OCCUPATIONAL HEALTH AND SAFETY IN CEMENT INDUSTRY

Selçuk Çankaya[1], Simge Çankaya[2]

[1]Wellpoint Health, Safety & Environmental (HSE)

[2]Kocaeli University, Department of Environmental Engineering, Kocaeli, Turkey

Abstract

Cement is the basic material for constructions which is made from a mixture of elements that are found in natural materials such as limestone, marl and/or clay. Cement manufacturing is an energy and resource intensive process with both local and global environmental, health and safety impacts. Because of these impacts, ensuring healthy and safe working conditions for employees is one of the most significant issues for the cement industry. In this review, cement manufacturing process was clarified briefly and potential hazards and their risks in cement industry were investigated.

Key words: *Cement, cement dust, cement manufacturing, occupational health and safety*

1. INTRODUCTION

Occupational health and safety has become a public health priority in industrialized countries and a primary concern, especially in high risk industries (Rachid et. al. 2015). Cement manufacturing is one of these industries. Cement is one of the most widely used construction material on earth. Because cement has been used commonly, its health effects have become an important issue both for employees and the environment (Koh et. al. 2011). In addition to the various health hazards, cement workers are especially exposed to dust which causes lung function impairment, chronic obstructive lung disease, restrictive lung disease, pneumoconiosis and carcinoma of the lungs, stomach and colon at various production process such as quarrying, crushing, raw material grinding, blending, kiln burning, cement grinding and packaging in cement industry (Meo 2004). Therefore, ensuring healthy and safe working conditions for employees and contractors is a fundamental key to corporate social responsibility, and is one of the most important issues for the cement industry (WBCSD 2004).

In addition, with the increasing complexity of industrial tissue and with the rapidity that the techniques develop in the big factories, risks assessment becomes a crucial and strategic answer to preserve workers health and safety on the one hand and to maintaining a qualified labor on the other hand (Tomar 2014).

The main objectives of this literature review are to define specific hazards in cement manufacturing process and investigate the health and safety risks from manufacturing process.

2. CEMENT MANUFACTURING PROCESS

Cement is a fine powder that consists of a mixture of hydraulic cement materials comprising primarily calcium silicates, aluminates and aluminoferrites. More than 30 raw materials, which are divided into four basic categories (calcium, silica, alumina, iron), are known to be used in the manufacture of portland cement (EPA 1994). These raw materials are presented in Table 1.

Table 1. Raw materials necessary for cement manufacturing (God n.d.)

Calcium	**Iron**	**Silica**	**Alumina**	**Sulfate**
Alkali waste	Blast-furnace flue dust	Calcium silicate	Aluminum-ore refuse	Anhydrite
Aragonite	Clay	Cement rock	Bauxite	Calcium sulfate
Calcite	Iron ore	Clay	Cement rock	Gypsum
Cement-kiln dust	Mill scale	Fly ash	Clay	
Cement rock	Ore washings	Fuller's earth	Copper slag	
Chalk	Pyrite cinders	Limestone	Fly ash	
Clay	Shale	Marl	Fuller's earth	
Fuller's earth		Ore washings	Granodiorite	
Limestone		Quartzite	Limestone	
Marble		Rice-hull ash	Loess	
Marl		Sand	Ore washings	
Seashells		Sandstone	Shale	
Shale		Shale	Slag	
Slag		Slag	Staurolite	
		Traprock		

Cement manufacturing process comprises of crushing, grinding, raw meal preparation, kiln burning and cement production basically. The following figure shows the process flow of a typical cement factory (Figure 1).

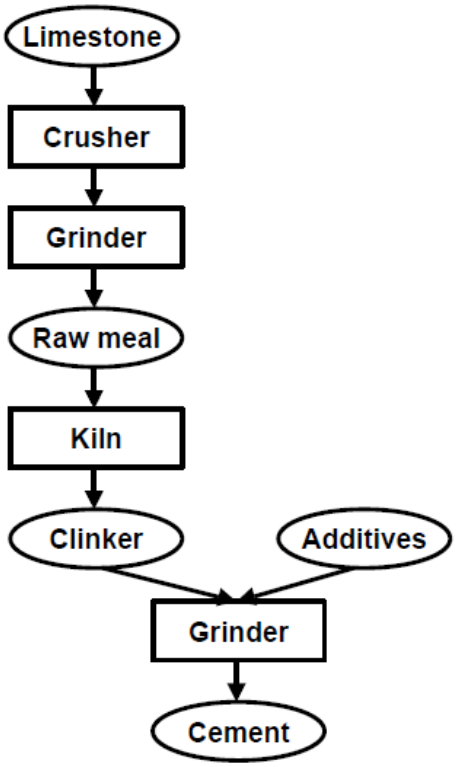


Figure 1: Simplified process flow of a typical cement manufacturing (Kema, Inc. 2005)

Quarrying of limestone and is performed by using explosives and all of the raw materials (limestone, marn, clay…etc) are transported to the plant. These raw materials are crushed, finely ground, and blended to the correct chemical composition. The fine raw material is fed into a large rotary kiln (cylindrical 4 furnace) which rotates while the contents are heated to extremely high (EPA 2010). The most commonly used kiln fuels are coal, natural gas, and occasionally oil (EPA 1994). Rotary kiln is heated by a 2000°C flame inside of it. The kiln is slightly inclined to allow for the materials to slowly reach the other end, where it is quickly cooled to 100-200°C (CEMBUREAU). Following re-cooling, the clinker is stored in silos , and then transformed into cement by using gypsum and other additives according to the production requirements. Finally, the cement is stored in silos and loaded on a truck or packaged into bags (LAFARGE).

3. CLASSIFICATION AND DEFINITION OF THE HAZARDS IN CEMENT MANUFACTURING

Cement manufacturing processes including health and safety risks were classified as follows:

- Quarrying
- Crushing
- Clinker production
- Milling processes at raw mill, cement milling and coal milling
- Material transport
- Filtering
- Storage
- Loading and delivery of final products

- Fuel storage activities
- Use of hazardous material
- Generating units (TRIA Project).

In Table 2, main hazard factors associated with cement manufacturing processes are presented. As shown from Table 2, main hazardous factors in quarrying of raw materials can be defined as dust and noise. Noise emits during balsting, crushing and operation of conveyors in quarrying operations. Noise sources in cement manufacturing plant mainly include milling machines, crushers, electric motors (Canfeng 2012).

Table 2. Main hazard factors associated with cement manufacturing processes (Cumbane 2011).

Cement Manufacturing Process	**Main Hazard Factor**
Quarrying	Dust, Noise
Raw material preparation	Dust, toxic gas (CO, CO2, NOx, SO2), noise, heat pollution
Clinker burning	Dust, toxic gas, high heat radiation, high worload
Clinker cooling and cement milling	Auxiliary materials and additives, dust, heat, noise
Packaging, storage and delivery	Dust, high workload

Dust emissions are one of the most significant impacts of cement manufacturing and associated with handling and storage of raw materials (including crushing and grinding of raw materials), solid fuels, transportation of materials (e.g. by trucks or conveyor belts), kiln systems, clinker coolers, and mills, including clinker and limestone burning and packaging/bagging activities (IFC 2007). Packaging is the most polluting process (in terms of dust) in cement production (Cumbane 2011).

Nitrogen oxide (NO_X) emissions are emitted from the high temperature combustion process of the cement kiln. Carbon dioxide defined as greenhouse gas is mainly associated with fuel combustion and with the decarbonation of limestone (IFC 2007).

In addition to specific hazards, there are also general hazards in all of the cement manufacturing process such as safe behavior, work equipment, safety labeling, personal protective equipment (PPE), manual load handling (TRIA Project).

Typical injury causes in cement plants are defined as slips, trips and falls (29%); falling or moving objects (19%) and lifting, overload and exertion (18%) as shown from Figure 2. Fatalities are the most serious tragedy that can happen in the cement Industry. 79% of all fatalities arise from 3 main causes: Traffic & Mobile Plant (43%), Falls from Heights & Items falling (21%) and Caught in Moving/Starting Equipment (15%). It was reported that contractors and young/temporary employees are high risk categories in cement manufacturing plants (WBCSD 2004).

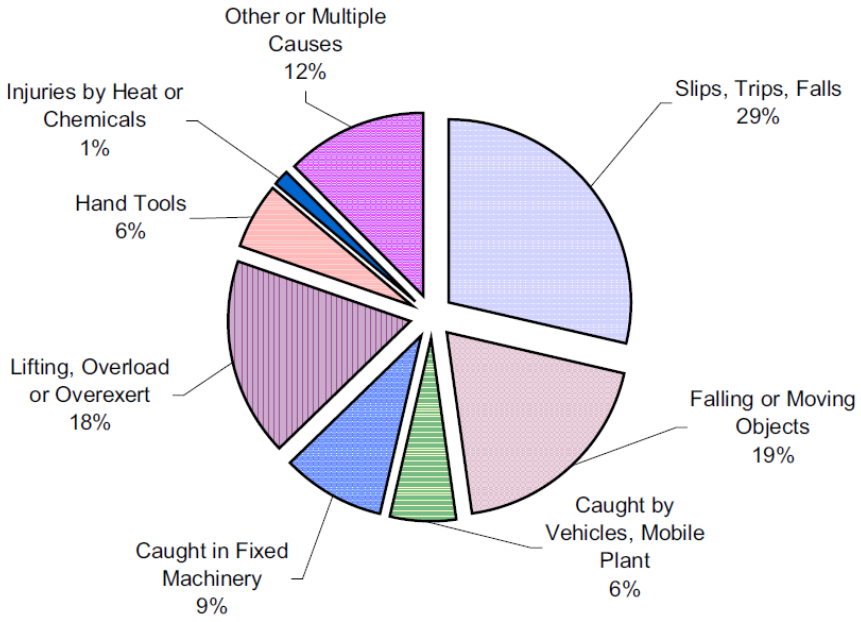


Figure 2. Injuries by causes (WBCSD 2004).

An example of potential hazards and preventive actions in a cement manufacturing plant was presented in Table 3.

Table 3. Potential hazars preventive actions in cement manufacturing plant (Adapted from OSHA)

Potential Hazard	**Preventive Action**
Slip, Trips & Falls	Good housekeeping Sufficient lighting Tidy work place Identify and fix fall hazards, such as slippery surfaces, damaged ladders and walkways
Confined areas (Lack of oxygen, Poisonous gas, fumes or vapour, Fire and explosions, dust, hot conditions…)	Must be avoided entry to confined spaces Remote cameras can be used Permit-to-work Cleaning before entry Provision of ventilation Testing the air Provision of lightings
Electric	Each panel should be labeled Safe electrical equipment should be purchased and used

	Appropriate PPE Training of personnel
Falling/Moving Objects	Tidy workplace Avoid working beneath cuber elevators, conveyor belts PPE (Personel protective equipment) usage
Fire (conveyor belts, electrical cables, fuels, waste combustible materials…)	Proper waste disposal good housekeeping Heat detectors usage Fire extinguisher Fire fighting procedures must be
Working at height	Usage of appropriate ladder and scaffolder Usage of Fall protection system Usage of appropriate PPE
Hot/cold surfaces (hot surface burns…)	Usage of appropriate PPE
Noise and Vibration	Technologies of noise attenuation, absorption and insulation Appropriate hearing protection
Excavation sites	All excavations in the plant should be surrounded with a handrail
Vehicles	Avoid overloading Make sure back-up alarms on all vehicles are functioning Be sure that trucks and other vehicles are in good working order, including audible back-up warning signals, before operating them
Safety guards of machines	Those parts must be provided with safety guards or devices Usage of appropriate guards (interlocking, automatic, self adjusting, two hand control devices…etc) Maintaining of conveyor belt systems
Manuel handling	Must be looked out for sharp edges, splinters and nails When lifting heavy objects, legs sohuld be used as much as possible to save back muscles
Tag Out - Lock Out (Electrical or Process isolation)	Electrical isolating switches must be turned off
Dust	Usage of automated packing machines

	Usage of enclosed conveyors Storage of crushed raw materials in closed bays Appropriate respiratory protection should be worn
Cement dust	Usage of respirator to minimize inhalation of cement dust Usage of soap and water avoid skin damage Avoid exposure to cement dust to prevent bronchitis and silicosis

4. CONCLUSIONS

The cement manufacturing industry is labor intensive and uses large scale and potentially hazardous manufacturing processes (Marlowe and Mansfield 2002). Therefore, health and safety is the number one priority in for the cement industry for its employees, contractors, end-users and those who are neighbors to its operations (Tomar 2014.) Exposure to dust and high temperatures, contact with allergic substances, and noise exposure can be defined as hazards associated with health; while falling / impact with objects; hot surface burns; and transportation, working at height, slip/trips/falls can be defined as hazards associated with safety.

It is the most critical issue that ensuring a health and safety culture in workplaces. For this purpose, health and safety policy should be adapted with other policies of the company. Additionally, risk management policy of company should be developed, and risk assessment should be performed regularly and efficiently.

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