

## Research Article

# Occupational Accidents in Cement Industries of Nepal

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## I N F O

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## A B S T R A C T

The study on occupational accidents in cement industry of Nepal provides an overview of the accidents and their causes in this sector. The purpose of this study was to find out nature of accidents happening in the cement industry, their causes and recommend appropriate approaches to prevent the accidents. For this study, 10 cement industries were visited to collect the data of accident that occurred in last three fiscal years. Among the 10 visited cement industries, three were limestone-based industries and seven were clinker based industries. It was found that in the last three fiscal years, almost all accidents were minor accidents while only few were major and no fatal accidents. The data showed that the number of accidents is decreasing each year, however the decrease number is not significantly different. The surface causes of accidents in the industry were due to worker's taking shortcut, being over confident in themselves, poor/lack of housekeeping, starting task without getting necessary information, neglecting safety procedures, being mentally distracted, lack of preparation for work, mishandling of machinery, manual material handling, lack of proper and suitable PPE and occupational stress. Beside these, the root cause of the accidents in cement industries is lack of integration of safety plan, policy and safety culture into each activities of the industry.

**Keywords:** PPE, Accidents, Workers Activities, Safety Procedures

## Introduction

International Labour Organization (ILO) has defined work/occupational accident as accidents that occur "while engaged in an economic activity, or at work, or carrying on the business of the employer". Occupational injury denotes any personal injury, disease or death resulting from an occupational accident (Laurie, 1998).

Unsafe workplace and unsafe working environment are integral part of industrial occupation due to the presence of hazard in their technology and process. The presence of hazard creates risk of accidents and diseases to the employees of the industry. Majority of Nepalese industries do not have satisfactory working condition.

Cement industries is one of the booming industries in Nepal. The high deposit of limestone attracts investors to invest in this sector. Cement industries requires high number workforce who are continuously exposed to different hazards present within the premises of the industry. The structure of workforce, poor health delivery system and its consequent effect on health of workers, nature of production process and mass poverty in the country shows the need for health and safety measure for workers in Nepal.

The Act has safety provisions for the workers who work higher than atmospheric pressure in the production process. The act has shown its special concern to protect from

occupational diseases, health hazards, injuries and accidents to the workers working the hazardous jobs like construction, transportation.

## Objectives of Study

The main objectives of the study were:

- To list out three years data of occupational accident in selected cements industries of Nepal.
- To find out the main causes of accidents in cement industries.
- To recommend the potential accident prevention approaches in cement industries.

## Methodology

Following methodology was adopted for the study.

- Desk study was carried out for literature review regarding industrial accidents, and cement industries in the country. Ten cement industries covering limestone based and clinker-based cement industries were selected for the study based on convenient sampling and operational industries.
- Walk through visit, questionnaire survey, interview with relevant personnel and direct observation was done in the selected industries
- Analysis and interpretation were done considering international norms and expert opinion. Books, publications, reports, literature and internet sites were used for the description of the accident in Nepalese context

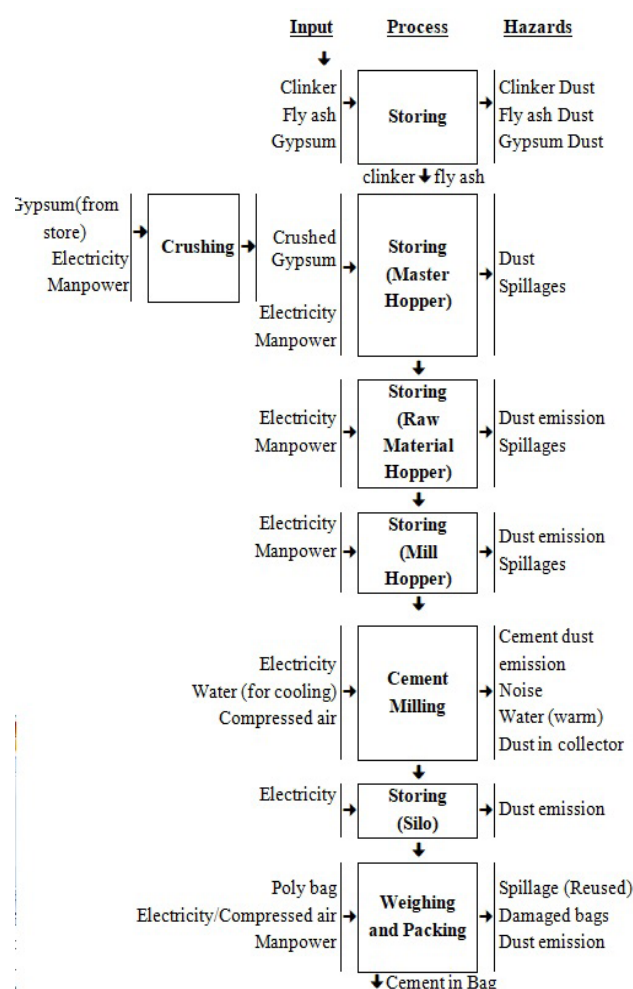
## Cement Sector in Nepal

Cement production in Nepal has been growing sharply over the past few years. The industry is among the country's most flourishing business sectors as the demand of cement is constantly rising. Most of the cement industry operated in Nepal is located in urban areas and Terai region. Almost all Cement industries possess similar technology and process. But the cement goods production varies industry to industry. Most of the industries mainly produce OPC (Ordinary Portland Cement) & PPC (Portland Pozzolana Cement) and few produce PSC (Portland Slag Cement (PSC). Cement grade Limestone, Silica rich clay and Gypsum are the main raw materials for the cement production and coal is the main fuel for Limestone based cement industries. Clinker, slag, fly ash and gypsum are the main raw materials for clinker based cement industries. Cement grade Limestone and Silica rich clay are available in the country where as gypsum, slag, fly ash and coal are imported mainly from India. 12 out of 59 are producing clinker the major constituents of cement. The domestic cement industry has an installed production capacity of about 6 million tons annually which is higher than the annual demand of 4 million metric tons. But the cement industries which are currently in operation

have been able to utilize only about 50 percent of their total production capacity. Local production fulfils about 80 percent of the requirement while the rest is imported from India. It is estimated that annual gross consumption of cement in Nepal is around 2,500,000 MT. Average 20% demand is increasing and 6 billion of local currency is invested through private party.

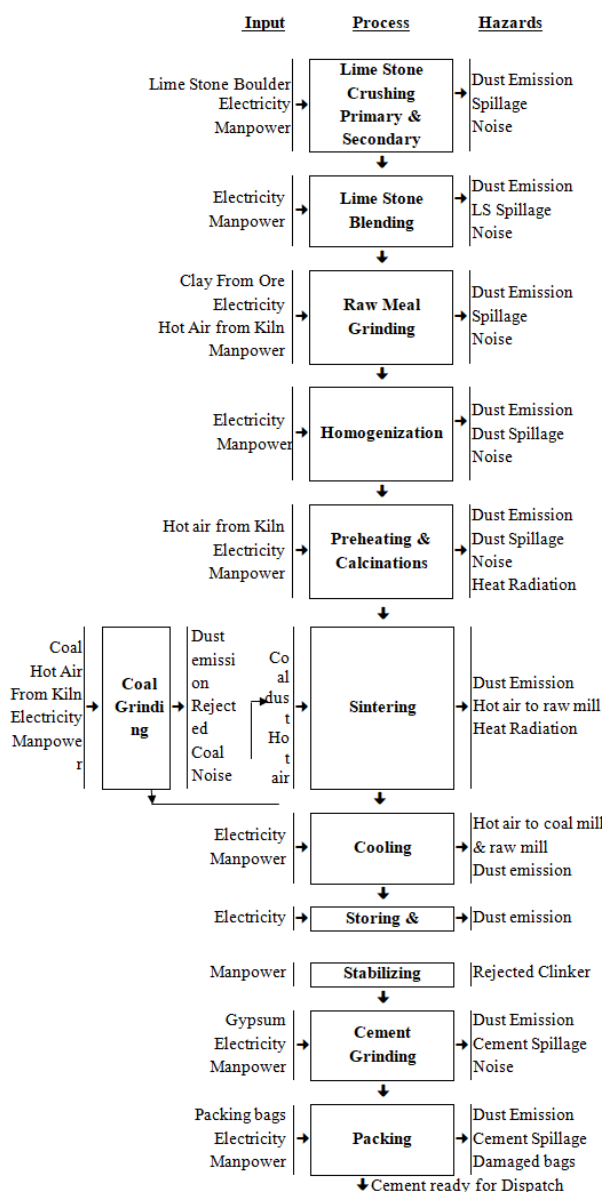
## Production Process of Cement Industries

### Process Flow Chart



**Figure 1. Clinker Based Cement Plant Process Description**

The manufacturing of cement is a two-step process, notably, clinker production and cement grinding. In the first step, the raw materials are fed to the kiln system to produce clinker. Clinker consists of silicates, aluminates and ferrites of calcium obtained from the reduction of calcium, silica, alumina and iron oxides present in the raw materials. In the second step, clinker is ground (in a grinding mill) with calcium sulphates (gypsum or anhydrite) to obtain cement with desired performance such as setting time and strength development.



**Figure 2. Process Flow Chart of Limestone Based Cement Plant**

### Raw Material Acquisition

Calcium carbonate, usually limestone is the basic raw material used in the plant. Limestone is quarried at mines and transported to the plant using rails, ropeways, trippers and dumpers depending on the available facility. The mines are equipped with the latest Machinery and Technology. The mined limestone is then crushed through primary jaw crusher and secondary hammer crusher. The crushed limestone is then transported to the plant site. Other raw materials, like coal, bauxite (for aluminum) iron ore and gypsum are procured from various suppliers.

### Raw Milling

The raw materials are crushed, ground and mixed to obtain a homogenous blend, and then stored. Crushing operation

takes place in a raw mill that could be either VRM or Ball Mill or both. The major energy input during this process is electricity.

After the material preparation and prior to entering the kiln system for clinker production, the raw materials are preheated - to enable the chemical reactions to occur quickly and efficiently in the kiln and calcined (calcinations) to separate calcium oxides from calcium carbonates contained in the raw materials. During the process, significant amount of carbon dioxide ( $\text{CO}_2$ ) is released. This complete operation takes place in Preheater tower through cyclones at different stages.

### Pyro-processing

In Pyro-processing, the raw mix is heated to produce clinkers. Clinkers are hard, gray, spherical nodules with diameters ranging from 0.32-5.0 cm (1/8 - 2") created from the chemical reactions between the raw materials. The Pyro - processing system involves three steps: drying or preheating, calcining (a heating process in which calcium oxide is formed) and burning (sintering). The Pyro-processing takes place in the burning zone of the kiln section.

The major thermal energy consumption of the plant is in this section. Coal Mill consumes electricity for pulverizing coal. In the kiln system, calcium oxides are sintered at a typical temperature of 1400-1500°C to form clinker, together with oxides of silica, alumina and iron that are present in the feed materials. The clinker production ends with the cooling phase in the cooler installed in the plant. The combusted gases move from kiln through Preheater tower, heating the raw material coming to the kiln through the raw meal silo.

### Clinker Cooling

The clinker cooling operation recovers up to 30% of kiln system heat, preserves the ideal product qualities, and enables the cooled clinker to be maneuvered by conveyors.

### Clinker Storage

Suitable transfer mechanism is used to transfer clinkers from coolers to storage areas and to the finish mill. Gravity drops and transfer points typically are vented to dust collectors.

### Cement (Finish) Milling

The clinker produced in the kiln stored in the silo/ stockpile is ground along with Gypsum (about 5%) to produce Ordinary Portland Cement (OPC). The generally used grinding equipment is the ball mill in various cement plants around the world. In recently installed plants the VRM has been installed for lowering energy consumption. The other types of cement such as PPC (Portland Pozzolana Cement) and PSC (Portland Slag Cement) are also produced by grinding clinker with fly-ash and blast furnace slag respectively.

## Packing and Loading

Once the production of cement is complete, the finished product is transferred using elevators and conveyors to large, storage silos. Cement is packed as per the standards/requirement. From here, cement is dispatched as per order, to different dealers and agents spread across the country.

## Result and Discussions

### Accidents in Cement Industries

It was observed that there was no systematic record keeping system of accidents in any of the visited industry. Labor Act 2017 has the provision of accident reporting system, but industries do not have the practice of submitting accidents records to the Government due to which there is lack of record. The observed industries did not have safety plan, policy and safety responsible persons. The working conditions were not practiced following safety-first principle. The visited industries neither had safety committee nor safety and health certification. Cut off of a small portion of finger or the whole finger was the most common type of accident whereas there were very few cases of losing half or a whole hand in the machinery while working. The Table 1 shows the accidents found in visited cement industries.

Most of the visited industries had adopted automatic and latest technology where direct worker's involvement is minimized which has led to decrease in number of accidents. Cement industries are not fire sensitive industries. There were few cases of small fires in last three fiscal years in these cement industries, but no fire disaster had occurred.

### Causes of Accident in Cement Industries

In the cement industries, accident rate is found low as compared to its accident-prone nature of industries. Most of the accident was caused during vehicle movement and material handling. The common causes of accidents in any industry is due to worker's taking shortcut, being over confident in themselves, poor/lack of housekeeping, starting task without getting necessary information, neglecting safety procedures, being mentally distracted and lack of preparation for work. In most of the cases, these causes are overlooked. Apart from these, some specific and technical causes of accidents in cement industry are as follows:

### Accident due to Machineries

Most of the visited industry had new machines and technology and had ongoing maintenance activities. Moving drives like gear and belt drives were not properly guarded in

**Table I. Accident in Cement Industries**

Cement Industries	FY 2015/16				FY 2016/17				FY 2017/18			
	Minor	Major	Fatal	Total	Minor	Major	Fatal	Total	Minor	Major	Fatal	Total
Cement 1	26	4	0	26	28	1	0	29	26	1	0	26
Cement 2	30	5	0	30	28	2	0	28	30	3	0	33
Cement 3	4	5	0	4	3	2	0	3	5	2	0	5
Cement 4	110	3	0	110	105	1	0	105	85	2	0	85
Cement 5	12	1	0	13	10	02	0	10	8	0	0	8
Cement 6	20	0	0	20	25	1	0	25	24	1	0	24
Cement 7	5	4	0	5	4	3	0	4	5	2	0	5
Cement 8	0	3	0	0	0	3	0	0	3	1	0	3
Cement 9	35	3	0	35	46	2	0	46	45	1	0	45
Cement 10	60	3	0	60	50	2	0	50	60	1	0	61
<b>Total</b>	<b>302</b>	<b>31</b>	<b>0</b>	<b>333</b>	<b>299</b>	<b>19</b>	<b>0</b>	<b>318</b>	<b>291</b>	<b>14</b>	<b>0</b>	<b>305</b>

The above data showed that the fatal accident did not happen in any of the visited cement industries in last three fiscal years. Almost all accident was minor accidents while only few were major. The data showed decrease in number of minor and major accidents in the consecutive years. However, the number is not significantly decreased despite of the safety measures and safety awareness programs by industries.

all machines. Some of the accidents recorded were during loading, unloading and maintenance works.

### Accident Due to Manual Material Handling

Cement Industries production layout seems very congested in all the cement industries. During the materials and machines handling, risk of accident is high. Uneven surface congested working place and manual works were the main causes of accident.



### Accident due to Electricity

Short circuit and electrocution are the major effect of electrical hazards in any workplace. Electrical distribution and installation seemed unmanaged in many cement industries. None of the visited industries had the drawing and design of cabling system. Loose connections were seen in many places of the industries.

### Accident due to lack of Personal Protecting Equipment

It was observed that there was no dress code, so females were wearing sarees and loose clothes and males were also wearing loose clothes while working. Many major and minor accidents happened due to trapping of loose clothes in moving drives. Any scientific based PPE were not seen in any cement industries.

### Accident due to occupational stress

Cement industries are the labor-intensive industries and most of the workers in this industry are unskilled or semiskilled and comes from an agriculture background. High noise and dust exposure made workers annoying and uncomfortable. Most of the workers were seen working in stress. Anybody working in stress may take a wrong decision which may cause risk of accident.

### Accident due to lack of safety culture

In the visited industries, the culture of safety practice was not found. Strong legislative provision, implementation of OSH provisions, management willingness for safety integrated productivity, and safety culture has not been developed in this sector. Uneducated, unskilled and agriculture-based workers are also the reason for not developing safety culture. Many accidents are happening due to lack of safety culture practices.

### Fire

There are few combustible materials in the process equipment of a cement plant, except for conveyor belts. Specifically, cases of fires in conveyor belt have arisen, where belt misalignment and/or friction caused heat build-up and subsequently lead to ignition. The fire can spread within minutes to the entire conveyor, resulting in toxic smoke emission and severe damage to the conveyor gantry.

- Recommendation for Prevention and Control of Accident in Cement Industries
- Implementation of Labor Act and Labor Regulation 2017

Labor Act has incorporated provisions for the health and safety of workers including neat and clean workplace with adequate ventilation, light and enough space for movement of workers. The law has the provision of safety plan, policy, safety committee, accident reporting which must be implemented by each industry. The Act has also

focused to arrange for a compulsory medical examination, at least once a year, for those working in the hazardous condition. The facilities of adequate water for drinking and washing, toilet facilities, constructing fence around each part of the hazardous machines as well as the restriction of overload carrying are covered in the Act to make safe working environment healthy and prevent workers from the problem of occupational & communicable diseases thereby decreasing the incidence of industrial accidents & injuries. So, implementation of Labor Act provisions will improve safety and health of workers in cement industries.

### Administrative and Engineering Recommendations

Besides the implementation of act, the implementation of following recommendations will help to reduce the rate of accidents in cement industries.

- Proper training programs should be conducted to educate the workers as well as their supervisors particularly on occupational safety and health (OSH).
- The machinery should be regularly checked and maintained.
- All moving drives i.e. belt drives, rollers and gear drivers should be properly guarded or fenced.
- Adoption of good housekeeping practices by marking with yellow line.
- Installation of proper cable size and connection to reduce the fire and electrocution.
- Scheduled and preventive maintenance should be done to reduce accidents.
- Dress code should be provided for all workers.
- Proper and suitable PPE should be provided to the workers.
- Fire prevention plan and fire extinguishing system should be adopted
- Provide stress management program regularly to the workers. Management should listen and solve the workers views and problem.
- The industry premises should be made "No Smoking zone".
- Compulsorily introduce induction training for all new workers.
- Emergency preparedness system should be introduced.
- Regular health check-ups and health awareness programs should be conducted for the workers.
- Appropriate work schedules should be developed, and the workers should be assured of their job.
- Health and accidental insurance for the workers should be provided.
- Provision of first aid.
- Provision of treatment in the hospitals.
- The working condition in the industries should be made more scientific and concerned government authorities should regularly check the standard.

## Good Practices in Safety

The following good practice in safety in cement plants will reduce the accidents:

### Mobile Plant

Common hazards associated with the heavy plant (e.g. dumper trucks, front loading shovels, fork lift trucks) used in bulk material transport include vehicle impact and twisted ankles during embarking and disembarking. Vehicle impact has the potential for particularly high severity incidents, both in quarries and on the manufacturing sites. Incidents can be reduced by improved driver training, increasing awareness of the people working alongside these vehicles, and by using dedicated routes and crossings to help keep vehicles and pedestrians apart. Modern vehicles also offer improved visibility, helping further reduce the risks as the older equipment is replaced.

### Working at Height

Controls relating to working at height or in confined areas (e.g. Permit-to-work, task risk assessment) are effective in reducing injuries by raising awareness of the hazards and ensuring the correct work methods are followed and that the proper precautions are taken. Mandatory use of safety equipment (harnesses, safety nets) to properly protect workers from falls, posting of permits, and regular inspections of the job site are commonly employed techniques.

### Plant Isolation/ Lock-Out

Plant Isolation is one of the most important areas of plant safety; with improvements in the technology in the industry. Fully isolated machinery from all energy sources is essential.

Any isolation of energy systems; mechanical, electrical, process, hydraulic and others, cannot proceed unless:

- ✓ the method of isolation and discharge of stored energy are agreed and executed by a competent person(s)
- ✓ any stored energy is discharged
- ✓ a system of locks and tags is utilized at isolation points
- ✓ a test is conducted to ensure the isolation is effective
- ✓ isolation effectiveness is periodically monitored

### Slips, Trips and Falls

Slips, trips and falls are another common cause of injuries in the industry. These can arise from the uneven surfaces in the quarries and roads and from lapses in good housekeeping within the manufacturing plants. Slips, trips and falls cause almost 30% of all injuries.

Slips, trips and falls can be minimized through following simple housekeeping procedures:

- Keep work places tidy
- Use the scrap and dirt bins where provided

- Tidy stacking and tidy layout prevents injuries
- Good housekeeping leads to greater safety
- Pile material so that it is stable and steady
- Put tools and other equipment where they cannot possibly fall or be knocked on to someone below.
- Clearly mark, fence or cover all openings in floor, roof or ground.
- Keep gangways, paths, roads and stairways clear of obstacles
- All excavations in the plant should be surrounded with a handrail
- Provide all scaffolds and platforms with toe boards and railings.
- When working overhead remove all loose material such as bolts, screws, tools, timbers, fittings, etc. when the job is finished.
- Never throw tools or materials, always pass them from hand to hand.
- A nut or bolt falling from a height can kill a person.

### Manual Handling

Due to the repetitive nature of some of the tasks related to cement production, it is very important to ensure that the correct training is given to employees in relation to manual handling. Following measures should be followed while manual handling

- Look out for sharp edges, splinters and nails.
- Pull out or knock down projecting nails before you pass material on or throw it out for scrap
- Don't try to carry a load you cannot see over.
- Remove obstructions before lifting.
- Stack goods carefully and tidily on trucks and trailers
- When lifting heavy objects, use your legs as much as possible to save your back muscles.
- Get a good grip of the articles
- Keep your back straight and chin in
- Slacken and bend your knees
- Take up a firm stand, lift steadily and do not twist your body
- When lifting or guiding pieces of equipment, watch for nipping points.

### Electrocution

As cement plants are very energy intensive, there will be significant power distribution equipment in all plants. Electrical maintenance must be conducted on a professional basis. Isolation/Lock-out procedures must be rigorously adhered to. Due cognizance must be given to the possibility of back-feed due to looped systems or energization in reverse direction: the electrical supervisor must manage these issues.

It goes without saying that non-competent or unauthorized persons should not open up or attempt to work on electrical

equipment. If such persons need to access inside electrical equipment (for example to re-set overload trips), then they must be protected against injury by contact with live terminal and bus bars (such as by covering these in plastic housing).

The other main electrical hazard to be considered is accidental contact with high voltage or equipment touching overhead wires. If such overhead wires exist, then appropriate warning signs and “gates” will be required to prevent contact. It will also be beneficial to provide instruction, in case of such an incident, in jumping clear without simultaneous vehicle to ground contact.

### Machine Guarding

Where there is a risk of physical contact with moving parts of work equipment which could lead to injuries, those parts must be provided with guards or devices to prevent access to danger zones.

### Heat Burns

Incidents and injuries resulting in burns arise from contact with hot clinker or cement powder. Hazards are particularly associated with hot Cement Kiln Dust (CKD), and dust on preheater systems. Chemical (alkali) burns may also result from contact with CKD. During normal operation the hot raw, intermediate and final products are contained or highlighted. There is chance of greater risk during abnormal operation of the plant, when clearing blockages, carrying out maintenance or in emergency situations. Heat burns also occurs from contact with combustible materials; oils, scaffold boards, ladders, electrical cabling etc.

### Conclusion

The study showed root causes of occupational accidents like lack of safety plan, policy and safety culture integration in cement industries. Most industries do not have basic Personal Protecting Equipment (PPE) and are ignoring the basic safety-first principle. The low level of awareness among the workers is another key factor due to which the available PPE are not used effectively. The industries also lack adequately trained personnel and are reluctant to hire experts from concerned field who can enhance the safety situation in the workplace. Similarly, housekeeping and the layout of the workplaces are not managed effectively which were the surface cause of occupational accident. The safety and health of the workers and their efficiency are reciprocal entities. Safety and health measures not only result in reduced rate of occupational accidents but also raise the productivity. With the adoption of safety initiatives/campaign/awareness from government and industrialist, rate of the occupational will decreases significantly and eventually lead to smooth operation of industry, better retention of workers and thus prevail sustainable industries in the country.

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