Construction Management and Project Engineering

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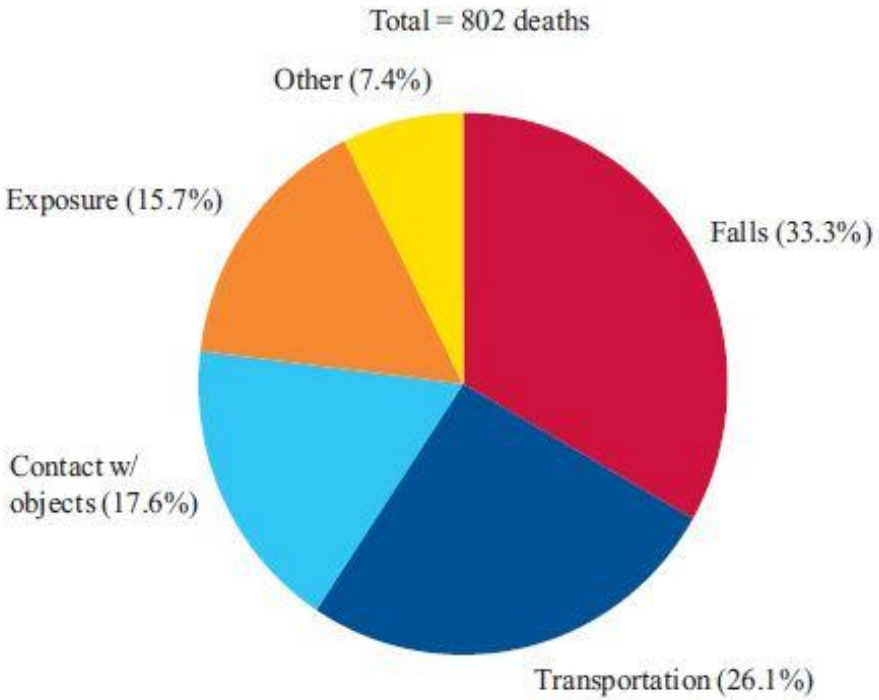
SEOUL NATIONAL UNIVERSITY

Leading Causes of Injuries in Construction

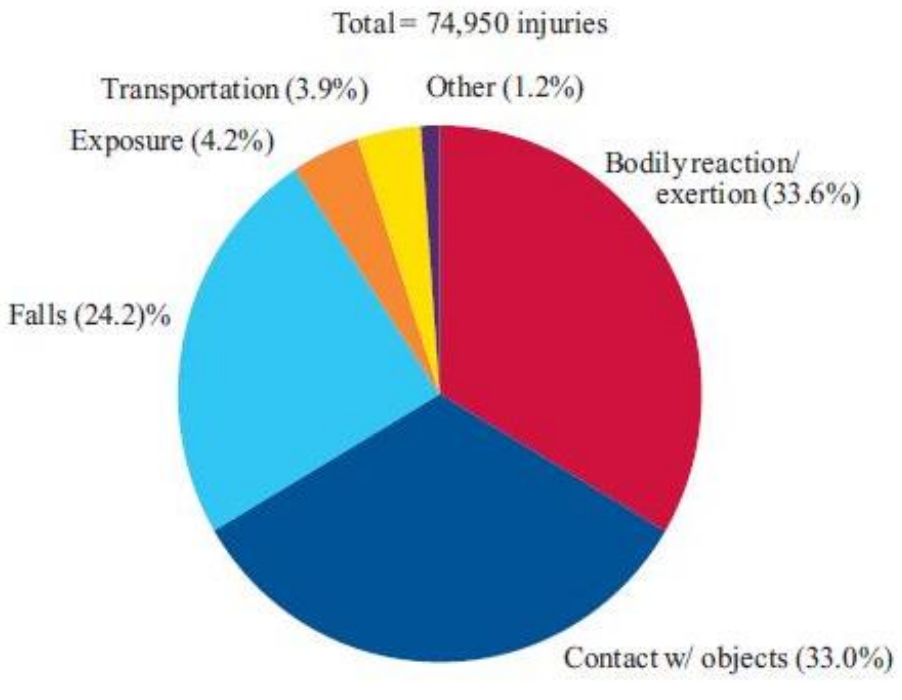
Leading Causes of Injuries

- Preventions and regulations for *falls, struck-by, ergonomic injuries*



Distribution of leading causes of **fatal ities** in U.S. construction, 2010

[CPWR 2013. The Construction Chart Book, 5th Ed.]



Distribution of leading causes of **non-f atal injuries** resulting in days away fro m work in U.S. construction, 2010

Fall Protection: Overview

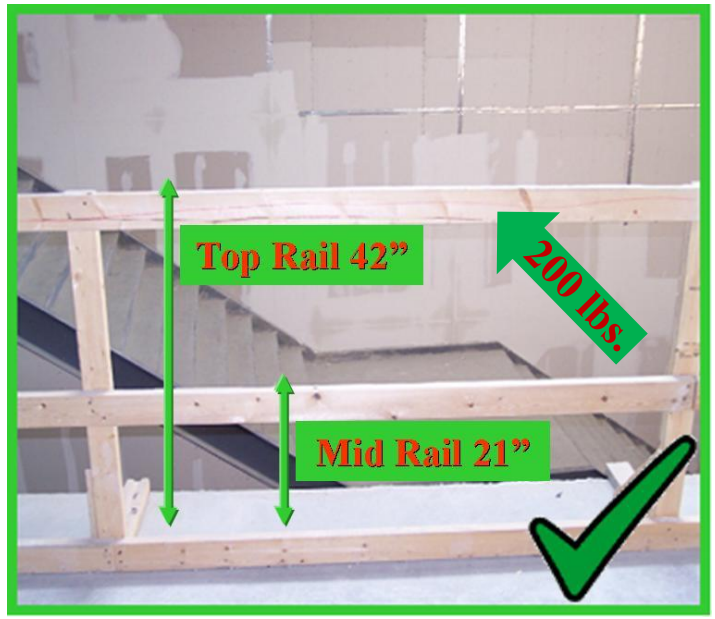
- Falls are one of the most frequent and severe hazards in the construction industry.

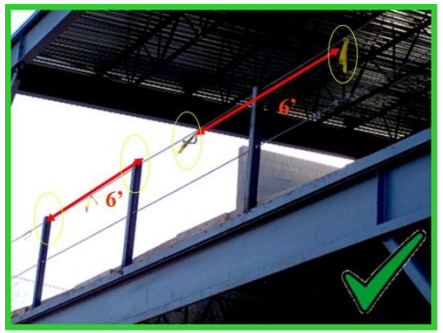
- Fall hazards from
  - Building structures
  - Exterior construction areas
  - Scaffolds
  - Stairs
  - Ladders

- Accident Prevention
  - Guardrails
  - Warning lines
  - Personal fall arrest systems
  - Floor covers

Fall Protection: Prevention

- Guardrail Systems: OSHA recommendations
  - Guardrail systems must have a top rail, a mid rail and a toe board.
  - The top rail must be at least 42” from the working surface.
  - The top rail must support 200 lbs. of force downward and outward.
  - The mid rail must support 150 lbs. of force.
  - Steel cable guardrails must have the top rail flagged every 6 feet.





[Caporali (2008). OSHA: Big Four Construction Hazards: Fall Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/falls_english_r6.pdf)]

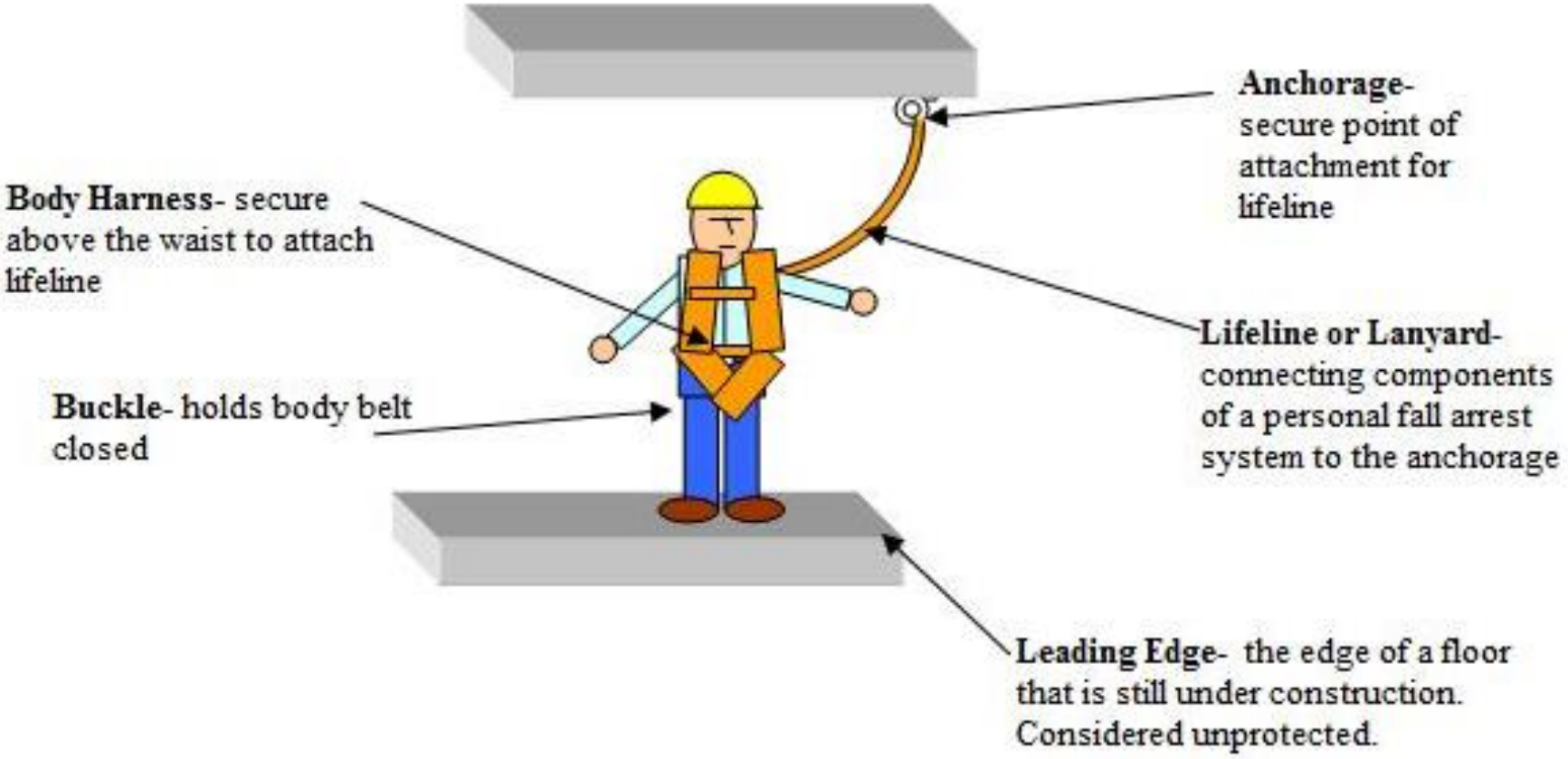
Fall Protection: Prevention

- Warning Lines: OSHA recommendations
  - Warning lines are used to keep workers away from an unsafe edge.
  - The warning line must be at least 6’ away from the edge.
  - Warning lines must withstand 16 lbs. of tipping force.
  - The warning line must be at least 34” from the ground.

[Caporali (2008). OSHA: Big Four Construction Hazards: Fall Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/falls_english_r6.pdf)]

Fall Protection: Prevention

- Personal Fall Arrest System: OSHA recommendations



Fall Protection: Prevention

- Floor Covers: OSHA recommendations
  - The cover must be marked to make sure everyone knows that it is a safety device.
  - All floor holes where an employee could fall through must be covered or guarded.
  - Pier holes must be guarded or protected.
  - Either a guard rail system or floor hole cover can be used.

[Caporali (2008). OSHA: Big Four Construction Hazards: Fall Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/falls_english_r6.pdf)]

Case Studies: Fall Prevention

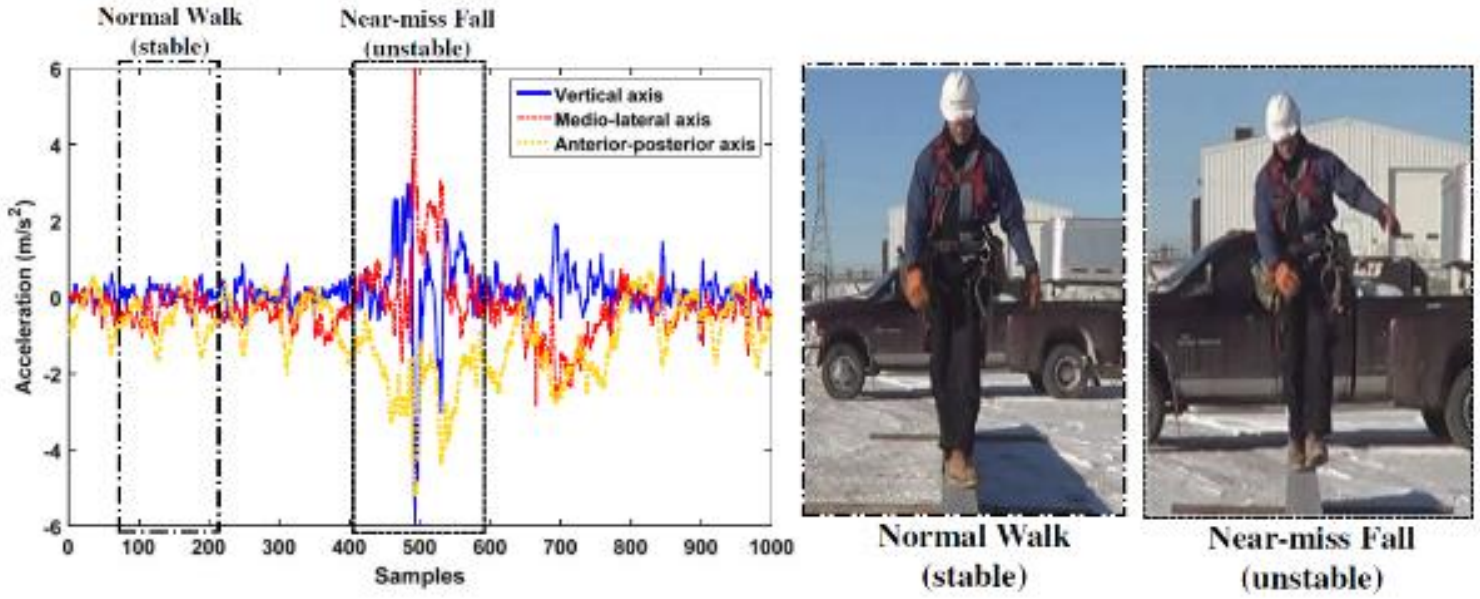
- Identifying fall hazard and assessing its risk using BIM

Fig. 9. Three-dimensional views for risk assessment 01 "People falling between different levels" (left) and after re-evaluation (right) with the pillars marked in colour based on the risk.

(Cortes-Perez et al. 2020)

Case Studies: Fall Preventions

- Monitoring near-miss falls / exposures to slip, trip, and fall hazards



(Yang et al. 2014; Yang et al. 2015; Yang et al. 2016)

Case Studies: Fall Preventions

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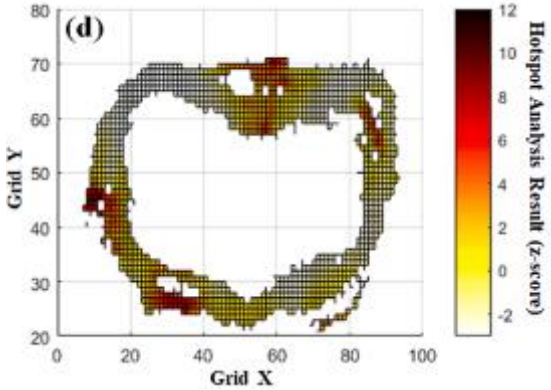
Safety Hazards



Data Aggregation of 10 Subjects

(Kim et al. 2017; Yang et al. 2019)

Case Studies: Fall Protection

- IOT devices for fall protection

Smart Harness (한림기술)

Airbags

Struck-by Protection: Overview

- Struck-by incidents are one of the most deadly hazards on construction jobsites.
- Types of struck-by hazards
  - Struck-by falling objects
  - Struck-by flying objects
  - Struck-by swinging/slipping objects
  - Struck-by objects on ground level
- Accident Prevention
  - Personal Protective Equipment (PPE)
  - Material storage
  - Proper materials handling
  - Work zone safety

[Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)]

Struck-by: Hazard Recognition

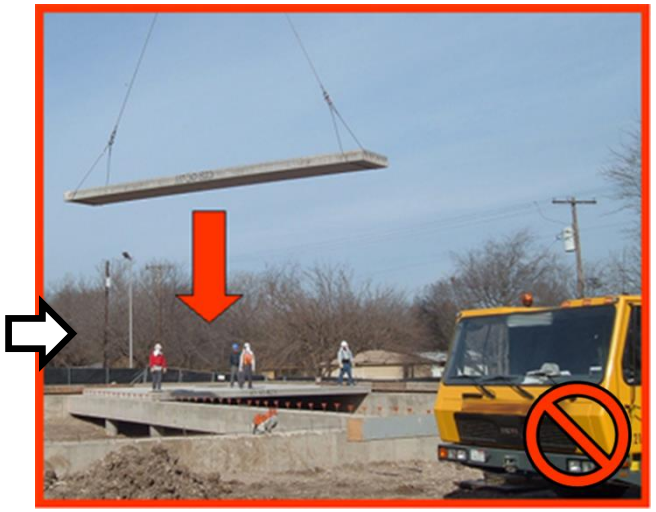
- Struck-by Falling Objects

Working or walking below elevated work surfaces may expose you to falling objects.

Store materials properly.

Materials being moved overhead expose you to falling objects.

Keep a safe distance from suspended loads.



[Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)]

Struck-by: Hazard Recognition

- Struck-by Flying Objects

Power tolls and activities such as pushing, pulling, or prying can create flying objects.

Air pressurized above 30 psi can drive oils and other particles through your skin.

Grinding or striking materials can create flying object hazards.

[Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)]

Struck-by: Hazard Recognition

- Struck-by Swinging/Slipping Objects

Do not work under loads a
s they are being lifted.

Secure all loads and lift them evenly
to prevent them from slipping.

[Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)]

Struck-by: Hazard Recognition

- Struck-by Objects on Ground Level

All traffic and moving materials on construction jobsites can create struck-by hazards.

Heavy equipment can create serious struck-by hazards.

Workers in work zones are exposed to struck-by hazards from construction equipment and motorist vehicles.

Never work near vehicle traffic without barricades.

[Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)]

Struck-by: Hazard Prevention

- Personal Protective Equipment (PPE)

Wear a hardhat if overhead hazard exist. Overhead hazards are, for example, falling and flying objects, or objects that you may bump into.

Wear safety glasses or a face shield if flying hazards exist.

A highly visible reflective vest will allow motorists and equipment operators to see you.

[Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)]

Struck-by: Hazard Prevention

- Material Storage

Secure materials so they do not fall on workers.

Maintain proper house-keeping in all storage areas.

[Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)]

Struck-by: Hazard Prevention

- Proper Materials Handling

Inspect all rigging before using.
Never work under a suspended load.
Stay clear of loads as they are being lifted.

Never walk or work under a load.

Never lift a load that is greater than the crane's lifting capacity.

[Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)]

Struck-by: Hazard Prevention

- Work Zone Safety

Use extreme caution when approaching heavy equipment. Only authorized personnel are allowed to get in the work zone. Never approaching moving equipment and from behind.

Traffic work zones must be clearly marked to make motorists aware of the work ahead.

Use physical barriers to protect workers from vehicle traffic.

[Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)]

Case Studies: Struck-by hazard prevention

- VR-based training for struck-by hazard

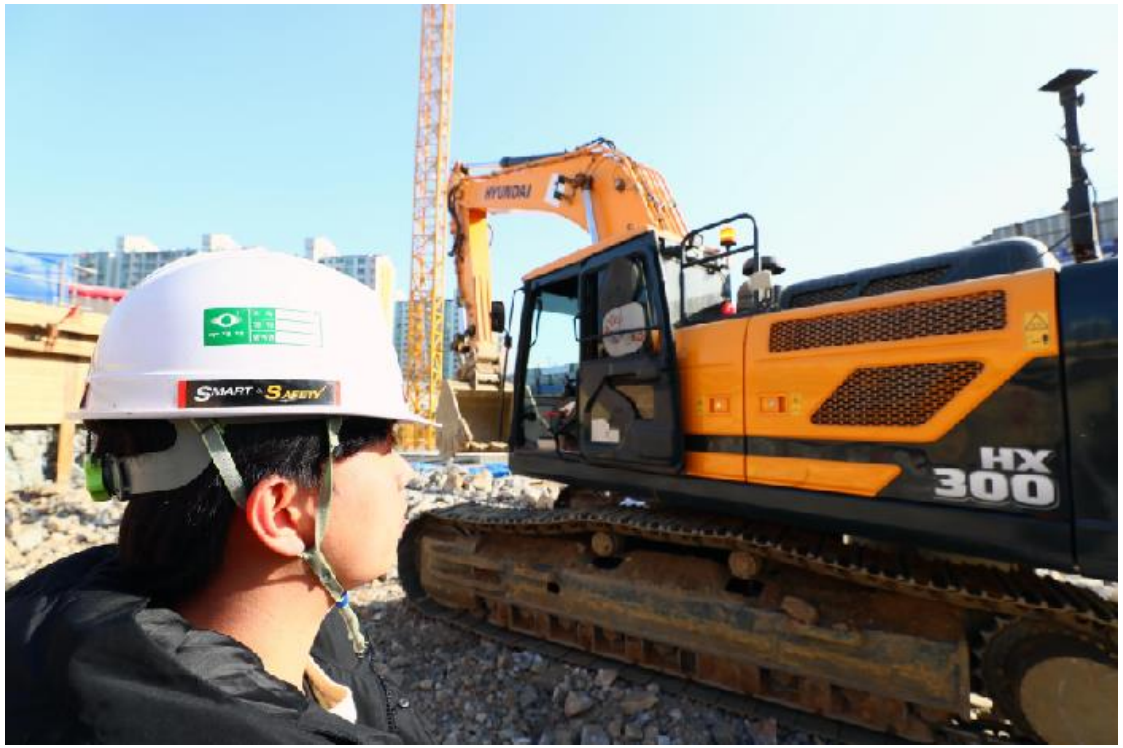
Virtual road cleaning ta
sk

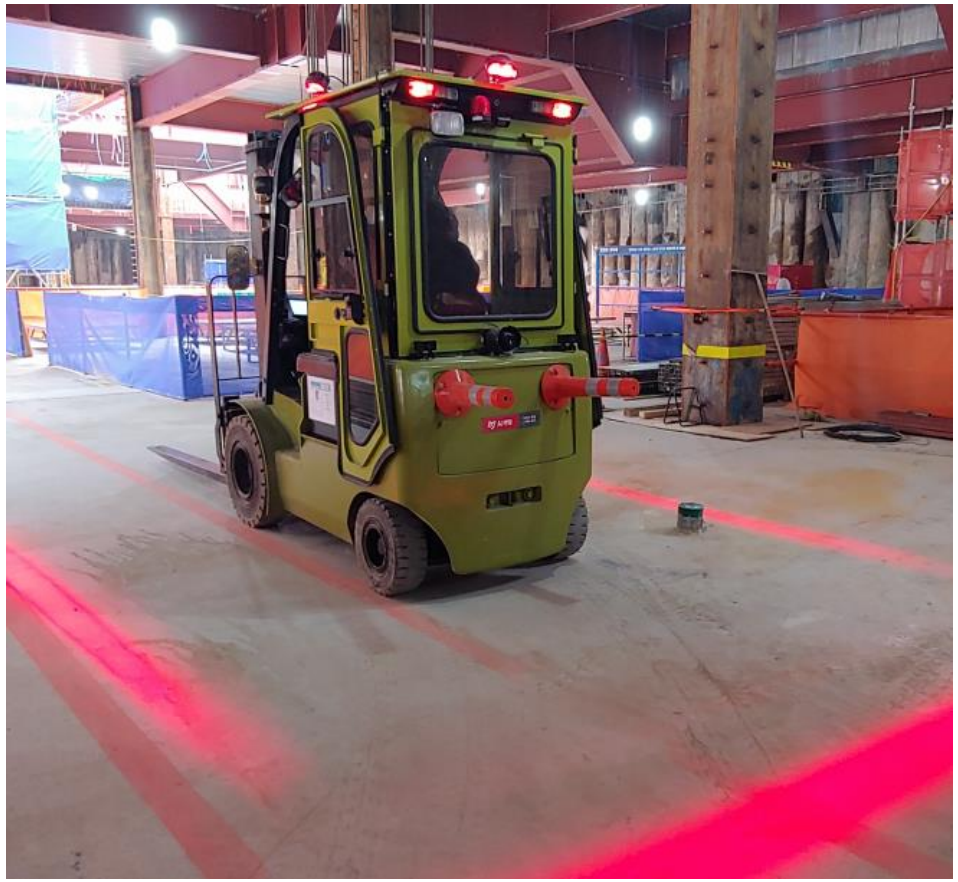
VR-accident experience

(Kim et al. 2021)

Case Studies: Struck-by hazard prevention

- Proximity sensors / indicators

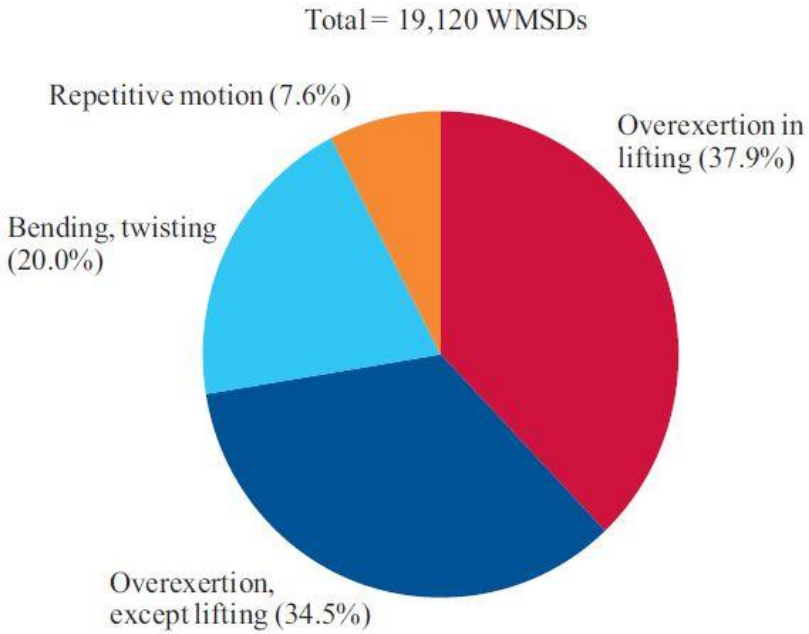




Ergonomic Hazards: Overview

- The rate of work-related musculoskeletal disorders (WMSDs) in construction was 16% higher than all industries combined in 2010.

- Ergonomic Risk Factors
  - Repetition
  - Awkward posture
  - Forceful exertion
  - Static posture
  - Mechanical contact stress
  - Temperature
  - Vibration



[CPWR 2013. The Construction Chart Book, 5th Ed.]

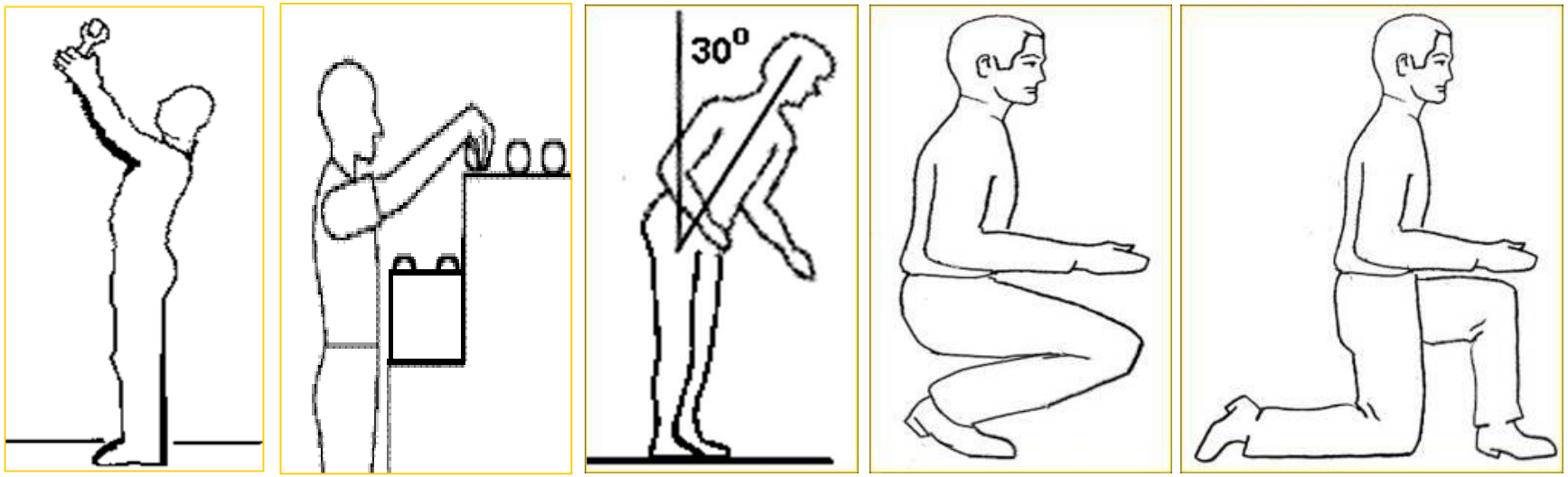
Ergonomic Hazards: Overview

- Accident Prevention
  - Engineering approach
    - ✓ Tool modification
    - ✓ Workplace design
- Administrative approach
  - Proper break time
  - Teamwork and rotation
- Work practice (e.g., training)
  - Use of a right tool
  - Avoid awkward postures

Ergonomic Hazards: Recognition

➢ Awkward Postures

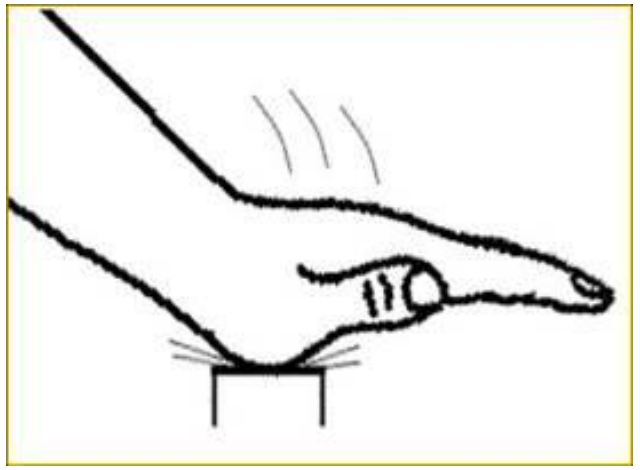
- Being in these positions for more than 4 hours total per day
  - ✓Hands above head
  - ✓Elbows above shoulder
  - ✓Back or neck bent forward more than 30 degrees
  - ✓Squatting
  - ✓Kneeling

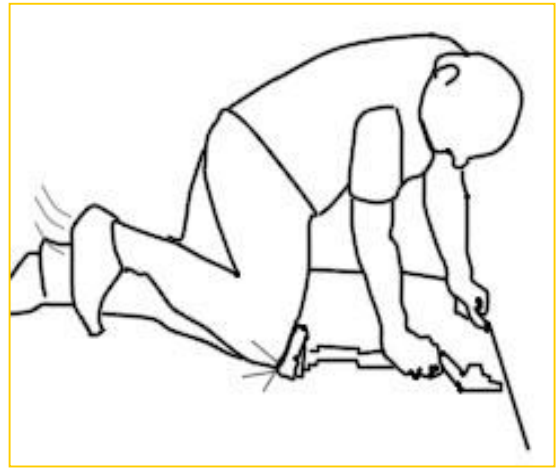


[David Ellsworth (2007). Basic Ergonomics]

Ergonomic Hazards: Recognition

- Repetition
  - Workers repeat same motion every few seconds for more than 2 hours per day with
    - ✓ Neck, shoulders, elbows, wrists, and hands
- Repeated impact using hands or knees as a hammer
  - More than 10 times per hour
  - More than 2 hours per day

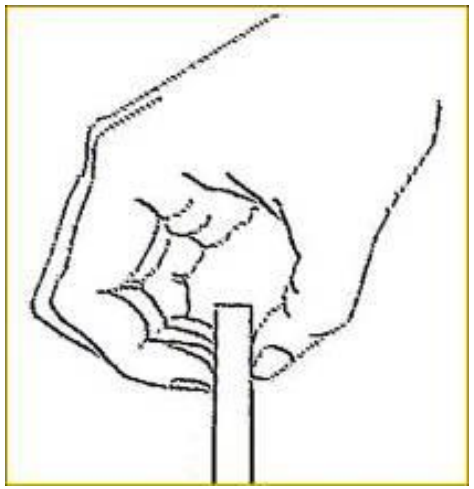


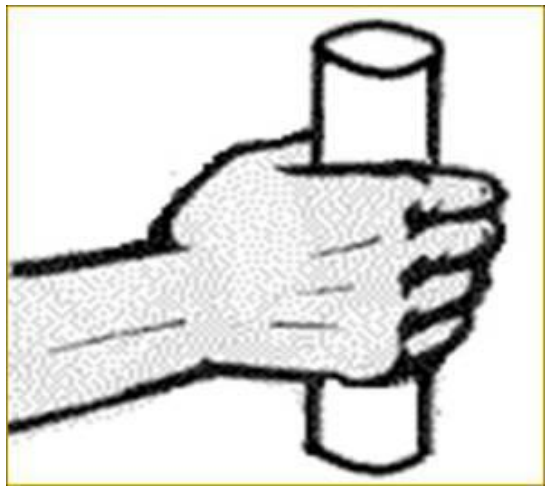


[David Ellsworth (2007). Basic Ergonomics]

Ergonomic Hazards: Recognition

- Forceful Exertion: Hands
  - Pinching: More than 4 hours per day of
    - ✓ Pinching unsupported object, 2 or more pounds weight
    - ✓ Pinching with force of 4 or more pounds



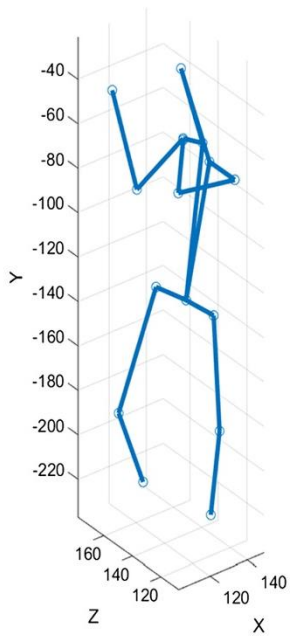


- Gripping: More than 4 hours per day of
  - Gripping unsupported object or with force of 10 or more pounds weight or force

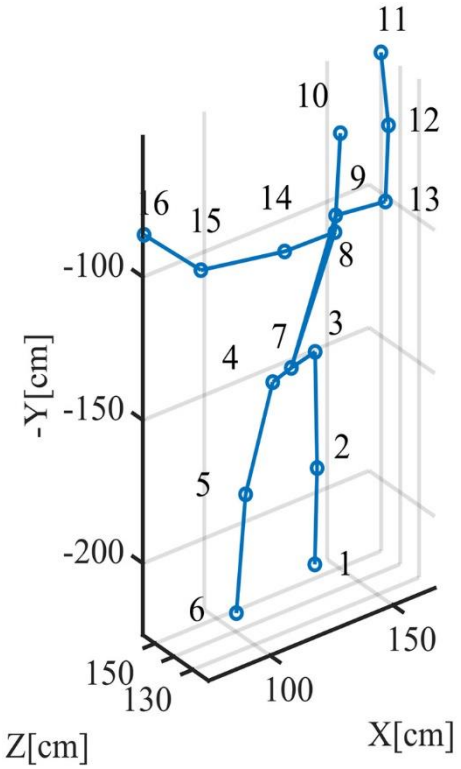
Case Studies: Ergonomic hazard prevention

- Vision-based ergonomic assessment

(c)



(d)

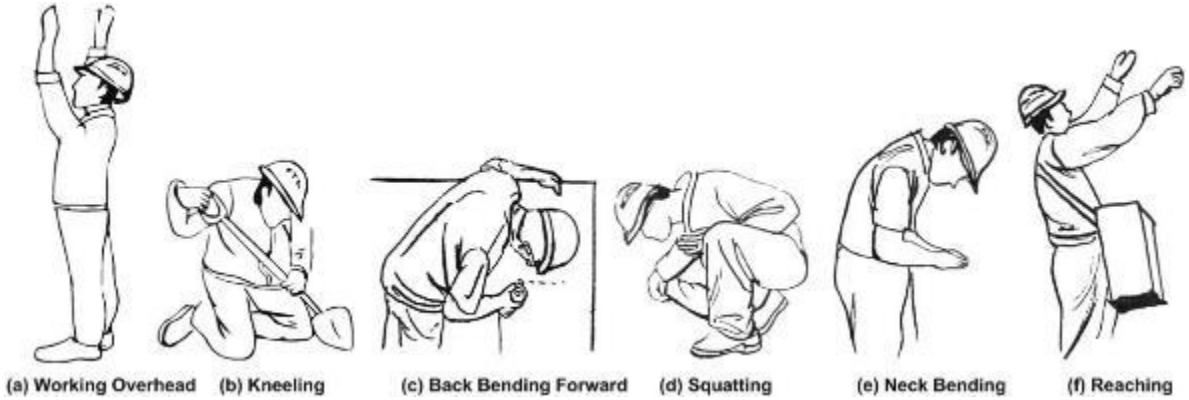


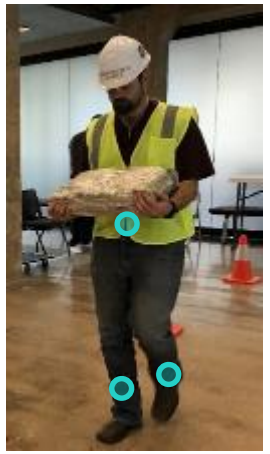
No.	Joint	X[cm]	Y[cm]	Z[cm]
01	Right ankle	145.00	225.00	156.52
02	Right knee	141.00	187.00	150.08
03	Right hip	139.00	145.00	148.55
04	Left hip	117.00	145.00	142.34
05	Left knee	113.00	187.00	151.53
06	Left ankle	107.00	225.00	148.58
07	Waist	127.00	145.00	145.52
08	Chest	127.00	87.00	122.39
09	Neck	127.00	81.00	122.01
10	Head	129.00	53.00	122.10
11	Right shoulder	167.00	51.00	150.11
12	Right elbow	159.00	67.00	135.70
13	Right wrist	147.00	83.00	121.68
14	Left shoulder	107.00	87.00	122.98
15	Left elbow	85.00	93.00	138.74
16	Left wrist	75.00	85.00	155.85

(Yu et al. 2019)

Case Studies: Ergonomic hazard prevention

- Awkward posture detection & Excessive Load carrying





Time-series IMU data

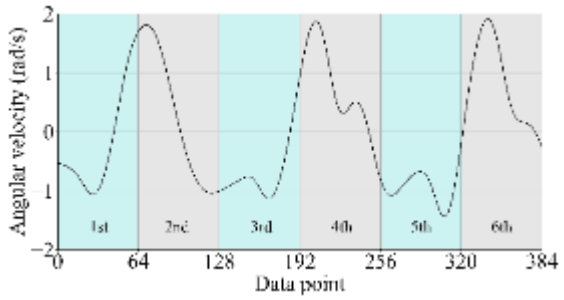
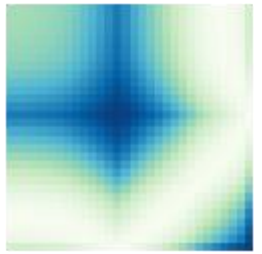


Image Data



Gramian Angular Field

Data Collection → Data Processing → Classification (SVM)

- Data Collection: Camera, R-GBD Camera, IMUs
- Data Processing: Motion Data Compression

	WO	KN	BB	SQ	NB	RE	Other
Accuracy	97.7%	99.2%	97.1%	99.7%	97.6%	96.2%	98.9%

(Chen et al. 2017)

IMU Collection → Image Data Conversion → Feature Extraction (CNN) → Classification (LSTM)

	Weight	Posture
Accuracy	92.46%	95.04%

(Yang et al. 2020; Lee et al. 2020a; Lee et al. 2020b)

Case Studies: Ergonomic hazard prevention

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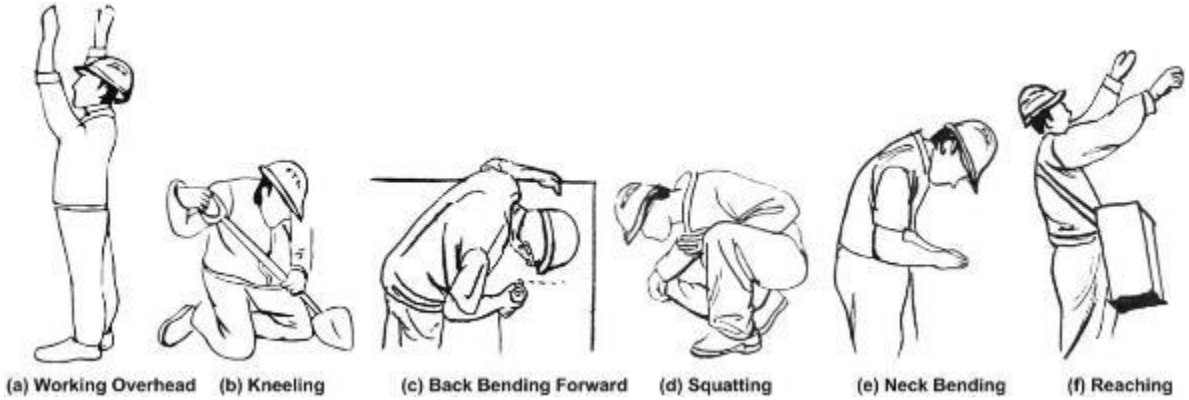

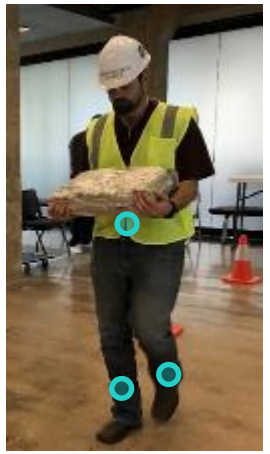

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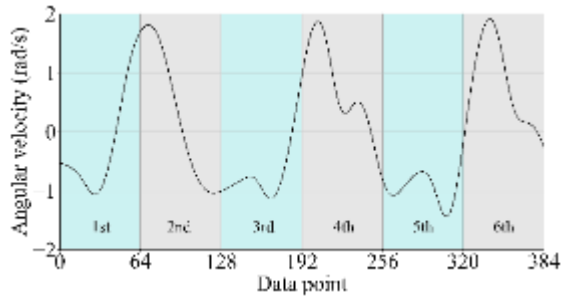

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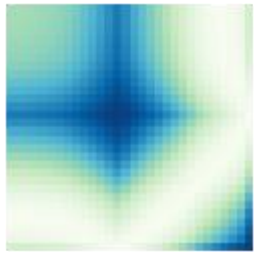

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Resource Material

Caporali (2008). OSHA: Big Four Construction Hazards: Fall Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/falls_english_r6.pdf)

Caporali (2008). OSHA: Big Four Construction Hazards: Struck-by Hazards (https://www.osha.gov/dte/grant_materials/fy08/sh-17792-08/struck_by_english_r6.pdf)

Construction Industry Institute (1993). Zero Injury Techniques.

David Ellsworth (2007). OSHA: Basic Ergonomics. (https://www.osha.gov/dte/grant_materials/fy07/sh-16637-07/basic-ergo.ppt)

Frank E. Bird book of Practical Loss Control Leadership Third Edition

Jimmie Hinze (1997). Construction Safety, Prentice Hall, New Jersey, USA.

Muhammad Syafiq (2011). Work Capacity, Stress and Fatigue. (http://syafiqsyed.files.wordpress.com/2011/03/work-capacity-stress-and-fatigue.ppt)

Study Resource: Safety Statistics

- Safety Statistics for Research
  - Korean Statistical Information Service (KOSIS)

    <http://kosis.kr/index/index.do>
  - U.S. Bureau of Labor Statistics (BLS)

    <https://www.bls.gov/>