

STAMP/CAST Application Cases of Industrial Accidents in Korea

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Dong-Hyun Seo

Senior Researcher, Ph.D.

Occupational Safety and Health Research Institute(OSHRI)

Korea Occupational Safety and Health Agency(KOSHA)

Introduction

MISSION & VISION

KOSHA has focused all its resources on protecting the safety and life of workers in various workplaces. We will fulfill our responsibility to create a fair society where all working people can enjoy the rights to be safe and healthy without discrimination. We will pave the way for a country whose workplace is safe and whose people are happy.

MISSION

Relief We are to realize social values of safety and health to ensure everyone of a life with a sense of relief.

Fairness We actively implement fair economy and administrative works while widely opening up eyes and ears to safety and health issues at all worksites

Inclusiveness We place the highest priority on the value of inclusiveness for those who are vulnerable to safety and health, incapable of even asking for help despite being in desperate need of help.

Innovation We provide innovative safety and health services by acquiring the latest technology and knowledge to maintain the expertise at the highest level at all times.

VISION

For Korea where all working people enjoy their rights
to be safe and healthy whenever, wherever

Core Value

Relief

Fairness-Inclusiveness

Innovation

Objectives



Fatality rate per
10,000 workers at
0.24%



Creating 27K
new jobs,
Attaining Superior
Level for Win-win
Growth category



Establishing
"Neo-safety
Workplace"
(To support Korean
Safety New Deal
Project)

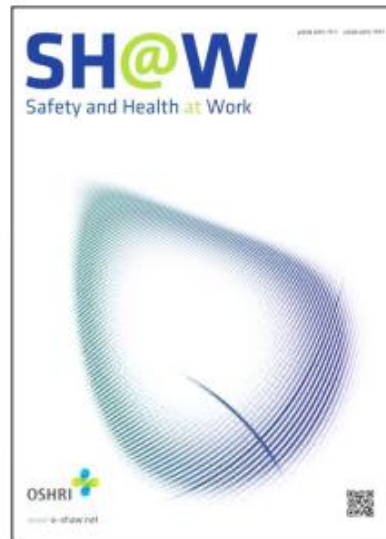


Establishing new
occupational accident
prevention platform,
Attaining Superior
Level for Customer
Satisfaction category

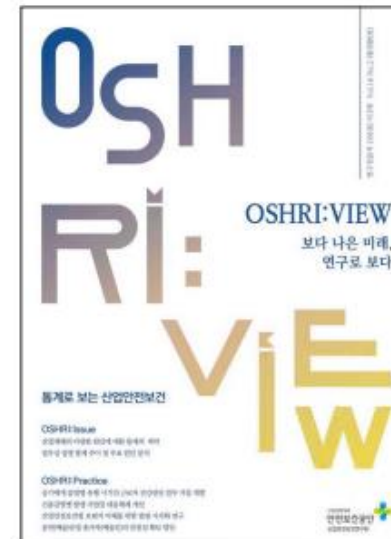
Introduction



산업안전보건연구원
연구보고서



안전보건 국제학술지
SH@W(Safety & Health at Work)



안전보건 연구전문지
OSHRI : View

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3. Conclusions

I. Why STAMP / CAST ?

I. Why STAMP / CAST?

☑ **The Model is Intuitive and Gives Multiple Information**

- ▶ System components and their interaction, and interrelationship
- ▶ Hierarchical structure, decision/direction and the feedback

☑ **Complexity of Modern Social Structure**

- ▶ Complex relationships between a company and its subcontractors,
or between subcontractors

☑ **Various Causal Factors and Problems**

- ▶ Safety responsibilities, mental model flaws, context in which decisions were made, safety culture, etc.

II. Case Study

II. 4 Accidents for STAMP-CAST Analysis

1) A Steel Company – **Caught between Crane and Facility Structure**

- ▶ Complex relationships between in-house subcontractors of a large company

2) Construction Site – **Building collapses onto bus during demolition**

- ▶ Complex relationships of various organizations and companies
- ▶ Complex stages to carry out building demolition

3) Small Factories Manufacturing Cell Phone parts - **Methanol Poisoning**

- ▶ Relationships of companies, contractors, temporary workers and organizations

4) Waste Plastic Pyrolysis Plants – **7 Fire and Explosion Cases**

- ▶ Seven accidents at the pyrolysis plants. Many process problems.

1) A Steel Company

☑ Accident Overview (Reference picture from other company)



(Source: <https://www.komachine.com/ko/companies/Hyundai-hoist/products/38775>)

1) A Steel Company

✓ Accident Overview



1) A Steel Company

Accident Overview

► A Worker Fell to Avoid An Approaching Overhead Crane

A steel company's in-house subcontractor workers were repairing the metal surface treatment facility. While dismantling the cover from the top of the facility, an in-house subcontractor worker saw an overhead crane coming towards him.

The worker tried to avoid the approaching crane but fell to the workbench about 1.5 m below.

As a result, the worker was injured in the chest and abdomen and died during treatment in the hospital.

1) A Steel Company

Accident Overview

► The main causes of the accident presented in the accident investigation report are as follows.

- 1) Failure to power off the crane and to install the stopping devices on the running rail.
- 2) Inadequate supervision of the maintenance work.
- 3) No director controlling the maintenance work.
- 4) Failure to recognize the worker on top of the facility.
- 5) No measures to prevent the worker from falling from height.

2) A Steel Company

Accident Overview

- * Owner of the metal surface treatment facility and the overhead crane
→ A Steel Company
- * Overhead crane operation
→ An In-house subcontractor for crane operation
- * Maintenance of the metal surface treatment facility
→ An In-house subcontractor for maintenance

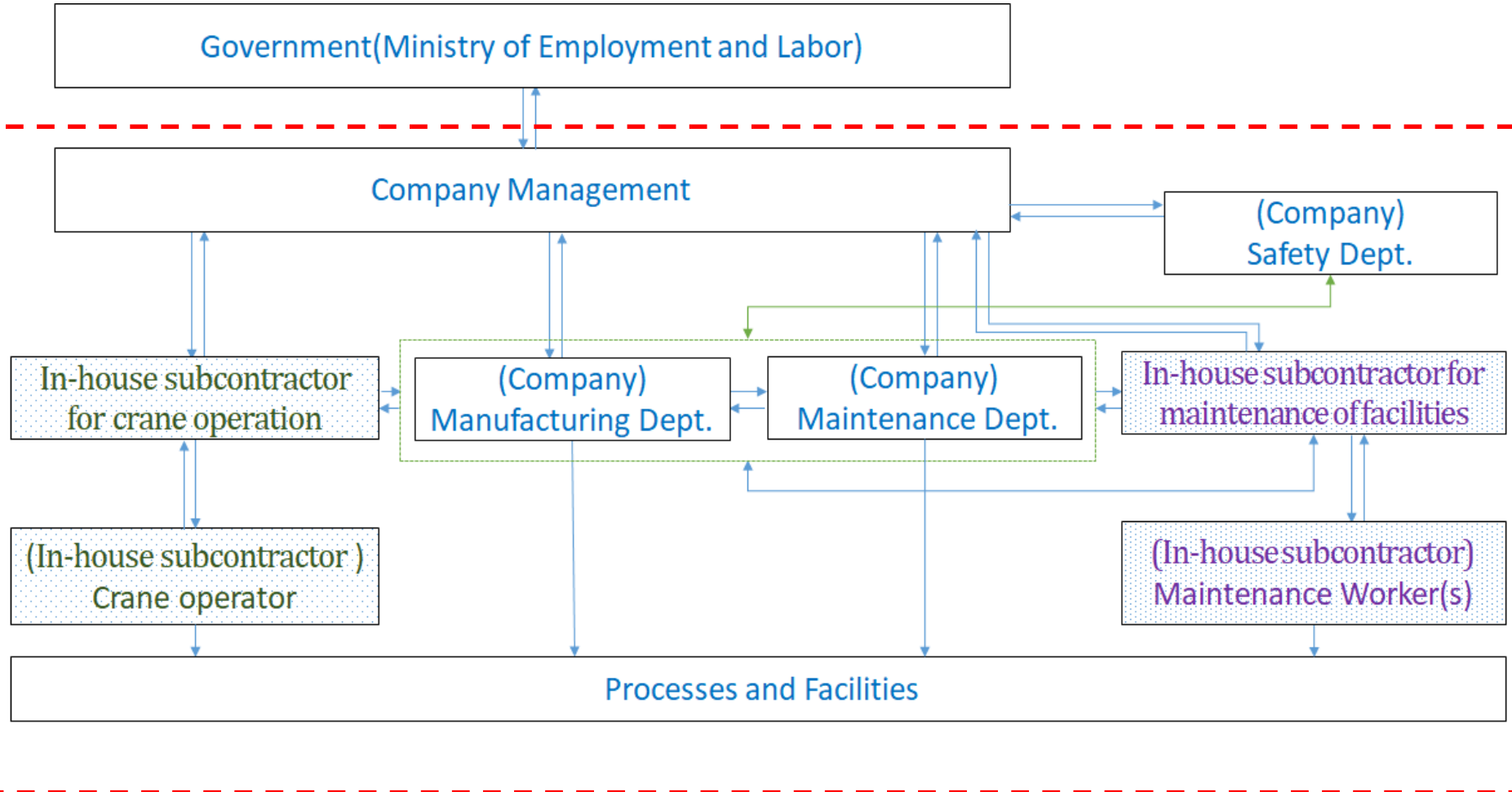
2) A Steel Company

☑ Accident Overview

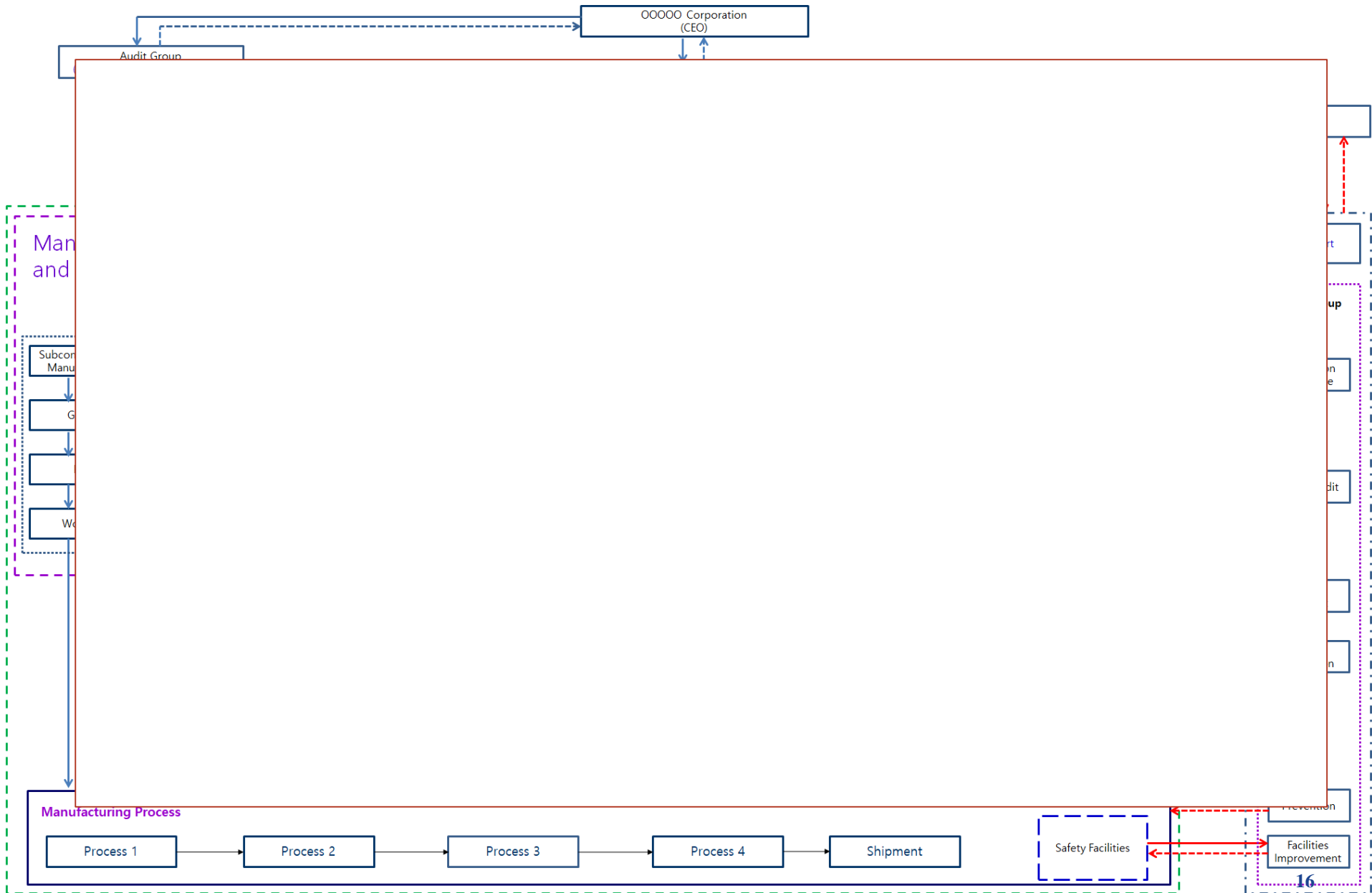
| Facility | Owner | Operator | Maintenance |
|---|---------------|--|--|
| Metal surface treatment facility | Steel Company | - | In-house subcontractor for maintenance |
| Overhead Crane | Steel Company | In-house subcontractor for crane operation | - |

This is not a simple accident.

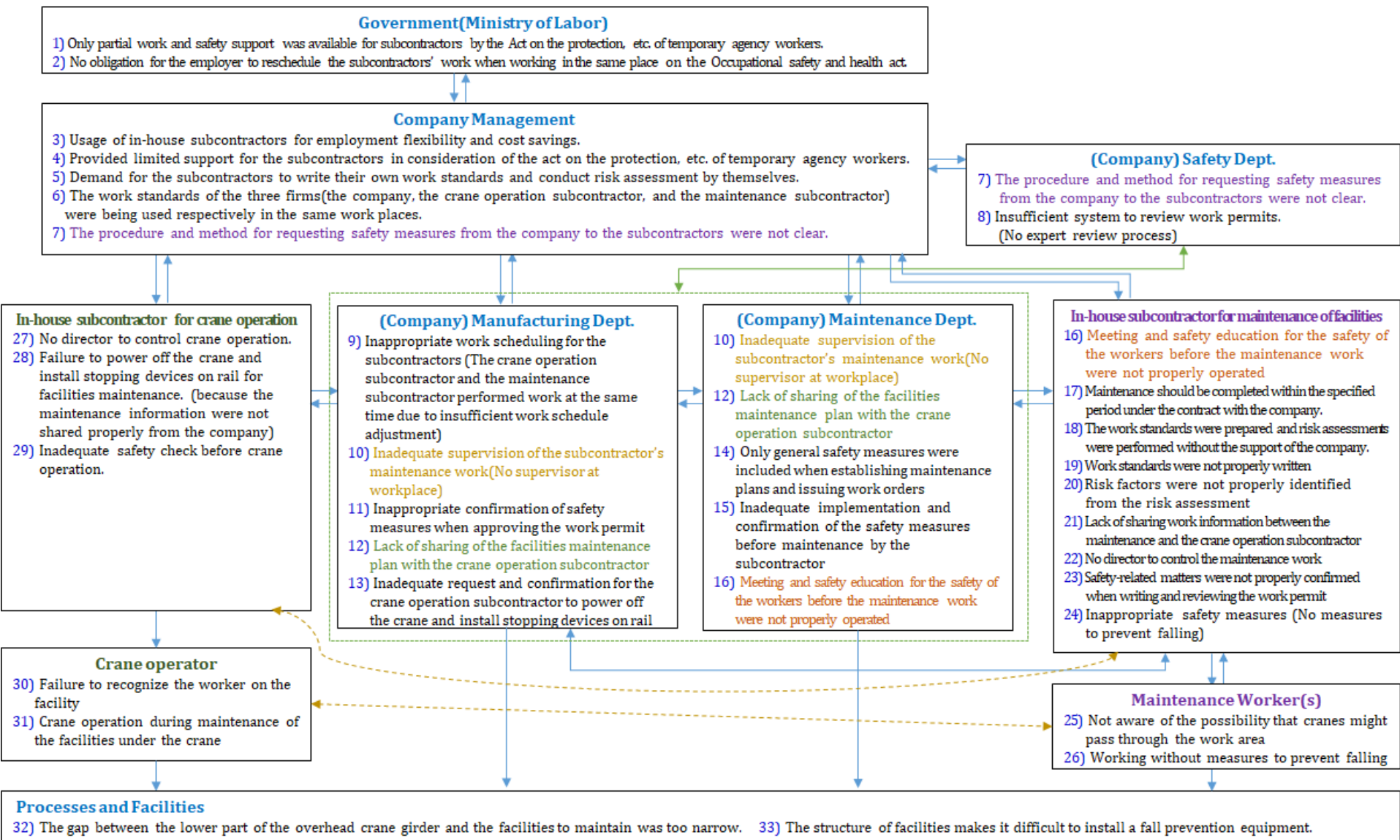
✓ Safety Control Structure (simplified)



✓ Safety Control Structure (detailed)

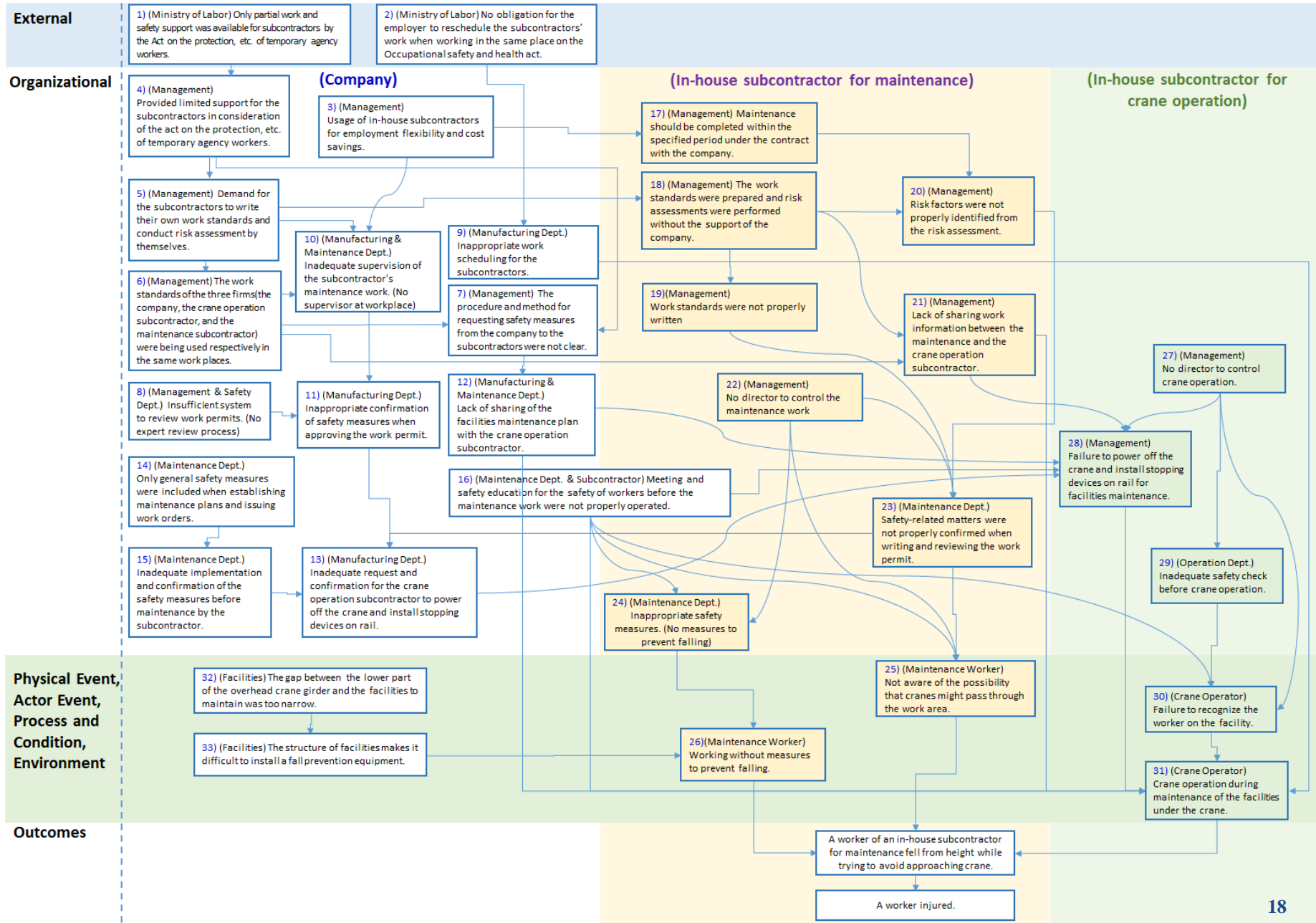


✓ Analysis





Analysis - AcciMap



Analysis – HFACS

| Classification | | Causal factors | | |
|---------------------------|----------------------------------|---|--|---|
| | | Company | In-house subcontractor for facilities maintenance | In-house subcontractor for crane operation |
| Organizational Influences | Resource Management | 3) Usage of in-house subcontractors for employment flexibility and cost savings. | N/A | N/A |
| | Organizational Climate | 4) Provided limited support for the subcontractors in consideration of the act on the protection, etc. of temporary agency workers. 5) Demand for the subcontractors to write their own work standards and conduct risk assessment by themselves. | 17) Maintenance should be completed within the specified period under the contract with the company. | N/A |
| | Organizational Process | 7) The procedure and method for requesting safety measures from the company to the subcontractors were not clear. | 18) The work standards was prepared and a risk assessment was performed without the support of the company. | N/A |
| Unsafe Supervision | Inadequate Supervision | 10) Inadequate supervision of the subcontractor's maintenance work. (No supervisor at workplace) | 22) No director to control the maintenance work. | 27) No director to control crane operation. |
| | Planned Inappropriate Operations | 9) Inappropriate work scheduling for the subcontractors. 11) Inappropriate confirmation of safety measures when approving the work permit. 12) Lack of sharing of the facilities maintenance plan with the crane operation subcontractor. 13) Inadequate request and confirmation for the crane operation subcontractor to power off the crane and install stopping devices on rail. 15) Inadequate implementation and confirmation of the safety measures before maintenance by the subcontractor. | 19) Work standards were not properly written. 20) Risk factors were not properly identified from the risk assessment. 21) Lack of sharing work information between the maintenance and the crane operation subcontractor. 23) Safety-related matters were not properly confirmed when writing and reviewing the work permit. 24) Inappropriate safety measures. (No measures to prevent falling) | 28) Failure to power off the crane and install stopping devices on rail for facilities maintenance (because the maintenance information were not shared properly from the company). |
| | Failed to Correct Problem | N/A | N/A | N/A |
| | Supervisory Violations | 14) Only general safety measures were included when establishing maintenance plans and issuing work orders. 16) Meeting and safety education for the safety of the workers before the maintenance work were not properly operated. | 16) Meeting and safety education for the safety of workers before the maintenance work were not properly operated. | 29) Inadequate safety check before crane operation. |

Analysis – HFACS

| Classification | | | Causal factors | | |
|-------------------------------|-------------------------------------|-----------------------|---|---|--|
| | | | Company | In-house subcontractor for facilities maintenance | In-house subcontractor for crane operation |
| Preconditions for Unsafe Acts | Environ-mental Factors | Physical Environment | 32)The gap between the lower part of the overhead crane girder and the facilities to maintain was too narrow. | N/A | N/A |
| | | Technical Environment | 33)The structure of facilities makes it difficult to install a fall prevention equipment. | N/A | N/A |
| | Substandard Conditions of Operators | | N/A | N/A | N/A |
| | Substandard Practices of Operators | | N/A | N/A | N/A |
| Unsafe Acts | Errors | Decision Errors | N/A | N/A | N/A |
| | | Skill-Based Errors | N/A | N/A | N/A |
| | | Perceptual Error | N/A | 25)Not aware of the possibility that cranes might pass through the work area. | 30)Failure to recognize the worker on the facility. |
| | Violati-ons | Routine | N/A | 26)Working without measures to prevent falling. | N/A |
| | | Exceptional | N/A | N/A | 31)Crane operation during maintenance of the facilities under the crane. |

2) Construction Site

✓ Accident Overview



(Source: BBC, <https://www.bbc.com/korean/news-57423228>)

2) Construction Site

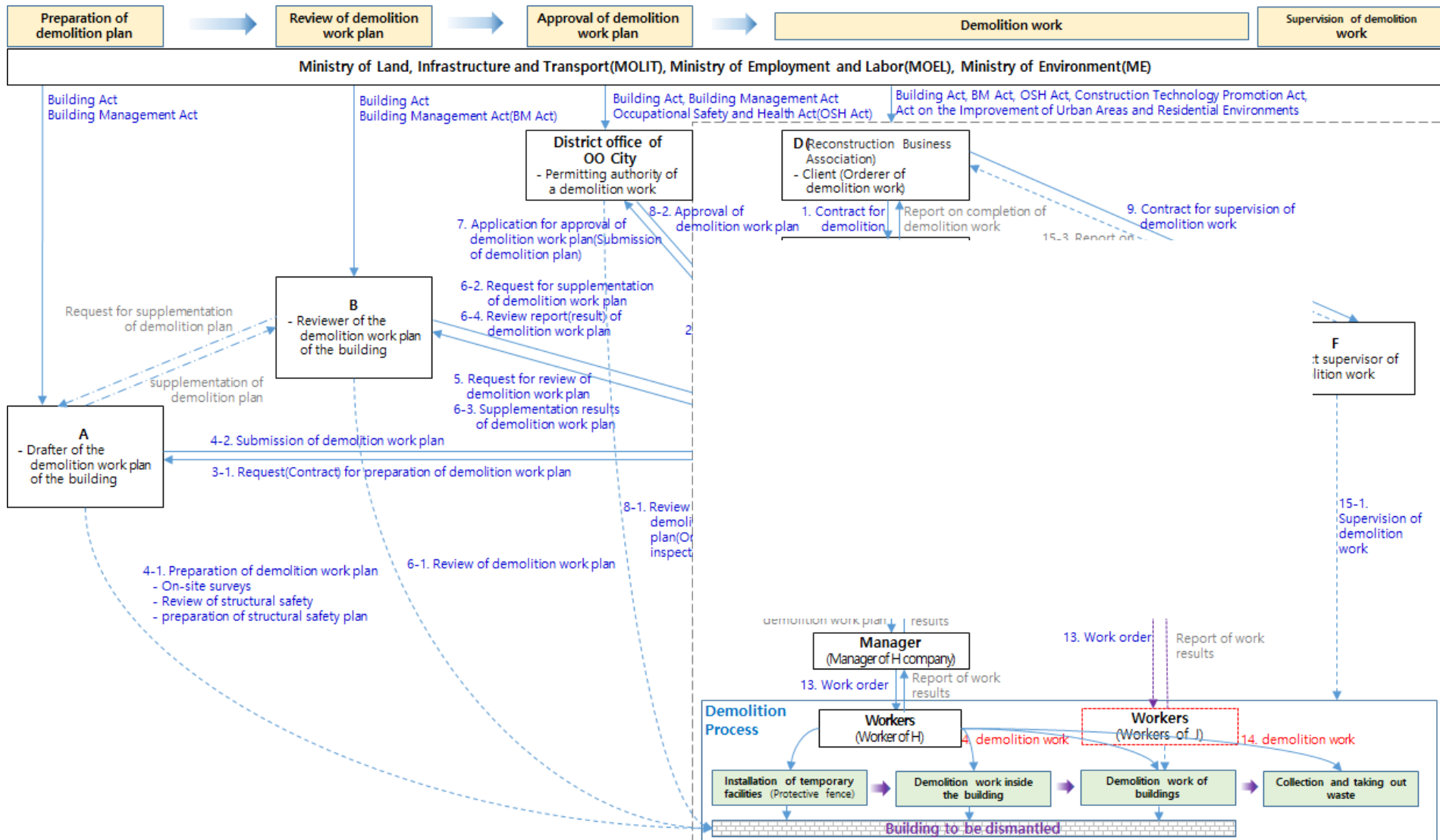
Accident Overview

OO-dong, an old housing district suffering from severe urban abandonment, was assigned for redevelopment. A Company won the contract to redevelop the old town and began the demolition work.

A five-story building in the midst of a demolition process fell onto a street in the redevelopment area. The building rubble buried a bus that was stationary on the street at the time.

The accident killed nine passengers on the bus and injured eight.

✓ Safety Control Structure





Analysis 2 – Analysis according to work flow

| No. | Work Stage | Organization or Company in Charge |
|-----|---|---|
| 1 | Contract for demolition | Reconstruction Business Association(D) → Contractor for demolition work(E) |
| 2 | Subcontract for demolition work | Contractor for demolition work(E) → Subcontractor for demolition work(G) |
| 3 | Request(Contract) for preparation of demolition work plan | Subcontractor for demolition work(G) → Drafter of the demolition work plan of the building(A) |
| 4 | Preparation of demolition work plan | Drafter of the demolition work plan of the building(A) |
| | Submission of demolition work plan | Drafter of the demolition work plan of the building(A) → Subcontractor for demolition work(G) |
| 5 | Request for review of demolition work plan | Subcontractor for demolition work(G) → Reviewer of the demolition work plan of the building(B) |
| 6 | Review of demolition work plan | Reviewer of the demolition work plan of the building(B) |
| | Request for supplementation of demolition work plan | Reviewer of the demolition work plan of the building(B) → Subcontractor for demolition work(G) |
| | Supplementation results of demolition work plan | Subcontractor for demolition work(G) → Reviewer of the demolition work plan of the building(B) |
| | Submission of review report(result) of demolition work plan | Reviewer of the demolition work plan of the building(B) → Subcontractor for demolition work(G) |
| 7 | Application for approval of demolition work plan(Submission of demolition plan) | Subcontractor for demolition work(G) → Permitting authority of a demolition work(C) |

☑ Analysis 2 – Analysis according to work flow

| No. | Work Stage | Organization or Company in Charge |
|-----|--|---|
| 8 | Review of demolition work plan (On-site inspection) | Permitting authority of a demolition work(C) |
| | Approval of demolition work plan | Permitting authority of a demolition work(C) → Subcontractor for demolition work(G) |
| 9 | Contract for supervision of demolition work | Reconstruction Business Association(D) → Project supervisor of demolition work(F) |
| 10 | Request for approval of demolition work | Subcontractor for demolition work(G) → Contractor for demolition work(E) |
| 11 | Approval of demolition work | Subcontractor for demolition work(G) / Contractor for demolition work(E) → Subcontractor for demolition work(G) |
| 12 | Sub-subcontract of demolition work(illegal) | Subcontractor for demolition work(G) → Sub-subcontractor for demolition work(H) |
| | | Subcontractor for demolition work(G) → Subcontractor of asbestos demolition work(J) |
| 13 | Work order | Manager of sub-subcontractor for demolition work(H) → Workers |
| 14 | Demolition work | Workers of sub-subcontractor for demolition work(H) |
| 15 | Supervision of demolition work | Project supervisor of demolition work(F) → Subcontractor for demolition work(G) / Contractor for demolition work(E) |
| 16 | Safety Inspection | Contractor for demolition work(E) → Subcontractor for demolition work(G) |

3) Small Factories Manufacturing Cell Phone parts

☑ Accident Overview



(Source: Nocutnews, 2016-03-09, <https://www.nocutnews.co.kr/news/4559006>)

3) Small Factories Manufacturing Cell Phone parts

☑ Accident Overview



(Source: Nocutnews, 2016-03-09, <https://www.nocutnews.co.kr/news/4559006>)

3) Small Factories Manufacturing Cell Phone parts

☑ Accident Overview – Methanol(Methyl Alcohol)

| | |
|---------------------------|--|
| Name (CAS Number) | Methanol(Methyl Alcohol) (67-56-1) |
| Exposure Work | Aluminum plate cutting and drying work Coolant replenishment |
| Color / Odor | Colorless/Characteristic |
| Toxicity | <p>The initial symptoms of methanol intoxication include central nervous system depression, headache, dizziness, lack of coordination, and confusion. Sufficiently large doses cause unconsciousness and death.</p> <p>The initial symptoms of methanol exposure are usually less severe than the symptoms from the ingestion of a similar quantity of ethanol.</p> <p>Once the initial symptoms have passed, a second set of symptoms arises, from 10 to as many as 30 hours after the initial exposure, that may include blurring or complete loss of vision, acidosis, and putaminal hemorrhages, an uncommon but serious complication.</p> |
| Workplace Exposure Limits | <ul style="list-style-type: none">- OSHA: The legal airborne permissible exposure limit(PEL) is 200 ppm averaged over an 8-hour workshift.- NIOSH: The recommended airborne exposure limit(REL) is 200 ppm averaged over a 10-hour workshift and 250 ppm, not to be exceeded any 15-minute work period.- ACGIH: The threshold limit value(TLV) is 200 ppm averaged over an 8-hour workshift and 250 ppm as a STEL(short-term exposure limit). |

3) Small Factories Manufacturing Cell Phone parts

Accident Overview

From January 2015 to October 2016, six cases of non-oral occupational methanol poisoning occurred in mobile phone parts manufacturers in Korea.

The workplace used a high concentration of 99.9% methanol as cutting oil when cutting aluminum parts with a CNC cutting machine. The cutting oil cooled the cutting tool and workpiece. Each CNC machine used about 18 liters of methanol a day.

After cutting, workers used an air gun to remove residual methanol from the aluminum parts. Methanol splashed on the workers' eyes and skin at that time, but they were not wearing safety glasses, protective gloves, and gas masks.

Therefore, the workers' hands got wet with methanol and they inhaled methanol vapor dispersed in the workplace through their respiratory systems.

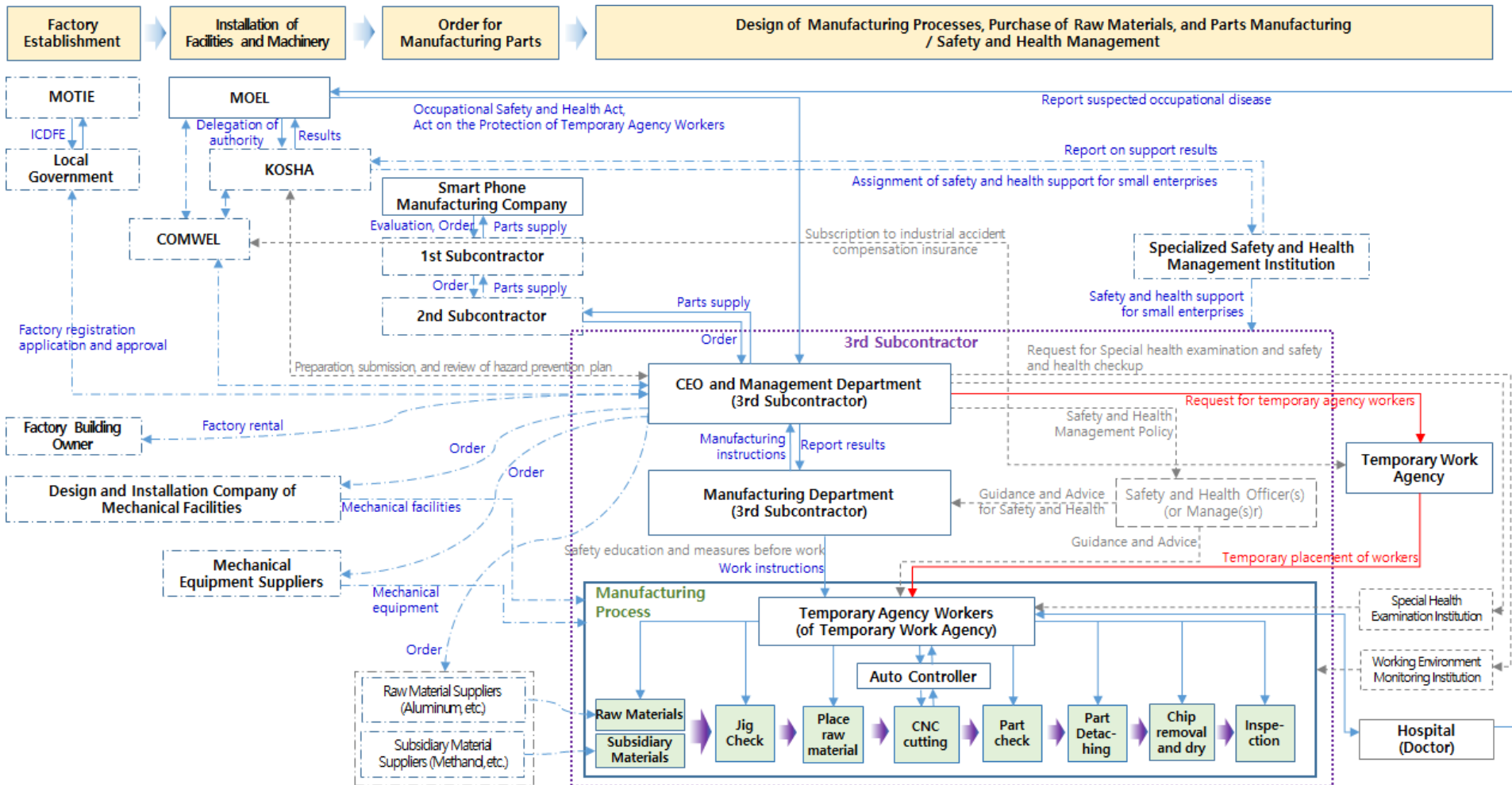
The poisoning accident caused blindness and brain damage to six workers in three workplaces.

3) Small Factories Manufacturing Cell Phone parts

References for Analysis

| No. | Author(Year) | Subject | Source |
|-----|------------------------------------|--|---|
| ① | Lee et al.(2017) | Why did non-oral occupational methanol poisoning occur in South Korea in the 21st century? | Journal of Korean Society of Occupational and Environmental Hygiene |
| | Lee et al.(2016) | Tracking investigation of methanol acute poisoning occupational disease patients in 2016 and post-management plans at smart phone manufacturing subcontractors | Solidarity for Worker's Health, Korean Industrial Hygiene Association |
| ② | Park et al.(2016a) | What Caused Acute Mehtanol Poisoning and What it the Countermeasure? | Journal of Korean Society of Occupational and Environmental Hygiene |
| | Park et al.(2016b) | Occupational health and safety vulnerability of workers in micro and small enterprises: The causes and measures | OSHRI, KOSHA |
| ③ | Lee(2016) | Toxicological hazards of methanol and causes of acute poisoning accidents | Work Law |
| ④ | Shin(2016) | Workers' rights evaporated with methanol, all that remains is the wound | Seoul National University Journal |
| | Chung(2018) | Workers' health is still a long way off after the methanol poisoning accidents | |
| ⑤ | Seoul Central District Court(2021) | Civil Division Judgment 48. Incident 2016 Gahap 535017 Compensation for damages(San(Occupational accident)).2021.2.4. | Court of Korea |

Safety Control Structure



4) Waste Plastic Pyrolysis Plants

☑ Accident Overview



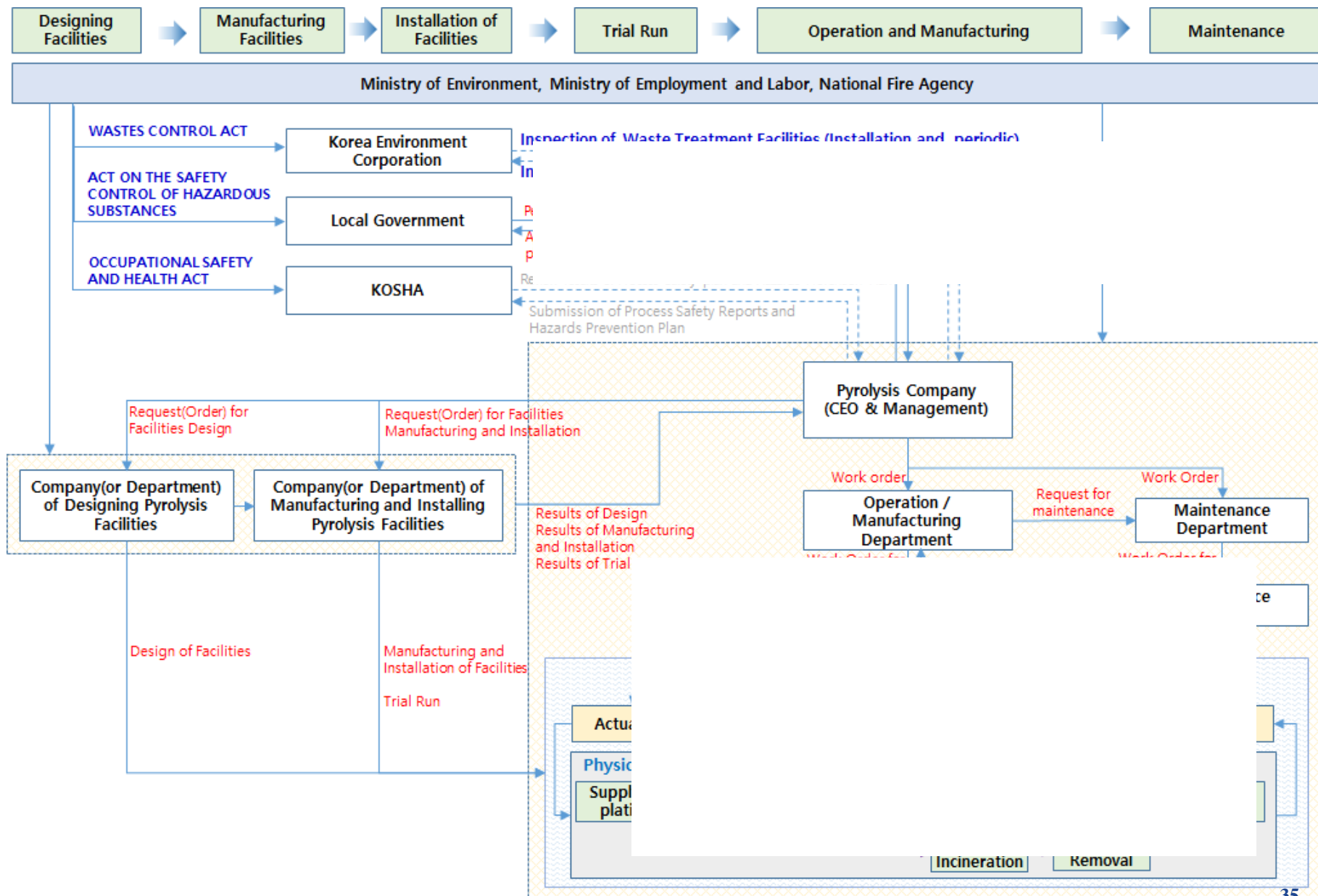
(Source: KOSHA, 화학사고 사례연구-폐기물 열분해 재생유 생산공정 화재 사고, 2021)

4) Waste Plastic Pyrolysis Plants

Accident Overview

| No | Company | Year | Type | Process | Outline of the Accident |
|----|---------|------|-----------|----------------------|---|
| 1 | AA | 2010 | Fire | Pyrolysis | Leaked gas and oil vapor ignited and caused a fire during the pyrolysis of compressed waste vinyl pellets. (1 dead, 2 injured) |
| 2 | BB | 2016 | Fire | Residue removal | A flame broke out inside the pyrolysis reactor while a worker cut the wire caught in the inlet of the pyrolysis reactor with a portable grinder. |
| 3 | | 2019 | Explosion | Gas incineration | A gas explosion occurred while opening the door of the gas incineration facility with a lit torch to burn the gas. (1 injured) |
| 4 | CC | 2020 | Fire | Waste Plastic Supply | When a worker opened the door of the pyrolysis reactor to put waste plastics into it, a fire occurred with the smell of gas.(3 injured) |
| 5 | DD | 2020 | Fire | Gas incineration | The waste gas generated and leaked from the waste plastic pyrolysis process caused a fire. (1 dead) |
| 6 | EE | 2021 | Explosion | Pyrolysis | The pressure inside the waste plastic pyrolysis reactor increased and broke the fixing bolts of the reactor cover, which made pyrolysis gas and oil vapor leak and cause a fire.(2 dead) |
| 7 | FF | 2021 | Fire | Trial run | After injecting pyrolysis oil into a centrifuge, a fire and explosion occurred during its test operation. (1 dead) |

✓ Safety Control Structure



III. Conclusions

III. Conclusions

1) Caught between a crane and a structure at a steel company

- A simplified model was created from the complex system structure and analyzed.
- It was analyzed with a focus on the relationship between system components.

2) Building collapse onto a bus during demolition

- An additional analysis according to the work process flow was performed using the STAMP model due to the long time delay between some actions and the accident.
- Some components were not included in the system model, resulting in inadequate analysis of related problems.

3) Methanol poisoning during smart phone parts manufacturing

- The analysis results reflected all the problems presented in the previous reports and identified additional problems.
- It was the first case applied in the field of occupational health in Korea.

4) Fire and explosion at waste plastic pyrolysis plants

- One STAMP model integrated seven accidents.
- It identified many problems regarding physical processes, and inside and outside the workplace.

III. Conclusions - Limitations

- ▶ Analyzing a complex system with STAMP takes a **long time**.
- ▶ STAMP analysis **requires a lot of data**, so it is necessary to secure related data or prepare a plan to participate in the accident investigation process.
- ▶ STAMP analysis alone has **limitations in finding all problems**, so using other analysis methods is also necessary.
For example, analyzing over time is not easy. Moreover, if the system model has an error, the identified problems would be limited.
- ▶ The relevant **experience and level of knowledge of the analyst** can have a great influence on the STAMP analysis results, as with other analysis methods.

However, despite these limitations,

- ▶ STAMP analysis was applicable to occupational safety and health fields in any industry.
- ▶ The STAMP model was helpful in understanding and analyzing the accidents because it was intuitive.

Thank you!