
• Service Provider	1.6	%

OPERATOR RESPONSIBILITY TREND-1987-2013



CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Secondary Responsible (All Incidents)

• Operator	20 -	27.8%
• Lift Director	18 -	25.0%
• Rigger	2 -	22.2%
• Site Supervisor	8 -	11.1%
• Mechanical/Maintenance	2 -	2.8%
• Crane Manufacturer	NA -	--
• Owner/User	2 -	2.8%
• Other	1 -	1.4%
• Manufacturer of Load	NA -	--
• Signal Person	4 -	5.6%
• Service Provider	NA -	--
TOTAL	72	

CRANE RENTAL
ASSOCIATION OF CANADA

HAAG Engineering

Secondary Responsible (All Incidents)

- 72 out of 507 (14.2%) crane incidents had at least one person that was aware of the situation but did not take action or did not perform their job.
- Operator responsibility is trending down; however, with the continuous advent of new technology and “leaner/meaner” cranes, training has to keep pace.
- Specific attention has to centered around the Lift Director and their increased responsibilities.

CRANE RENTAL
ASSOCIATION OF CANADA

HAAG Engineering

Service Provider Statistical Data

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Service Provider-Crane/Operator

216 Incidents-Categories

• Commercial Construction	91
• Highway/Road & Bridge	19
• Industrial/Manufacturing	55
• Logging/Arborist	5
• Marine Industry	10
• Mining Industry	1
• Oilfield-Land Base	21
• Oilfield-Off Shore	1
• Residential Construction	13
• Agricultural	--

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Service Provider-Crane/Operator

216 Incidents-Type of Operation

• Standard Production Lift	137
• Critical Lift	22
• Crane Travel	15
• General Lift	11
• Crane Not In Use	10
• Assembly/Disassembly	8
• (Assisting with Outriggers)	
• Lifting Personnel/Basket	8
• Demolition	5

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Service Provider-Crane/Operator

216 Incidents-Crane Types

• Mobile Hydraulic	131
• Track Lattice	30
• Mobile Lattice	25
• Boom Truck	13
• Mobile RT	9
• Tower-Hammer Head	5
• Other	2
• Special Gin Pole	2
• Mega Crane	1
• Tower-Luffing	1

Service Provider-Crane/Operator

216 Incidents-Crane Capacity

15-99 Tons	105
100-199 Tons	54
200-299 Tons	41
300-599 Tons	9
2-14 Tons	5
Greater than 600 Tons	2

Service Provider-Crane/Operator

216 Incidents-Type of Work

MEP Equipment/Transformers	46
Materials Handling/Miscellaneous	36
Steel Erection-Girders-Rebar	36
Assembly/Disassembly	15
Demolition	12
Pre-Cast Girders/Beams/Tees	11
Wooden Beams/Trusses	8
Arborists	7
Swinging/Booming/Operations-No Load	7
Traveling with No Load	6

Crane Not in Use	5
Structural Steel Platforms	5
Handling Forms	4
Concrete Tilt-Wall	3
Power/Wind/Generators	3
Ship Loading/Unloading	3
Transmission Towers-Cell Towers	3
Traveling with Load	2
Concrete Placement	1
Lifting Personnel	1
Maintenance on Crane	1

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Service Provider-Crane/Operator

216 Incidents-Accident Types

- Crane Overturn 38
- Worker Contact/Load-No Accident 33
- Unstable/Dropped/Lost Load 29
- Boom/Jib Collapsed 24
- Rigging Failure 18
- Power Line Contact 12
- Landed Load-Stability Failure 8
- Worker Contact/Crane-No Accident 6
- Trip/Slip/Fall/Jump From Crane 4
- Other 3
- Assembly/Disassembly 2
- Personnel Basket Failure 2
- Boom/Jib Dropped 1
- Crane Travel/De-Railed 1
- Signaling 1

Service Provider-Crane/Operator

216 Incidents-103 Injuries By Trade

• Rigger	51
• Other Field Personnel	23
• Ironworker	17
• Signal Person	5
• Pedestrian/Bystander	3
• Operator	2
• Management	1
• Oiler	1

Service Provider-Crane/Operator

216 Incidents-42 Deaths By Trade

Other Field Personnel	13
Rigger	12
Ironworker	7
Operator	6
Management	2
Oiler	1
Pedestrian/Bystander	1
Signal Person	--

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Summary of Overall Findings

Use of Study to Improve Safety

- Identify those accident topics in each industry which are most problematic
- Implement internal lift planning and/or operational procedures
- Identify corresponding areas of certification or training trends
- Respond to industry interests relative problematic issues

Latest Industry Hot Topic

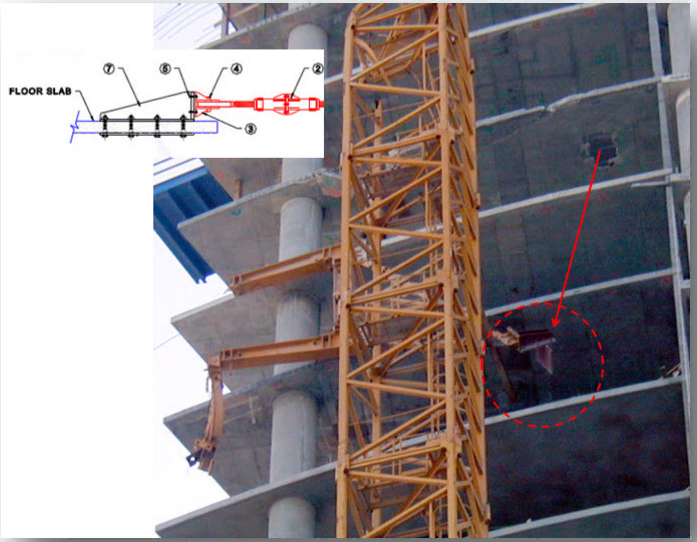
- Major Oil Companies/Refineries in the US are pushing for removal of the override key from the cab of the crane.
- Incorporate some type of warning device that let's workers and supervisors know that the crane has been overridden.
- Key outside the cab or given to a supervisor
  - EN 13000:2010 Required that the override switch be located outside the operator's cab to discourage the use of the override function by the operator.
  - Report, August 2015: After 5 years, *"In Europe there have been no accidents reported on cranes delivered after May 2010 related to operating outside of the permitted capacities. Moreover, we have had zero complaints from operators and no reports of situations where the new position of the override switch caused an issue."*

Findings: <u>Commercial</u>

- The highest occurrence of accidents were associated with:
  - Unknown or wrong weight
  - Overriding or turning off the LMI
  - Rigging
  - External engineering design
  - Improper signals-Tower crane incidences

Engineering Issues

- Weight/Stability Calculations-Demolition
- Special Application-Field Changes-Speed
- Design Change/Refurbish-Other than OEM
- Tower Crane Base Design
- Tower Crane Floor Tie-In
- Shop-Built Crane



CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Findings: Industrial/Manufacturing

- Elevated number of accidents associated with operator errors in manufacturing
  - Reduce number of operators permitted to operate the crane
  - Operator Training in accordance with ASME & OSHA requirements- National Certification Program
- Complex shapes with unknown center-of-gravities in Industrial lifts

Findings: Highway/Road & Bridge

- Almost 50% of the accidents occurred with no load on the hook
  - The majority of the “no-load” accidents were associated with crane movement with poor or substandard preparation
  - Largest number of critical lift accidents
  - Secondary issues were crane movement on the site associated with power line contact
  - Third factor was A/D

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Findings: Highway/Road & Bridge

- Significant number of complex and critical lifts corresponded to the highest percentage of Site Supervisor responsibilities
- Highest number of accidents with the boom striking stationary objects and collapsing
- Greater number of deaths than injuries per incident
- Workers in elevated positions that are near load
- Demolition and erection of long span girders-Lateral Torsional Buckling
    - >140 feet – PLAN YOUR PICK POINTS

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Findings: Residential

- Lack of lift planning experience resulted in elevated accidents associated with the Lift Director and Rigging
- Workers lack of understanding of load drift-use of tag lines
- Instability of the load after being lifted confirmed problematic issues with rigging
- Lack of experience field personnel often required the operator to rig and direct the lift
- Get confirmation that there will be certified riggers on the site or bring your own and bill the time.

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Findings: Marine

- Boom close proximity to side of the ship resulted in multiple buckled booms
- Multiple objects are rigged for each lift-dislodged/falling portions of the load
- Most lifts are IN THE BLIND-multiple workers trying to control/place/pick load-
- Workers touching or close proximity to load

Findings: Logging/Arborist

- Unknown weights-all estimates or best guess resulting in overturn
- Climber controls the operation (Lift Director)
  - Rigs the load that has unknown c.g.
  - Location of the cut determines the weight of the load
  - Once the tree is cut, the crane cannot release the load
- Lifting workers with the crane – ANSI Z133

Key Issues for Crane Rental Companies

- 94% of crane accidents examined occurred as a result of some type of error due to human decision making
  - Remember, certification is a mechanism to demonstrate a person has achieved a certain, minimum level of expertise in their trade
    - Continued training and actual operational experience for a specific crane or rigging is paramount
    - An operator may be certified to run a specific size/type of crane…but is he/she familiar with the actual crane he/she will be operating…Make sure the operator is familiar and comfortable with that crane
    - Even short stints of operations are beneficial

Key Issues for Crane Rental Companies

- More fatalities of Other Field Personnel (OFP) as a result of crane accidents than of those actually involved in the lift
  - Prior to making a lift have the operator ensure that personnel are clear of the load-remember, loads drift when first picked
  - Do not allow personnel close to the load that are potential pinch points

CRANE RENTAL
ASSOCIATION OF CANADA

HAAG Engineering

Key Issues for Crane Rental Companies

- 48.5% of all overturns (stability) occurred as a result of overloading the crane
  - 17.4% of those were associated with operational aid turned off or disconnected

  - Wrong weight determination or provided by others. Proceed carefully until the load indicating device confirms the load is within allowables
  - Override key…..Establish a procedure for the operator when confronted with potential overload. Refuse to lift.

Key Issues for Crane Rental Companies

- 29.8% of all crane accidents had no load on the hook
  - Train operators on the allowed configuration when traveling
  - When travelling/moving, know where power lines are located
    - Particularly when working concrete traffic barriers
    - Appoint a spotter to warn operator prior to reaching lines

Key Issues for Crane Rental Companies

- 56.7% of all rigging failures occurred as a result of lack of softeners
  - Identify sharp edges on loads
  - Ensure softeners are in place
  - Ensure softeners remain in place after the load is initially lifted
    - Recommend raising the load 8-12 inches
    - Ensure all softeners have not moved/slipped

Continued Expansion of the Study

Currently 925 (716) Crane Accidents Evaluated

Study Now at 600 (506)

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering

Tip of the Iceberg

- Database provides nearly endless combinations of information
- Tailored charts can be produced to specific to Industries, Crane Types, Crane Sizes, Lift Types, Accident Types, Type of Collateral Issues, and many more
- Retrieve information about specific planned lifts to better understand potential issues and prepare better safety plans and lift plans
- Production of White Papers, Trends and Articles resulting from study data

Tower Crane Life Expectancy

An Examination of Recent Trends to Establish Age Limits-January 2015

HAAG Engineering

TOWER CRANE LIFE EXPECTANCY

AN EXAMINATION OF RECENT TRENDS TO ESTABLISH AGE LIMITS

Jim D. Wiethorn, P.E.
Matthew R. Gardiner, P.E.
Anthony E. Bond, P.E.
Edward P. Cox, P.E., PhD
Ray A. King, E.I.T.

HAAG Engineering

TOWER CRANE LIFE EXPECTANCY

AN EXAMINATION OF RECENT TRENDS TO ESTABLISH AGE LIMITS

Over the past decade there have been increased discussions and attempts around the world to set and/or legislate a maximum service life of tower cranes, and in some cases mobile cranes based solely on their age. As a result of the recent publication *Crane Accidents: A Study of Causes and Trends to Create a Safer Work Environment, 1983-2013*, Jim D. Wiethorn, P.E., the Specialized Carriers and Riggers Association (SC&RA) approached Haag Engineering Co. to evaluate and compare the basis of these claims to our experience in crane accident analyses and Crane Study results. SC&RA submitted questions which their membership wanted addressed that relate specifically relate to the ages of the cranes. As part of our analysis, we examined the Crane Study results with respect to the crane ages at the time of the incidents to the actual causative factors of the accidents, with an emphasis on tower cranes. Additionally, we researched and addressed a variety of issues raised in support of and rebuttal to proposals for regulations in various parts of the world. The purpose of this analysis was to determine if any correlation exists between crane accidents and ages of cranes, to evaluate whether basis for these claims would suggest an age limit for such equipment.

HISTORICAL RESEARCH

The earliest known policy to stipulate calendar ages of cranes as a limit to their service lives was enacted in **Singapore** during October 2006, although development of the regulation first began in April 2004. The guidelines address imported tower cranes with both current registration and those seeking first time use in the country. The statutes governed the introduction of *used* tower cranes from other countries that met the following criteria.

1. First Time Use of A Tower Crane:
   - *Model and type-approved for use in Singapore and accompanied by a recent (not more than 2 years) inspection certificate from the statutory authority from the country it was used.*
   - *Any tower crane not manufactured in Singapore that is 5 years or older shall be subjected to an inspection by a third-party inspection agency acceptable to the Commissioner for Workplace Safety and Health.*
   - *Used tower cranes are not permitted in Singapore if the unit is 1) from a country that does not have requirements on statutory inspection; 2) the crane is 15 years or older (date of manufacture); 3) or the tower crane has an inspection certificate from a country that was last issued more than 2 years ago.*

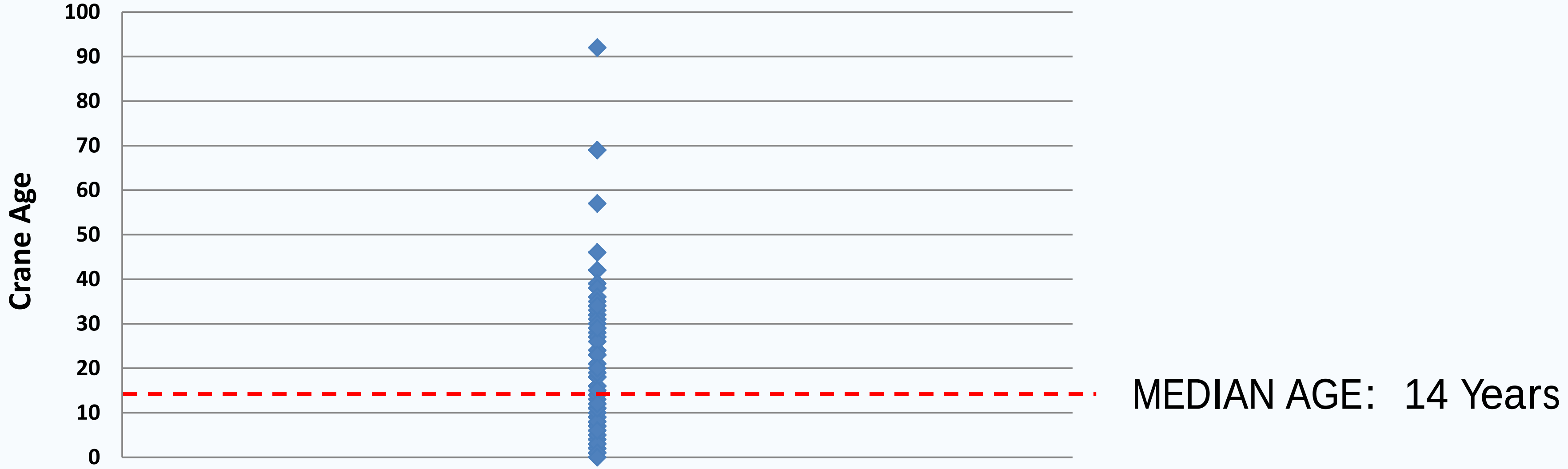
CRANE RENTAL ASSOCIATION OF CANADA

www.haagengineering.com/technical-papers

HAAG Engineering

Age of Cranes at Time of Incidents

- Range from 0 to 92 years old
- Average age is 16.9 years
- Median age is 14 years
- Data confirmed there is no correlation between crane age and accidents



CRANE RENTAL
ASSOCIATION OF CANADA

HAAG Engineering

Wind vs Tower Cranes

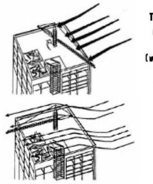
WHAT REALLY HAPPENS?

Exclusive to *ACT*, **Jim Wiethorn** and **Peter Juhren** discuss what really happens when tower cranes operate in wind.

Wind vs. tower cranes

Tower cranes can lift loads to heights that conventional cranes cannot approach. Their lack of mobility and needs for structural support (foundation) is outweighed by their ability to reach long distances at great heights. Since they are best suited for operating at great heights, concerns about high winds, particularly since lowering them to lesser elevations cannot be done easily. To overcome this perceived disadvantage, tower cranes are designed to swing (weathervane) with the wind, thereby minimizing the profiles exposed to the wind pressure. However, unlike conventional single vertical towers, tower cranes have additional built-in characteristics which provide additional resistance to wind effects.

In out-of-service configuration, the tower leans slightly toward the counterweight side of the tower. When a tower crane weathervanes properly, the jib rotates and aligns with the path of the wind. Wind forces must be quite strong to overcome this initial lean and push the tower back to vertical. With increasing wind pressure, the tower ultimately will lean opposite the counterweights, and with greater wind forces component members can experience loads exceeding their ultimate strengths.



Tower cranes are designed to swing (weathervane) with the wind, which minimizes the profiles exposed to the wind pressure.

When a tower crane weathervanes properly, the jib rotates and aligns with the path of the wind.

Human intervention

This unique wind resistant design feature can be reduced or even eliminated by erroneous human intervention. During our years of examining tower crane failures, too often we have determined that operators, erectors and even management personnel have intervened in ways which led to the ultimate demise of tower cranes. Their well-intended actions led directly to crane failure. One repeated mistake derives from the myth that high winds will cause the upper of the tower crane to spin violently and cause failure of the crane. Believing this myth, operators apply one brake to slow the rotation during high wind events. One operator interviewed explained that he was taught to apply a single brake prior to exiting the tower crane in anticipation of high winds for this very purpose. Similarly, inadvertent applications of the brake prior to high winds have occurred.

In 2003 during construction of FedEx Forum in Memphis, TN, a severe thunderstorm was approaching the city and emergency procedures were implemented. Emergency procedures included directives to the three tower crane operators to take their cranes out-of-service and seek shelter. One of the operators left the cab and began evacuation without manually disengaging the swing brake. When he reached the base of the tower and turned off the power, the spring loaded brakes manually set. Reported wind speeds were on the order of 105 mph, and the tower crane that was restrained could not weathervane. The involved tower crane base experienced distortion, but did not fail. Additionally, the tower was leaning about 40 feet. After the event, we found that the two properly prepared tower cranes had weathervaned and the damaged unit had not.

In 2012 as Hurricane Sandy approached New York City, workers prepared a luffing tower crane near the top of a 100-story building. Examination revealed four safety lanyards which workers had used to tie-off while inserting tower sections to raise the crane height, remained secured to the outrigger beam. Two of the lanyards wrapped around the outrigger beam remained tied off, reportedly to prevent the D-rings from striking the crane. The D-rings of the two remaining lanyards were pulled tight and fitted over protruding bolts on both sides of the slewing ring, effectively restraining the upper from rotating. During high winds, the upper could not weathervane because

In 2003 during construction of FedEx Forum in Memphis, TN, a severe thunderstorm produced wind speeds up to 105 mph.

In 2012 as Hurricane Sandy approached New York City, workers prepared a luffing tower crane near the top of a 100-story building. As wind speeds increased, frontal winds blew against the luffing boom and ultimately pushed it over the rear of the upper.

THE AUTHORS

Jim D. Wiethorn, P.E., is principal/chairman of Haag Engineering, forensic engineers and consultants since 1924. **Peter Juhren** is vice president of operations of Morrow Equipment Company, one of the largest tower crane suppliers in the United States.

the lanyards restrained rotation. As wind speeds increased, frontal winds blew against the luffing boom and ultimately pushed it over the rear of the upper.

Billboards in the sky

Perhaps the primary issue with companies leasing tower cranes is lessee (user) desire to have the company name prominently displayed on the counter jib of the tower crane. Tower cranes, often being the tallest structure on a construction project, are the preferred choice for advertising the project, developer or construction company. They become billboards in the sky. Around almost any site, there will be signs naming the general contractor in addition to the manufacturers or crane owner's signs. Wind effects on tower cranes are reduced drastically when users simply follow the manufacturer's recommendations and instructions when it comes to installing signs.

In most cases, the manufacturer calls for signs to be limited to 32 square feet and to be placed in only specific locations. Incorrectly placed signs, and signs larger than the manufacturer recommends, increase the wind impingement area and can have dire consequences. Operation of the crane can be affected, and crane control, even in low wind conditions, can be difficult. In extreme cases, the crane will not weathervane due to the wind area balance between the jib and counter jib, orienting the crane in a worst case scenario, wind blowing directly from the side. Signs never must be placed on the vertical tower sections.

In regions with severe icing possibilities, even a properly shaped and vented sign can become a hazard. In 2002 a winter storm with freezing rain and high winds swept through the Chicago area. A properly sized and vented sign became covered with ice, freezing the vents and much of the diamond mesh on the counter jib solid. Ultimately, witnesses watched from an adjacent apartment complex as the upper began to spin with increasing speed until the entire upper severed from the tower and fell to the concrete formwork below.

In many instances, the normal free-standing height of a tower crane must be increased to work effectively on a structure being constructed.

In many instances, the normal free-standing height of a tower crane must be increased to work effectively on a structure being constructed. The tower must be attached properly to the structure to reduce stresses on the tower. The Engineer of Record (EOR) must design means to react operational loads quantified by the crane manufacturer into the structure. Tie-in braces often are placed on tops of the slabs, thereby inducing bending moments in the slabs during normal operations and during high wind events. The EOR must understand the introduction of crane bracing loads into the slab and reinforce the slab properly. In 2005 during the passage of Hurricane Wilma through Hollywood, FL, a prepared tower crane experienced high winds. During the event, a brace attachment to the slab pulled a section of concrete the size of the bolted plate out of the slab. The sudden release of tower restraint caused immediate buckling and collapse above the brace attachment point. Evidence revealed the slab had not been properly reinforced for operational tie-in loads.

Varying wind conditions

Construction of tall, contemporary buildings often in high density urban areas, creates different issues with tower cranes and wind. The redirection of wind and compression of air flow into narrow paths result in increased local wind speeds. In more complex settings, wind tunnel testing often is required to define wind effects at the site and on the crane. Multiple cranes at a single site can each experience different wind loadings depending on surroundings and wind direction.

In 2010 toward the completion of a 47-story hotel building in Atlantic City, NJ, six tower cranes stood on the site, each with a different height and location by the hotel tower or by the adjacent meeting room wings. An early morning nor'easter storm swept through the site and ultimately pushed the hammerhead jib on one of the cranes over the rear. The involved crane did not weathervane, and subsequent examination determined the brakes had not been set on the upper swing mechanism. Examination of site revealed a large flat surface on one side of the building approximately 450 feet wide and 47 stories tall. The top of the building sloped downward approximately 115 feet across the width of the building. The involved tower crane was at the high point of the sloped roof and closest to the top of the building. Following the event, we determined that all cranes except the involved unit had weathervaned as intended. Testing of the building and tower crane position in a wind tunnel revealed that wind impinging against the flat surface of the tall building was re-directed vertically, diverting the horizontal wind flow which normally weathervanes the upper. The shape of the building and proximity of the jib to the top of the building prevented intended vaning.

It is necessary for the end user to evaluate each potential tower crane location and analyze its surroundings for potential effects with the crane owner and engineer of record (EOR). Initial evaluation of the crane location must assure the crane can weathervane 360° without obstruction, particularly other structures. The EOR must have experience with tower crane loading patterns and be experienced on how to secure the crane properly to the structure to react operational loads. Users of tower cranes erected in hurricane-prone areas must inform the owner of the special wind-zone area they want the design to comply with. The request should include detailed information for the implementation of specific out-of-service guidelines, in the event of a predicated storm landfall. Following manufacturer's guidelines and pre-planning greatly diminish the potential for tower crane collapse or damage. ■

In 2010 a 47-story hotel building under construction in Atlantic City, NJ had six tower cranes working at the site. An early morning storm swept through the site and pushed the hammerhead jib on one of the cranes over the rear.

CRANE RENTAL ASSOCIATION OF CANADA

American Cranes & Transport (ACT) – May 2016

HAAG Engineering

Thank you!
Questions?

jwiethorn@haagglobal.com

CRANE RENTAL ASSOCIATION OF CANADA

HAAG Engineering