Week 12

Construction Safety Management

457.657 Civil and Environmental Project Management

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Lecture Agenda

- Construction Accident Types and Risks
- Measurement
- Cost of Injuries
- Safety Management
- Other Safety Research Examples

Common Goals of Construction Projects

- **Deliver projects**
  - Within budget
  - On schedule
  - With the required quality

- **Is Safety also a Goal?**
  - **Safety is FIRST!** Nothing can replace human life.
  - A serious jobsite accident can ruin a company
    - Indirect costs, Schedule delays, Poor quality
    - Its reputation

Accident Examples (1)

Investigators probe Brisbane workplace accident

Posted January 17, 2009 13:08:00

An investigation is underway into a workplace accident at a construction site in inner-city Brisbane.

A 24-year-old man was taken to hospital in a critical condition after he was hit by an excavator at the Adelaide Street site yesterday afternoon.

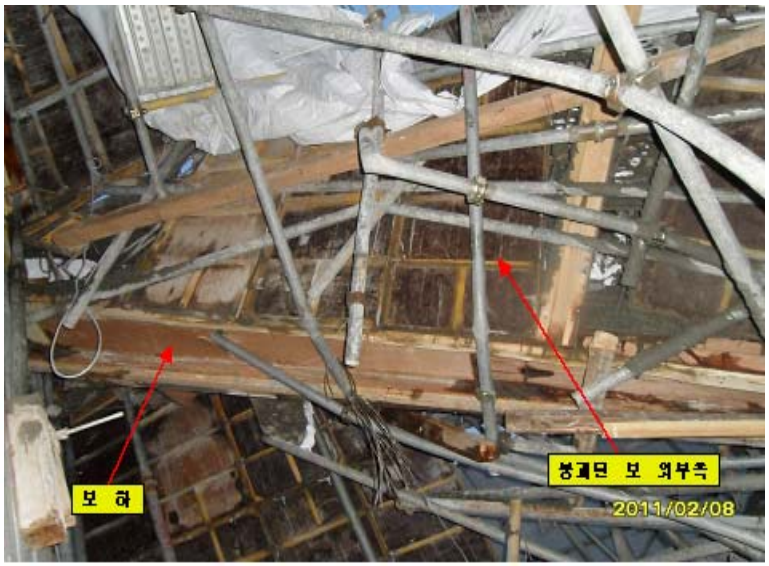
Police say it appears the man fell and the excavator drove over his legs.

Workplace Health and Safety officers are investigating.

Accident Examples (2)

서울대학교 사범대학 부설초 및 부설여중 교실 증축공사 거푸집 동바리 붕괴 (2011. 2. 8.)

지상 3층 다목적 강당 북측면 지붕층 기둥 및 보 콘크리트 타설 작업 중, 불안전하게 2단으로 설치된 거푸집 동바리가 콘크리트 타설 하중을 견디지 못하고 다목적 강당 내부로 붕괴되면서 동바리 하부에서 작업 중이던 작업자가 콘크리트 더미에 매몰되어 사망하고 지붕 층에서 작업 중이던 작업자 2명은 부상을 입은 재해임



Construction Accidents

How Do Construction Workers Die?

- **Fall Accidents** account for 33% of the construction worker fatalities

How Do Construction Workers Die?

- **Fall Accidents account for 33% of the construction worker fatalities**

"An employee was cutting rafter tails on the flat roof of the covered outside walkway of a school that was undergoing renovations. He was standing on the end of a rafter to cut it when the rafter broke at the notch and he fell 12 ft 10 in. to the ground. He was wearing a safety harness and shock-absorbing lanyard, but it was not tied off to the lifeline." (OSHA Inspection #119633477, 2004)

How Do Construction Workers Die?

- **Struck By Accidents** account for 22% of the construction worker fatalities

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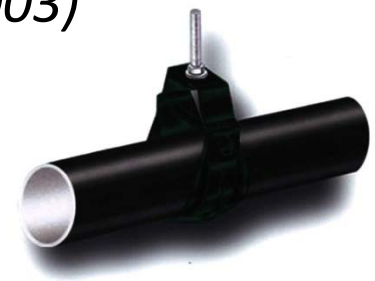
- **Struck By Accidents account for 22% of the construction worker fatalities**

"An employee was installing utility piping in the lower levels of a high rise office building. The pipe hangers were installed into the concrete ceiling of the parking garage. One of the hangers pulled out of the concrete and the 3-in.-diameter steel pipe fell on the employee. The pipe struck him on the head, he did not wear an appropriate safety hat, resulting in a concussion and a fractured foot." (OSHA Inspection #300793882, 2003)



How Do Construction Workers Die?

- **Caught In/Between Accidents** account for 18% of the construction worker fatalities

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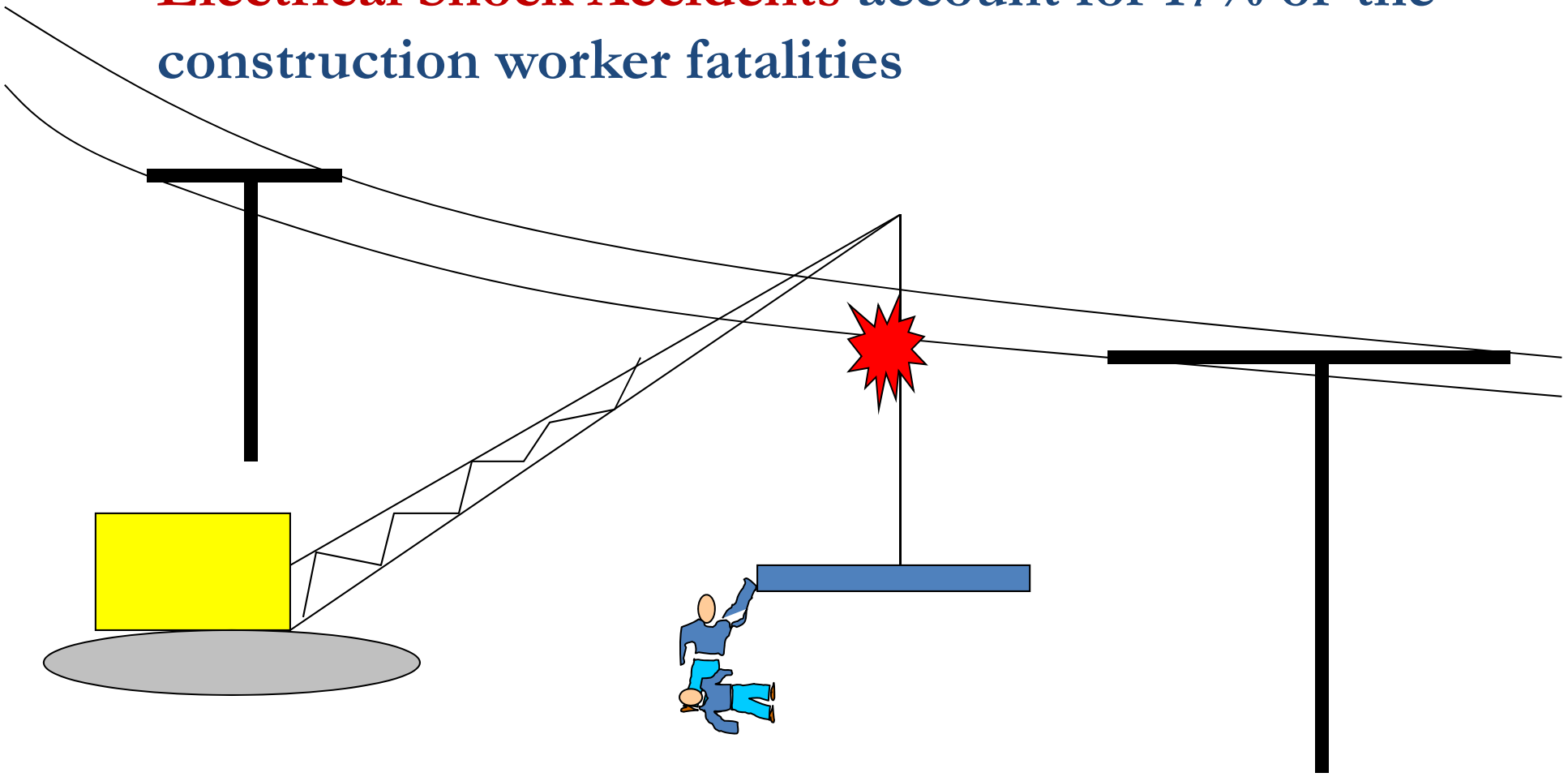
- **Caught In/Between Accidents account for 18% of the construction worker fatalities**

"An employee had started the two motors on a digger. This machine is used to bore holes for the installation of fencing. He left the operator's position to conduct a walk around inspection of the machine. While walking in front of the rotating auger, he slipped and fell. His gloved left hand was caught by the auger and he was pulled into the auger." (OSHA Inspection #307481002, 2004)

How Do Construction Workers Die?

- **Electrical Shock Accidents** account for 17% of the construction worker fatalities



How Do Construction Workers Die?

- **Electrical Shock Accidents account for 17% of the construction worker fatalities**

"An employee was installing a street light pole at a new bridge being constructed. The light pole contacted a 13,800 volt overhead power line, and he was electrocuted." (OSHA Inspection #313060675, 2009)

How Do Construction Workers Die?

- **Other Accidents** account for 10% of the construction worker fatalities – **Explosions**

How Do Construction Workers Die?

- **Other Accidents** account for 10% of the construction worker fatalities – **Fires**

Distribution of Injuries

Skin (4%)

Others (4%)

Fractures (4%)

Soft Tissue Injuries (6%)

Lacerations (23%)

Eyes (11%)

Head/Neck (2%)

Shoulder/Humerus (5%)

Spine (17%)

Forearms/Hands (12%)

Knees (6%)

Feet/Ankles (6%)

Lecture Agenda

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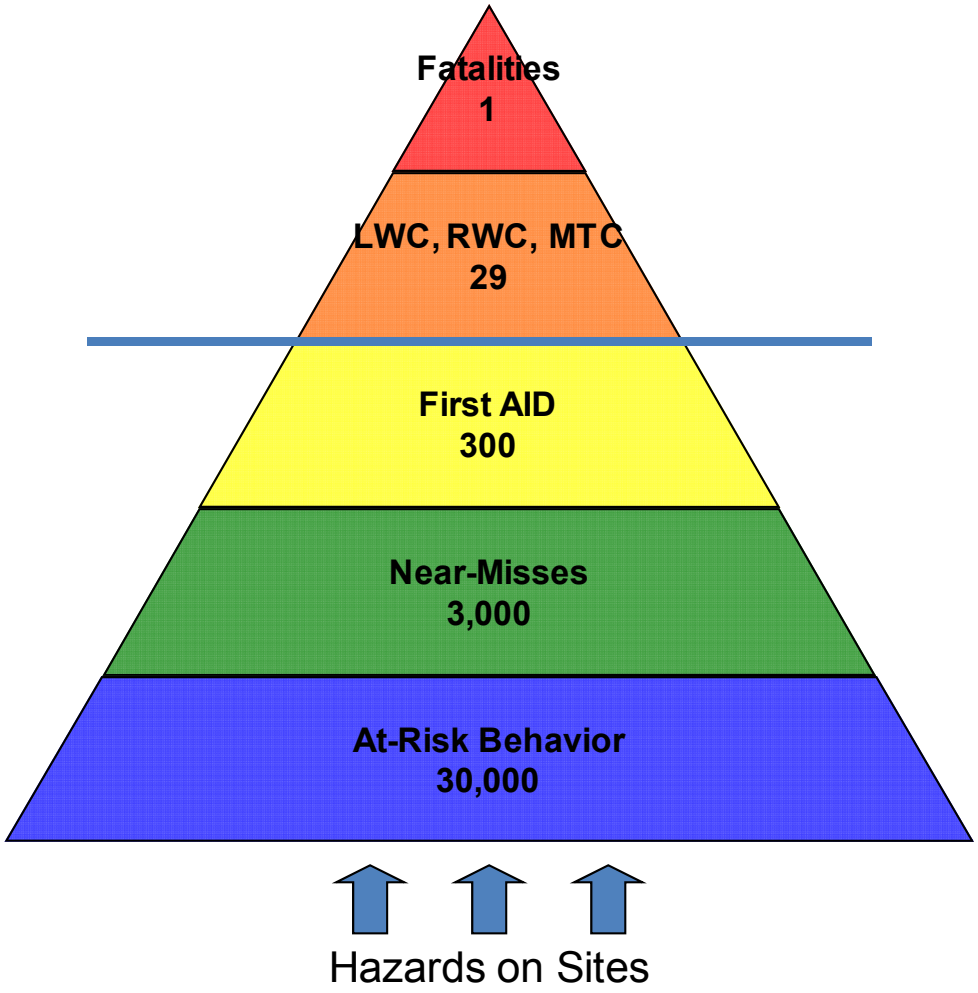
Accident Categories



Fatalities

LWC (Lost Workday Case)

RWC (Restricted Work Case)

MTC (Medical Treatment Case)

First AID

Near-Misses/At-Risk Behavior

Accident Categories

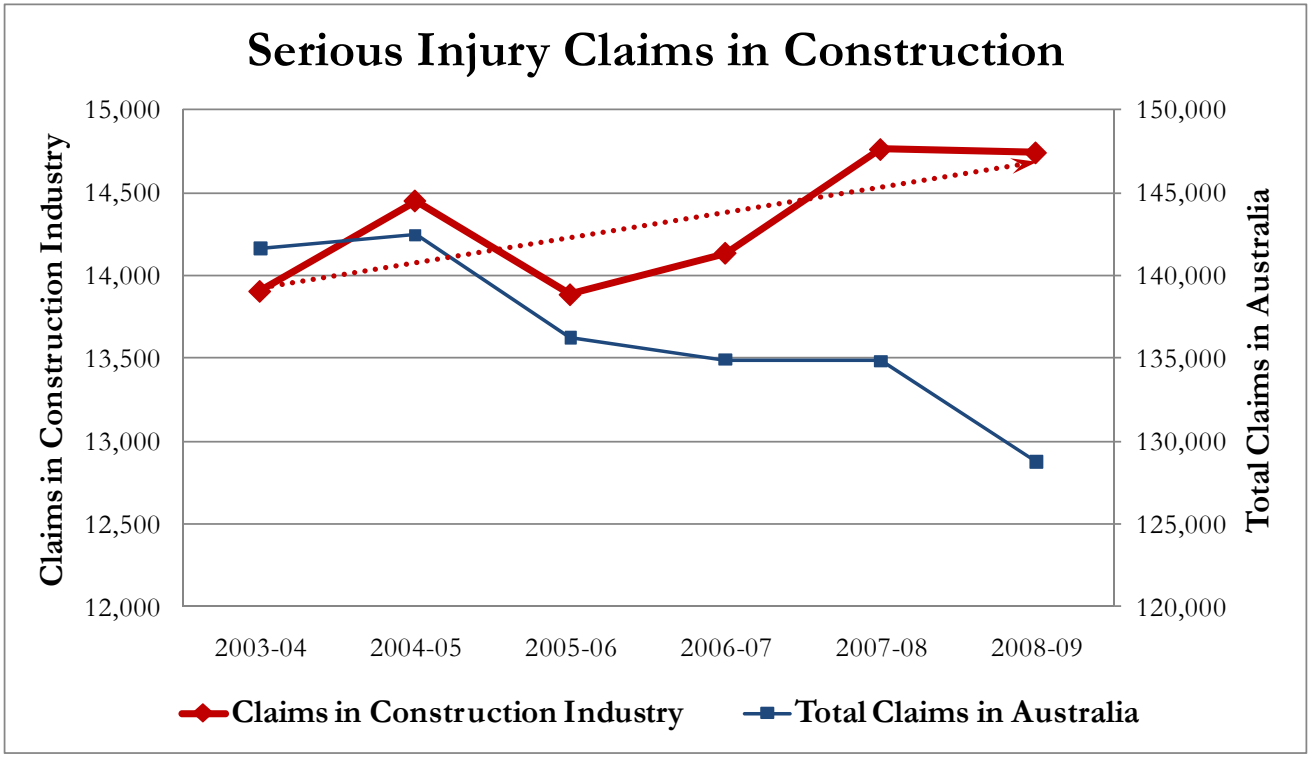
- **Recordable Injuries**
  - Injuries that require treatment by a physician
  - If a worker becomes unconscious at work
  - If a worker is injured and needs to be assigned to other work
  - All lost time injuries and fatalities
- **Not-recordable Injuries**
  - First aid cases, Near-misses, At-risk behaviour
  - X-Rays taken that confirm that a bone is not broken and the worker can continue to work.
  - Physician examines a worker but does not perform any treatment.

Safety Measurement

- **Injury Frequency**
  - Number of serious claims and fatalities
  - Recordable Incidence Rate (RIR) per 1,000 employees
  - Frequency rate per million hours worked
  - Time lost due to claims (working weeks)
  - Payment for claims (time lost, salaries, medical treatment)

Safety Measurement

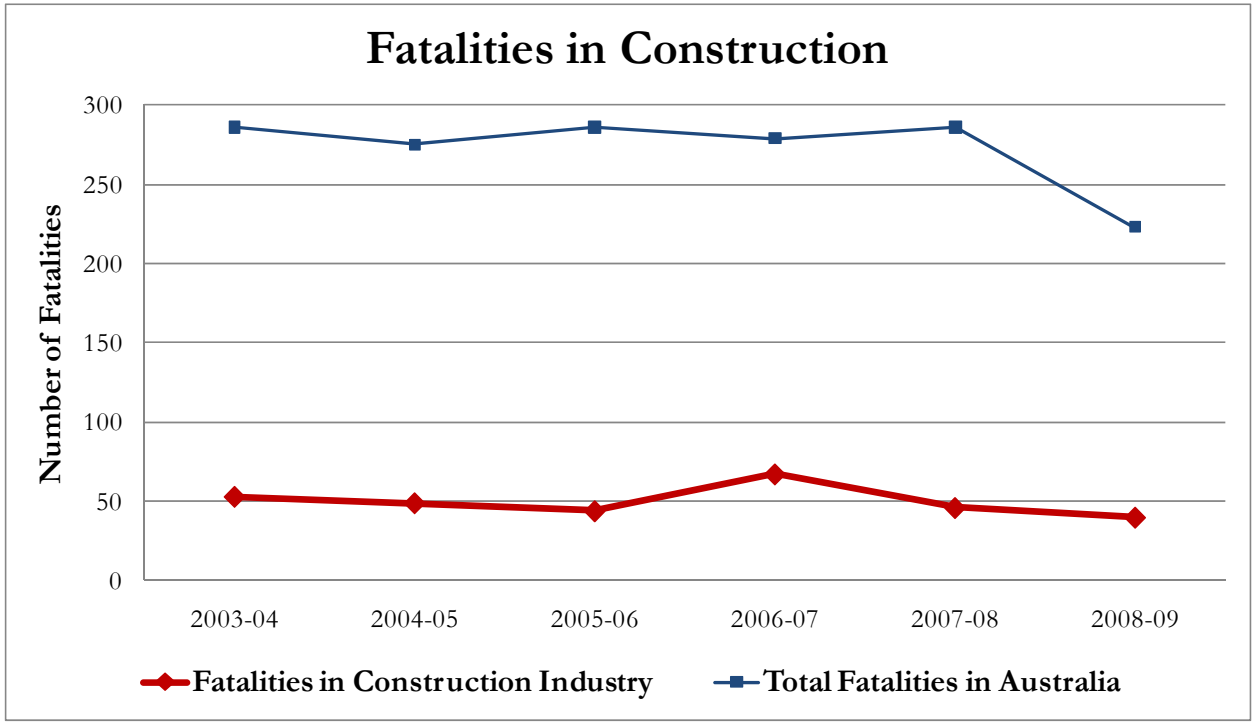
- Number of Serious Claims



– In 2008-09, every working day, an average of 40 construction workers got injured at construction sites!

Safety Measurement

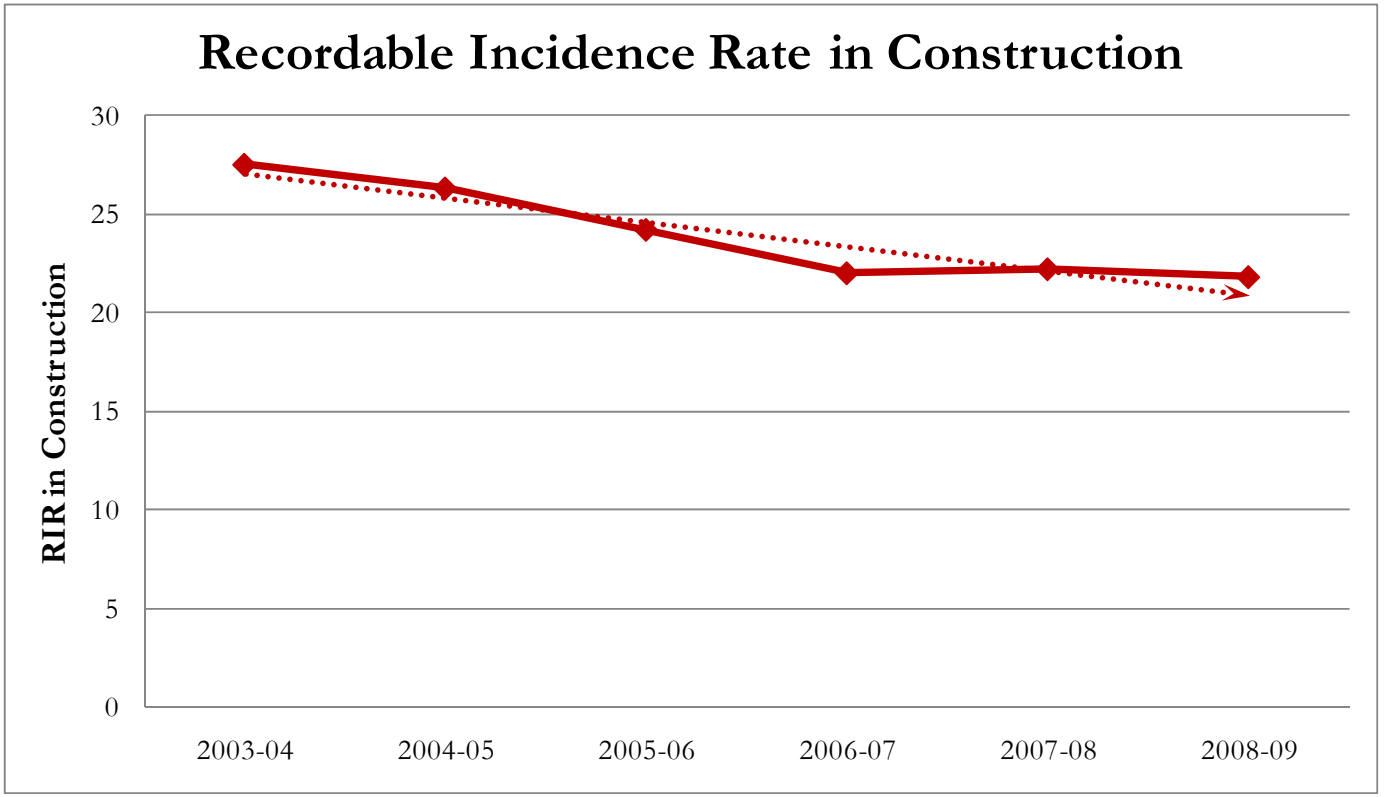
- **Number of Fatalities**



- In 2008-09, the Construction industry employed 926,400 people representing **9%** of the Australian workforce.
- Yet, about **18%** of the industrial fatalities occurred in construction!

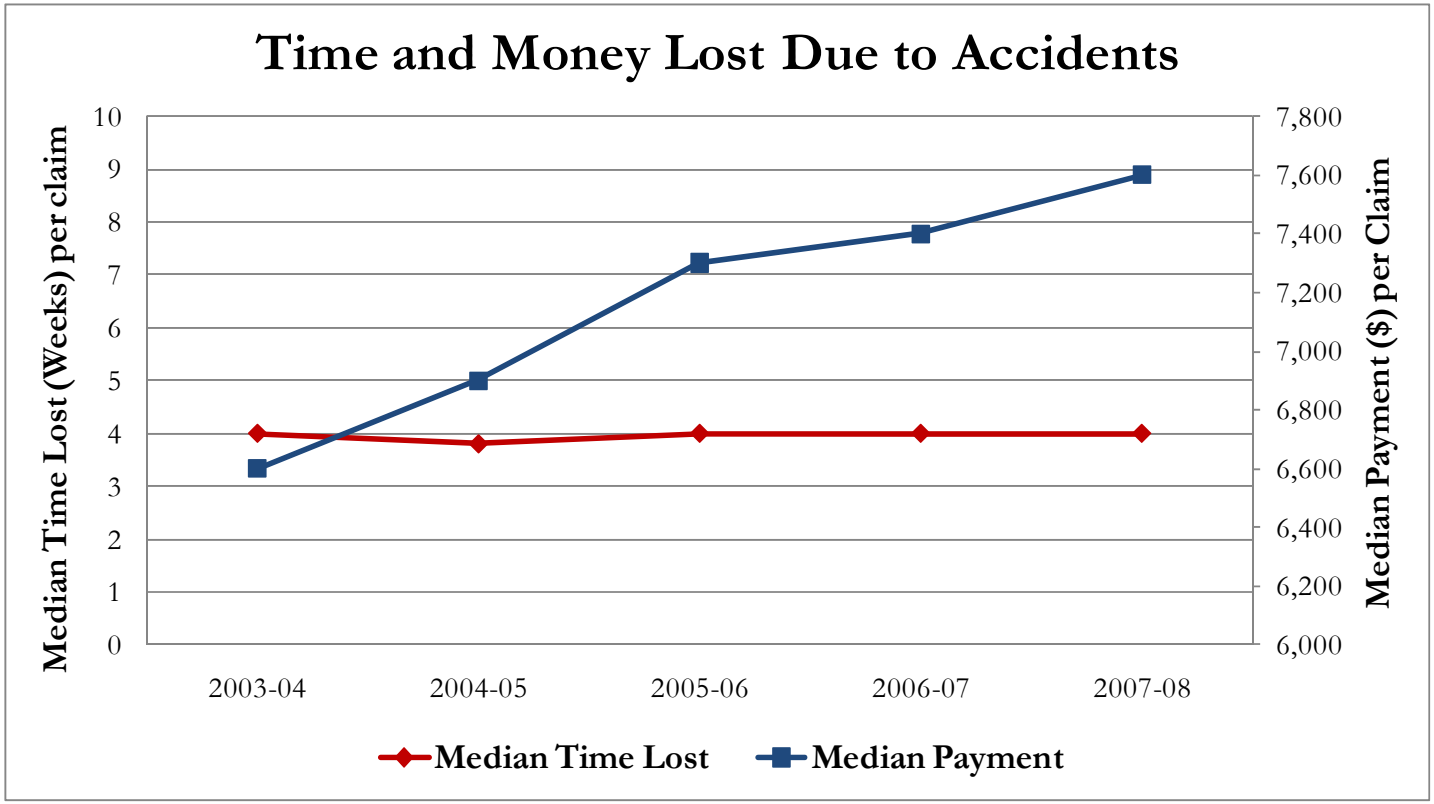
Safety Measurement

- **Recordable Incidence Rate (RIR)**
  - Defined by AS1885.1-1990 $$\text{RIR} = \frac{\text{Number of Claims}}{\text{Number of Workers}} \times 1{,}000$$



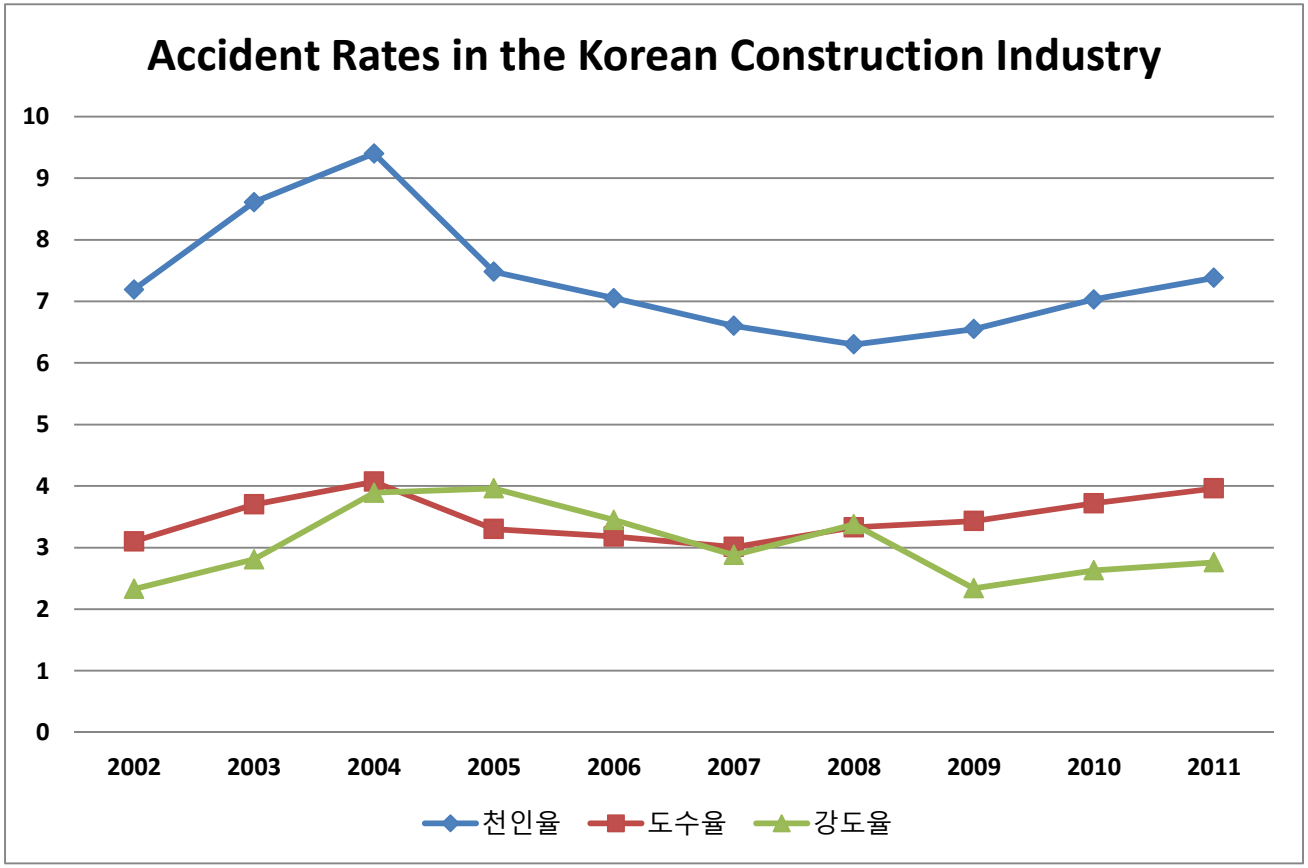
Safety Measurement

- **Median Time Lost and Payment**



– In 2007-08, $7,600 × 14,760 claims = **$112 million**

Safety Measurement – Korea



천인율 = 재해자수/근로자수 x 1,000
도수율 = 재해건수/연근로시간수 x 1,000,000
강도율 = 총근로손실일수/연근로시간수 x 1,000

Lecture Agenda

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Cost of Injuries

- **Direct Costs of Injuries**
  - Costs of medical treatment
  - Costs of pharmaceutical supplies
  - Costs of hospitalisation
  - Costs of reimbursement to partial lost wages
- **These are paid by Workers' Compensation Insurance**

Cost of Injuries

- **Workers Compensation Insurance**
  - Colloquially known as "compo" in Australia
  - Provides wage replacement and medical benefits for employees who are injured in the course of employment
  - Statutory Compensation and Rehabilitation Act
    - WorkCover Corporation: SA, NSW, QLD, WA, TAS
    - WorkSafe: VIC, ACT, NT
  - Employers need to buy insurance and insurance premium is adjusted on a company-by-company basis (higher-risk companies with higher premiums) by following the state-level manual rate (compensation insurance base rates by states and craft types).

** 연면적: 각 층의 바닥면적의 합계*

Workers Compensation Insurance – Korea

- **산재보험**
  - 건설면허업자가 시공하는 모든 건설공사와 건설면허업자가 아닌 자가 시공하는 (1) 총 공사금액 2천만원 이상이고 연면적이 100m2 초과인 건축물의 건축 또는 (2) 연면적이 200m2 초과인 건축물의 대수선에 관한 공사는 산재보험 의무가입 대상
  - 사업주의 날인 후 산재가 발생한 현장의 소재지를 관할하는 공단지사에 신청
  - 날인 거부 시, 산재신청인 본인이 근로복지공단에 제출할 수 있음
  - 산재보상 vs 공상처리 (회사와의 합의)
    - 회사에서 치료비와 치료기간 중 급여를 준다는 조건으로 합의를 강요하여도, 이와 같이 공상으로 처리하면, 후유증이 발생하거나 장애가 남은 경우에는 그에 대한 보상을 받기가 힘듬. 또한 원청 회사 측의 과실로 산재를 당한 경우 별도로 손해배상청구를 할 수도 있으므로 산재보상이 더 유리.

Cost of Injuries

- **Indirect Costs of Injuries**
  - Tend to be hidden
  - Can be incurred for a long time after an injury occurs

- **Indirect Costs: Injured Worker Costs**
  - Lost productivity: Restricted activity & Lost workday cases
    - On the day of the injury
    - When getting follow-up care or treatment
  - Reduced productivity when resuming work

Cost of Injuries

- **Indirect Costs: Crew Costs**
  - Lost/Reduced productivity
    - While helping the injured worker
    - From watching or talking about the injury
    - From feeling uneasy as a result of the injury
    - When working short-handed

Cost of Injuries

- **Indirect Costs: Other Sources**
  - Costs of transporting injured worker to receive treatment
  - Costs of replacing worker
    - Administrative costs of hiring
    - Costs of training
    - Reduced productivity from lack of familiarity
  - Costs of replacing damaged materials and/or equipment

Cost of Injuries

- **Administrative and Long-term Indirect Costs**
  - Various administrative costs
    - Assisting the injured worker
    - Investigating the accident
    - Preparing accident and injury reports
    - Communicating with top management
    - Communicating with the media
    - Time spent with regulatory personnel
  - Third-party liability suits
    - A suit for every 20 cases (e.g. the tort of negligence)
    - Lawyer fees per case: about $20,000 (win or lose)

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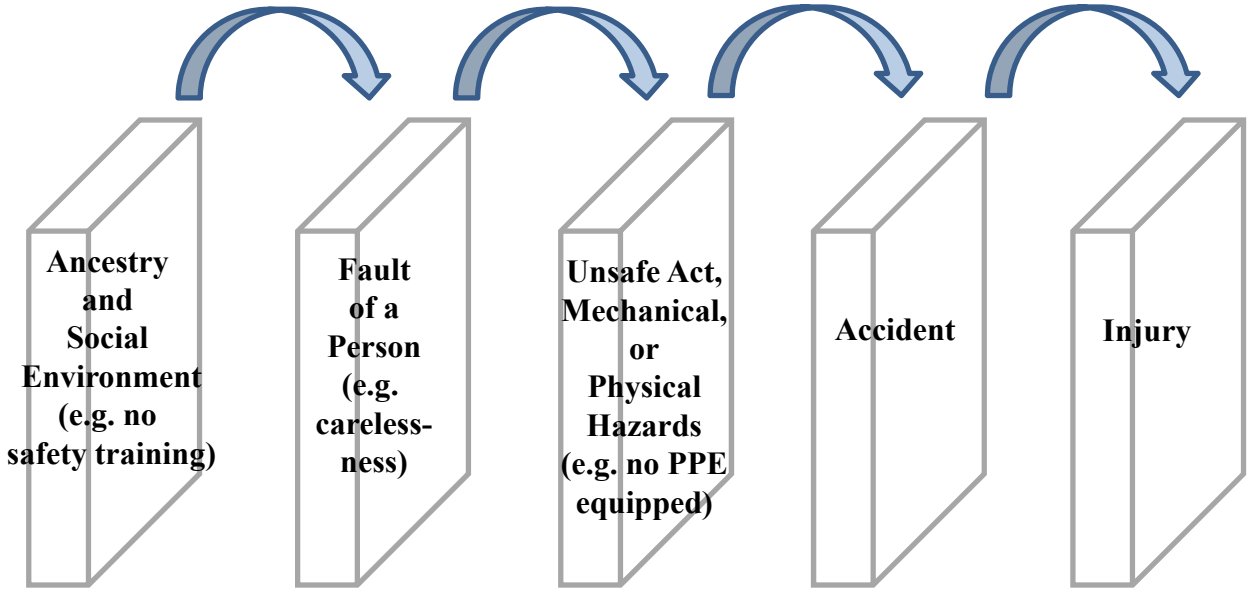
Accident Causation

- **Heinrich's Domino Theory (1936)**
  - First scientific approach to accident and prevention
  - Investigated 75,000 industry injuries
  - 88% by unsafe acts, 10% by unsafe conditions, 2% unavoidable

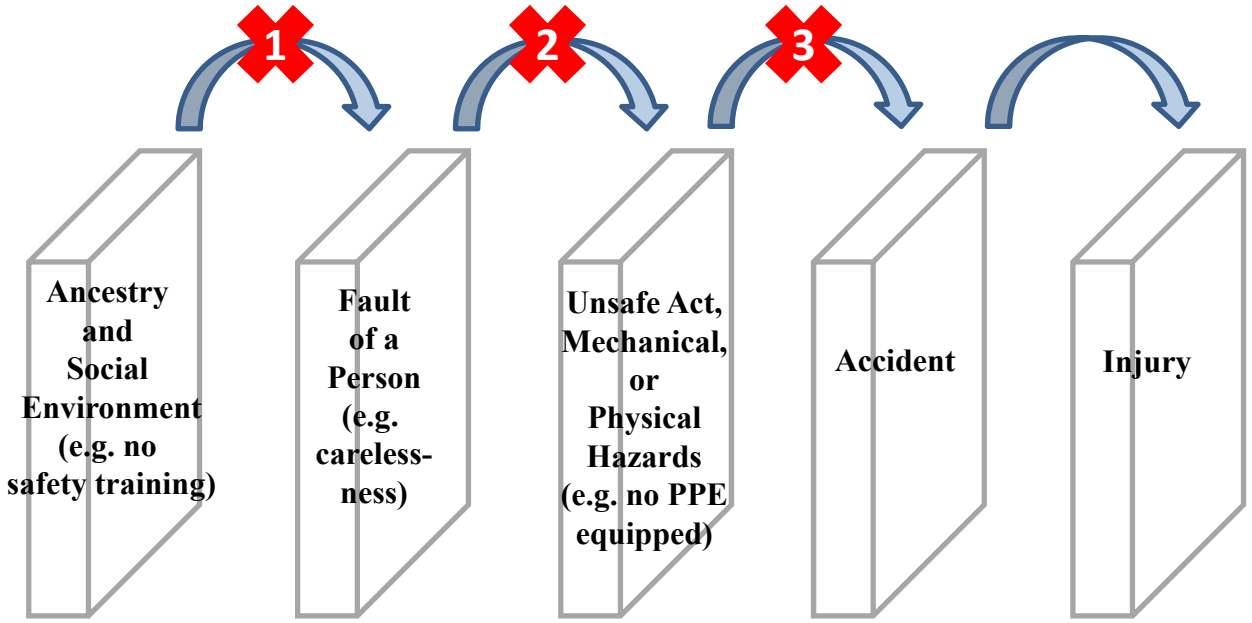


Accident Causation

- **Heinrich's Domino Theory (1936)**
  - A personal injury (the final domino) occurs only as a result of an accident.
  - An accident occurs only as a result of a personal, physical, or mechanical hazard.
  - Personal, physical, or mechanical hazards exist only through the fault of careless persons or poorly designed or improperly maintained equipment.
  - Faults of persons are inherited or acquired as a result of their social environment or acquired by ancestry.
  - The social environment is where and how a person was raised and educated.

Safety Management

- **Heinrich's Domino Theory (1936)**

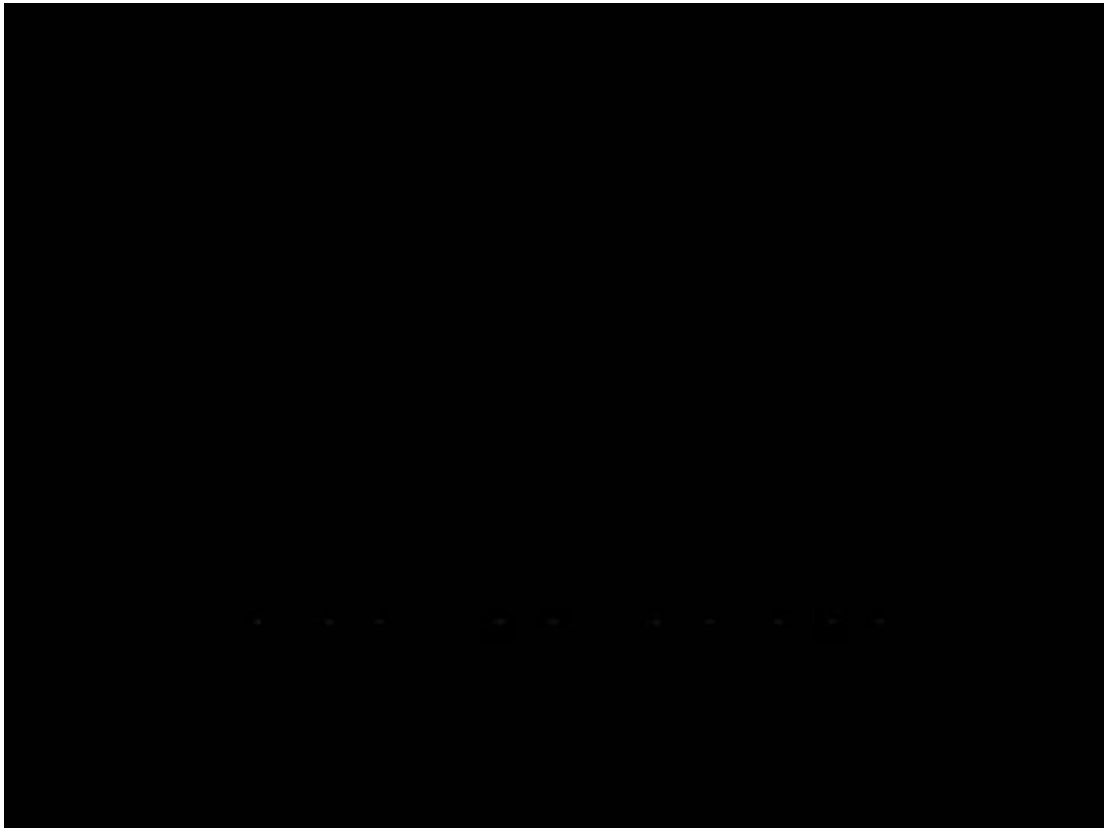


1. Improve social environment that affects worker's acts
2. Control workers' behavior in a safer manner
3. Eliminate unsafe acts of workers and unsafe working conditions

Safety Management

- Three “E”s

Safety Management



Safety Management – Three "E"s

- **Education**
  - Organizational support for safety education (e.g. orientation, training, workshops, etc.) for all level of project members
  - Regular safety meetings and daily toolbox talks
  - Worker involvement
    - Worker-to-worker observation practices
    - Worker safety perception survey
    - Worker participation on safety committees

Safety Management – Three "E"s

- **Education**
  - Safety planning meetings
    - Think through construction process
    - Anticipate safety risks and problems
    - Take actions to address them and perform work safely
    - Pre-project: safety goals, project risks, safety person and responsibility → Site-specific safety plan
    - Pre-task: job hazard analysis

Safety Management – Three "E"s

- **Risk Identification**
  - "An employee was using an extension ladder to paint and apply sealer to a house. He was beginning to move the fully extended ladder to a different location when it tipped over and contacted the overhead power line. Subsequent investigation found that his failure to retract the ladder before moving made it top-heavy and was the probable cause of its overturning." (OSHA Investigation Report #305493470, 2002)

Safety Management – Three "E"s

- **Risk Identification on a Construction Site**
  - Possible environmental risk factors

Safety Management – Three "E"s

- **Risk Identification on a Construction Site**
  - Possible human risk factors

Safety Management – Three "E"s

- **Risk Identification on a Highway Work Zone**
  - Driver at fault
  - Illumination
  - Weather condition
  - Road surface condition
  - Road geometric alignment
  - Speed limit
  - Work zone safety equipment
  - Signage failure
  - Others

Safety Management – Three "E"s

- **Enforcement: 산업안전보건법 (고용노동부)**
  - 근로자수 100인 이상 사업장은 사업장내 산재예방을 총괄 관리하는 책임자 선임: 위반 시 500만원 이하 과태료
  - 근로자수 50인 이상 사업장에 대해 사업주 및 관리감독자를 보좌, 지도할 안전, 보건관리자 선임
  - 근로자수 100인 이상 사업주는 안전, 보건관리 규정을 작성하여 사업장내에 비치해야 함.
  - 기타 안전관리, 안전검사, 안전 및 보건상 조치, 화학물질 및 작업환경 안전 검사, 건강진단, 안전 및 보건교육, 산업재해 발생보고와 관련된 의무사항 명기

Safety Management – Three "E"s

- **Enforcement**
  - Site inspection checklist
  - Scaffolding Code of Practice
  - Sample scaffolding checklist

Safety Management – Three "E"s

- **Enforcement**
  - Staffing for safety
    - Placement of full-time safety experts and professionals
    - Contractual requirement for a full-time representative
  - Subcontractor safety management
    - Contractual requirement for safety plans
    - Sanctions for non-compliance with safety standards
    - Safety orientation and training
  - Daily, random alcohol and drug testing

Safety Management – Three "E"s

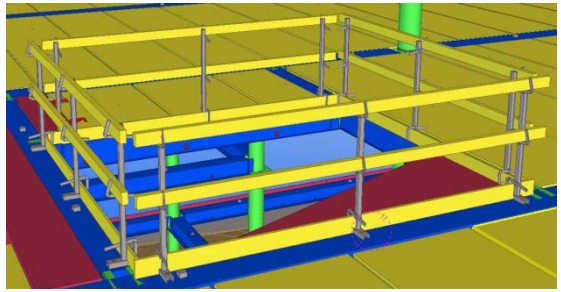
- **Enforcement**
  - Accident reporting and investigation
    - Formalize investigation and reporting process
    - Investigate and report near-misses
    - Form project accident review team
    - After accident, alcohol and drug screening of all involved
  - Evaluation, recognition and rewards
    - Frequent low dollar incentives to motivate workers
    - Factor into salary raises and promotion

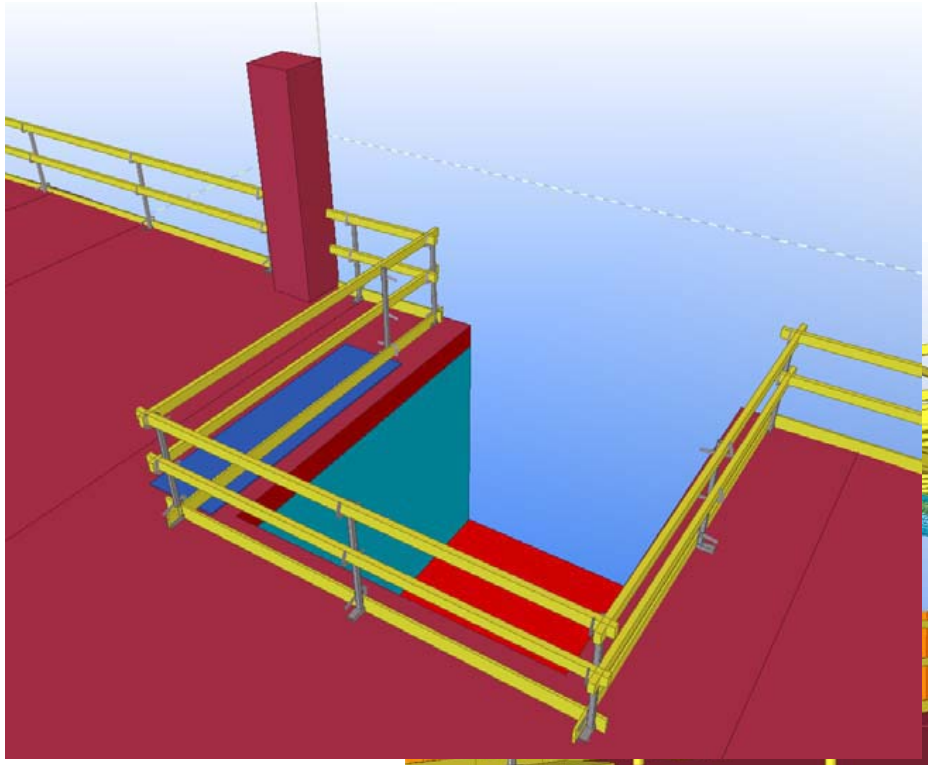
Safety Management – Three "E"s

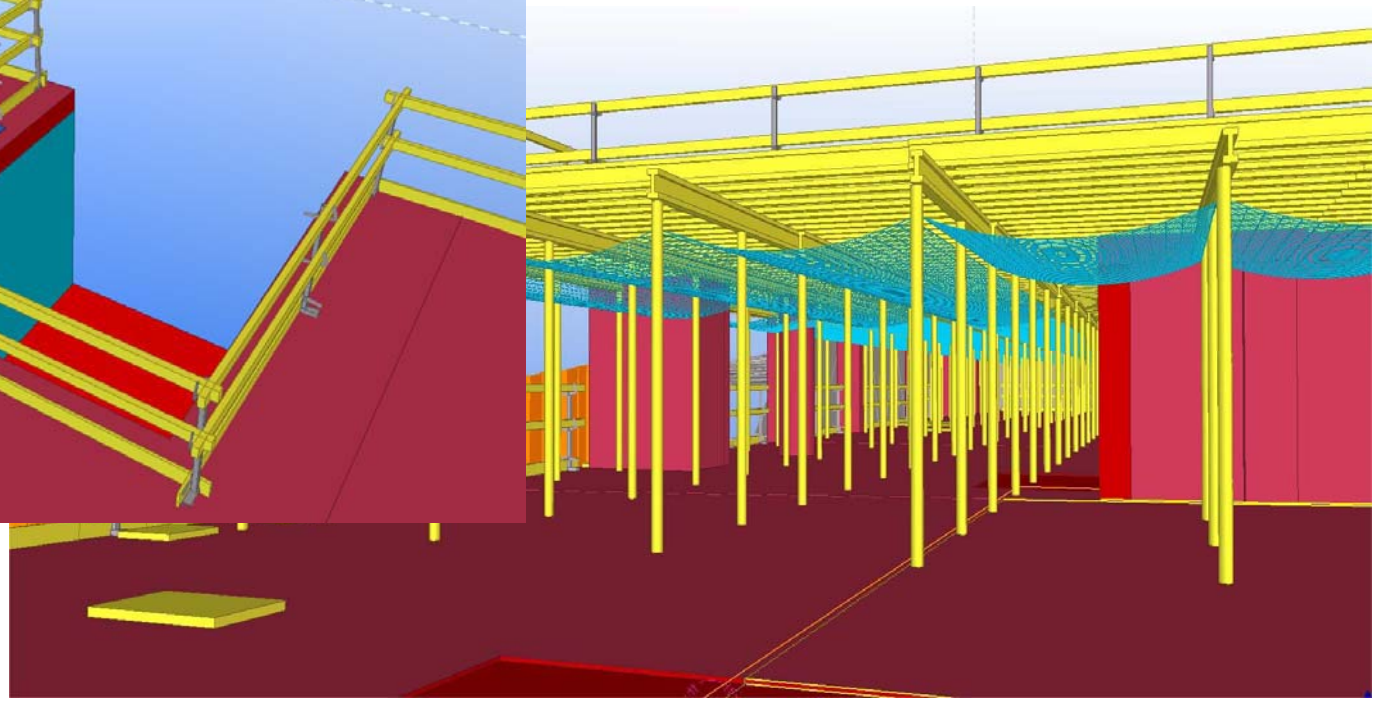
- **Engineering**
  - Design for safety
    - Consider construction processes and constructability during designing phases
    - Achieved through active communication between designers and builders

Safety Management – Three "E"s

- Design for Safety (VTT, 2010)







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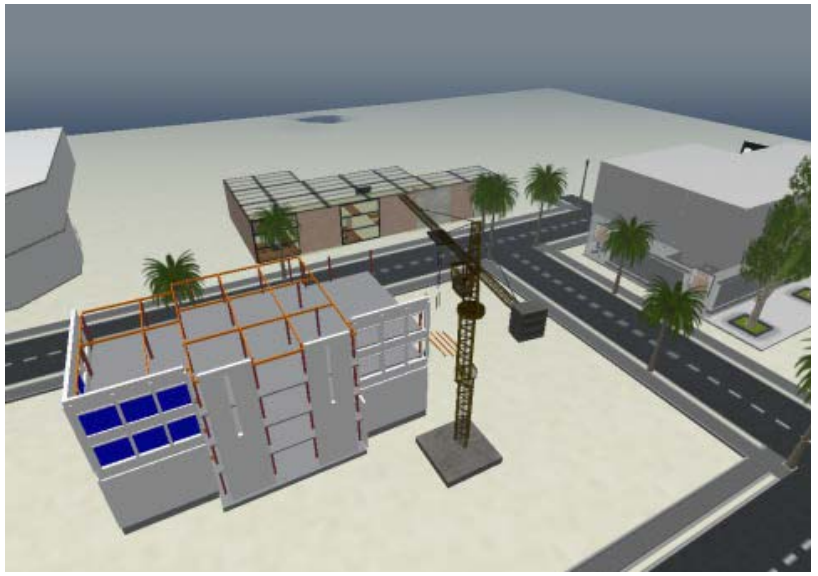
Other Safety Research

- **Virtual Reality (Simulation) Based Safety Training**
  - With virtual unsafe cases, do safety inspection
  - e.g. scaffolding safety (stability, planks, braces, guardrails, etc.)

(Ku and Mahabaleshwarkar 2011)

Other Safety Research

- **Virtual Reality (Simulation) Based Safety Training**
  - With virtual unsafe cases, simulate equipment operation
  - e.g. crane operation training



(Ku and Mahabaleshwarkar 2011)

Other Safety Research

- Proximity safety alert (Teizer et al. 2010)