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Impact of the Use of Hazardous Chemicals on Workers in the "Y" Construction Revitalization Project in Semarang City

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Abstract: Construction revitalization projects have become an inseparable part of repairing, renewing and improving the quality of city buildings and infrastructure. The construction industry is one of the sectors that plays an important role in infrastructure development in various countries, including Indonesia. The revitalization project of the "Y" construction project in Semarang City, Indonesia, has become part of the repair and renewal efforts of urban buildings and infrastructure. This study aims to determine the hazardous chemicals used and their impacts at the project site. This study is based on the analysis of hazardous chemicals found in the "Y" construction Revitalization Project which specifically focuses on the process of installing walls and floors. The variables to be studied are the work process, hazards and risks of work accidents and occupational diseases, and control of existing hazards and risks. The results of the study indicate that the use of chemicals in cement has a significant impact on workers' health if not managed properly. By implementing proper safety procedures, the negative impacts of chemicals can be minimized, thereby creating a safer, healthier, and more productive work environment. Awareness and compliance with safety procedures by all workers and project management are essential to protecting workers' health.

Keywords: cement; construction; hazardous chemicals; toxicology

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INTRODUCTION

The construction industry is one of the sectors that plays an important role in infrastructure development in various countries, including Indonesia. In recent decades, construction revitalization projects have become an integral part of efforts to repair, renew, and improve the quality of buildings and city infrastructure. One of the key components in the implementation of this project is the use of various chemicals, both as part of the construction material and as a support for the work process (Moniaga & Rompis, 2019). Various industries contribute to large amount of dusts, which may come from the process of making cement, metal, ceramics, crushing stone, metal, asbestos, and silica with a particle size of 3-10 microns that can accumulate in the lungs. Exposure to dust, especially silica dust, which is often found in cement mixing activities, remains a major issue in occupational health worldwide (Aulia et al., 2023).

Silicon dioxide (SiO_2), calcium oxide (CaO), aluminum oxide (Al_2O_3), and magnesium oxide (MgO) are some examples of hazardous chemicals that are often used in the construction industry. Silicon dioxide, also known as silica sand, can be found in numerous types of rock, sand, clay, shale, and gravel. Exposure to this material most often occurs in workers in the stone cutting, mining, construction, concrete, and ceramics industries. Long-term exposure to these hazardous chemicals can trigger various health problems in workers, ranging from respiratory problems to internal organs damage. Silicon dioxide, for example, can cause silicosis, a lung disease caused by inhaling silica dust (Margan et al., 2022). Exposure to large amounts of calcium oxide dust can cause disorders of the respiratory system, such as irritation of the respiratory tract and difficulty breathing (Seru et al., 2021).

Exposure to silica dust is still an occupational health problem throughout the world. An estimated 2 million people in the United States and 3 million people in Europe are exposed to silica dust in their work environment. In Asia, an estimated 23 million people in China and 10 million people in India are exposed to silica dust in their work environment. In 2018, there are 51 individuals based in Central Java working in the cement production section who

are at risk of silicosis. Silicosis is the most common health disorder caused by exposure to silica dust. Silicosis is a form of pulmonary pneumoconiosis characterized by alveolar proteinosis and diffuse fibrosis, causing progressive restrictive disorders of lung function. Lung function disorders caused by silicosis are decreased expansion capacity, vital capacity, and lung diffusion capacity (Wijaya et al., 2019). In the construction process, silica dust can be released during activities such as grinding, cutting, and casting concrete. When workers are involved in these activities, small particles of silica measuring less than 10 micrometers can be inhaled and enter the respiratory tract. Once accumulated in the lungs, these silica particles trigger a chronic inflammatory reaction, in which immune cells attempt to clear the particles but often fail, leading to ongoing inflammation and scarring (fibrosis). As a result, this condition can progress to silicosis (Nij & Heederik, 2005).

PT. X Semarang is a construction company involved in the construction of buildings in the Semarang area. In the construction process, this company uses various chemicals that have the potential to pose health risks to its workers, such as silicon dioxide, calcium oxide, aluminum oxide, and magnesium oxide. Based on field observations, it turns out that not all workers use masks as personal protective equipment (PPE) so that there is an increased risk of health problems due to dust exposure. This study was conducted to assess the level of health risks arising from exposure to hazardous chemicals at the construction site of PT. X Semarang. By presenting information about the risks and impacts of the use of hazardous chemicals on workers, as well as providing additional insight as an effort to increase understanding of potential hazards in the work environment.

METHODS

Based on the data collection method, this research is classified as an observational study because the researchers only conducted observations without providing any treatments or interventions. Based on the analysis, this research falls under descriptive research as it aims to describe the use of chemicals in construction projects. Additionally, this study is categorized as field research since the data was collected through direct observation by visiting the construction site four times.

The object of this research is the chemicals used in the "Y" Revitalization Construction Project in Semarang City, with a specific focus on the processes of wall and floor installation. The variables examined include work processes, hazards and risks of work-related accidents and occupational diseases, as well as the control measures for existing hazards and risks.

RESULT AND DISCUSSION

In the construction process, several activities produce high dust concentrations, such as cement mixing, concrete making, brick and concrete cutting, interior wall construction, concrete drilling, and surface smoothing (Suanboon et al., 2024). Building construction absolutely requires concrete as a structural element, where the concrete formation process involves cement as the main component (Langitan et al., 2022). Cement is a construction material with special characteristics that can bind (adhesive) and unite (cohesive) various mineral fragments into a solid and compact structure. This material is included in the category of hydraulic cements because it can harden after reacting with water. Portland cement is known to have the advantages of flexibility and adaptability which allows for relatively low maintenance costs (R. S. Lestari & Razif, 2019). However, the use of Portland cement has consequences for workers that need to be considered.

Potential Hazards in the "Y" Construction Revitalization Project

In building construction, there are various work processes that are usually carried out such as: making formwork, casting columns, transporting materials, working on walls & floors, installation, and finishing. From the hazard analysis on the "Y" construction revitalization project, it was found that physical and chemical hazards that often arise due to physical activities carried out on the job cannot be separated from the use of chemicals such as in making formwork, casting columns, working on walls & floors. In the building construction process, especially at the wall and floor construction stages, the use of cement is not just a construction procedure but also carries potential complex health risks for workers. When workers are exposed to cement dust, substances such as aluminum and silica can trigger inflammatory processes that damage the liver, skin, and lungs (Ahmad et al., 2021).

Hazardous Chemicals

Silicon Dioxide

Silicon dioxide (SiO_2) is a non-metallic oxide compound in the form of a white, odorless, and insoluble solid powder. This compound has various crystal structures, similar to the carbon that forms granite and diamonds. Although it has the same composition as sand and glass, silicon dioxide molecules have a cubic shape. The manufacturing process involves a reaction between sulfuric acid (H_2SO_4) and sodium silicate (Na_2SiO_3) (Aris et al.,

2023). Micron-sized silica is often used in building materials, especially as an admixture in concrete. Silica gel fills the empty spaces between cement particles, thus functioning to strengthen and increase its durability (Junaidi, 2015). High silica content, usually accompanied by low alumina content, produces cement with a slow binding process, but has high strength and resistance to chemical attack. Conversely, if the alumina content is high and silica is low, the cement will bind faster with high strength (Nadia & Fauzi, 2011). In the "Y" Construction revitalization project in Semarang City, a material containing silica was used, namely cement. Silica acts as one of the main components in the chemical composition of cement, which functions to determine the strength and durability of the material.

Calcium Oxide

Calcium oxide (CaO) acts as an important component that can optimize the strength of concrete structures through the binding process in the cement mixture (Haika Muhammad Fikrie & Herlina, 2023). Limestone, which is composed of calcium carbonate (CaCO3), is the main source of calcium oxide (CaO). In the cement-making process, limestone is heated at high temperatures in the calcination process to produce calcium oxide (Sirapanji et al., 2016). In the cement-making process, calcium oxide plays a key role because it is not only the largest component but also has the ability to react with silicate and aluminate compounds to form chemical structures that are the basis for cement formation. Calcium carbonate itself is a mineral that is found in rocks all over the world. This chemical component is not only found in nature, but is also contained in biological structures such as eggshells, snail shells, and various marine organisms. Calcium carbonate not only acts as a source of calcium oxide but also has an important function as a filler in the concrete mixture. Its presence can make concrete denser, reduce empty spaces between materials, thereby increasing the resistance of concrete to water and various environmental influences. As a binding material, calcium carbonate is applied to various building elements, including brick joints, roof covering materials, concrete block reinforcements, and basic tile compositions (D. R. E. Lestari & Risdianto, 2022).

Aluminum Oxide

Aluminum oxide plays a role in the formation of calcium aluminate (C3A) compounds that contribute to the cement hydration reaction and affect the development of strength and cement hardening time. Aluminum oxide is also involved in the formation of calcium alumina ferrite (C4AF) compounds which are formed through reactions with iron oxide and calcium oxide during the kiln firing process. This alumina oxide also determines the viscosity of the melt from the kiln firing with a directly proportional value, which plays a role in increasing the resistance of cement to sulfate and modulating the mechanical properties of cement. Alumina oxide also contributes to the formation of the main mineral structure in ceramics, increasing strength and resistance to extreme temperatures. Aluminum oxide also affects the viscosity of the material melt during the ceramic firing process, which is vital to ensure the quality and consistency of the resulting ceramic products.

Magnesium Oxide

One of the chemicals found in cement is magnesium oxide (MgO). This compound is produced through the combustion of magnesium carbonate ($MgCO_3$), where different combustion temperatures produce MgO with different levels of reactivity. At a temperature of 1500-2000 °C, dead burned magnesia is formed, at a temperature of 1000-1500 °C hard-burned magnesia is produced, while at a temperature of 700-1000 °C low-burned magnesia is obtained. The level of magnesium oxide in cement needs to be limited to prevent negative impacts that can be caused. The magnesium oxide content affects the expansion value of the cement; if the level is too high, this can cause unsoundness to cracks in the concrete. Magnesium oxide has expansion properties when undergoing a hydrolysis reaction, so it can fill cavities in the concrete structure. However, if the expansion is too large, cracks can occur due to the slow hydration reaction of magnesium oxide which is completed after the cement hardens. In addition, the product of the magnesium oxide hydration reaction, namely magnesium hydroxide ($Mg(OH)_2$), has a larger volume than the initial volume of MgO and H_2O that react, thus contributing to the risk of cracking (Purnama et al., 2022).

Impact of Hazardous Chemicals Contained in Cement

Cement is a material often used in construction, contains hazardous chemicals such as silicon dioxide, calcium oxide, aluminum oxide, and magnesium oxide that have the potential to pose serious health risks to workers. These chemical components can cause irritation to the skin, eyes, and respiratory system (Khairiah et al., 2012). Cement dust can be a risk factor for Chronic Obstructive Pulmonary Disease (COPD). There are two types of COPD that can be caused by exposure to cement dust, namely chronic bronchitis and emphysema. Chronic bronchitis is an inflammation of the walls of the respiratory tract that causes the tract to become slimy and narrow, thus disrupting airflow. Meanwhile, emphysema is an anatomical disorder of the lungs characterized by widening of the air cavities in the bronchioles and damage to the walls of the alveoli (Rachmani, 2019).

The dangers of silica arise when workers inhale fine silica particles. Exposure to inhaled silica dust can increase the risk of health problems, both acute and chronic. This risk is even higher when tiny silica particles float in the air, because they are difficult to see and detect by the human eye. Long-term exposure to crystalline silica can cause serious diseases characterized by potentially fatal lung damage (Putro et al., 2024). Inhaling crystalline silica dust in the workplace can cause various health problems, such as pulmonary fibrosis (silicosis), decreased lung function, lung inflammation, and lung cancer. In addition, this exposure is also associated with glomerulonephritis and disorders of the liver, spleen, and immune system (Chen et al., 2012).

Recommended Chemical Control Measures

Contractors must comply with the regulations and standards that have been determined as in the Minister of Manpower and Transmigration Regulation No. PER.13/MEN/X/2011 which states that physical and chemical factors in the workplace have a threshold value of 0.05 mg/m^3. Meanwhile, the threshold value for silica dust based on SNI Number 19-0232-2005 is for inhalable particles 10 mg/m3 and respirable particles 3 mg/m3 (Khairiah et al., 2012). Based on the five control hierarchies (elimination, substitution, engineering control, administrative control, and use of personal protective equipment), the most appropriate recommendation for managing chemical hazards in cement at the Semarang City "Y" Construction Revitalization Project site focuses on administrative and the last step is the use of personal protective equipment.

This strategy allows project managers and supervisors to effectively minimize the risks associated with hazardous chemicals from cement to ensure the safety and health of workers on site. In administrative control, work schedules can be arranged to limit long-term exposure to cement dust, and regular health assessments can be conducted to detect early signs of exposure-related health problems. Training sessions should also be provided to ensure all workers are aware of the potential hazards associated with cement chemicals. Clear safety instructions should be prominently displayed on site to reinforce safe practices. Workers play an important role in minimizing risks by storing cement, ensuring it is securely covered to prevent dust release. Workers should also adhere to established standard operating procedures (SOPs) by consistently wearing appropriate personal protective equipment (PPE), including gloves (Cotton Gloves & PVC Gloves), masks (N95), and goggles to protect against direct skin contact and inhalation.

CONCLUSION

The use of chemicals in cement in the "Y" construction revitalization project in Semarang City has a significant impact on workers' health if not managed properly. The content of chemicals such as silicon dioxide, calcium oxide, aluminum oxide, and magnesium oxide largely contributes to various health problems, especially respiratory disorders. One factor that influences the level of danger of these chemicals is the length of service of the exposed worker, where long-term exposure increases the risk of critical respiratory diseases, such as silicosis or pulmonary fibrosis. Risk control through a hierarchy of controls approach is essential to minimize the impact of these chemicals. Steps that need to be taken include administrative steps, such as rotating work schedules to limit the duration of exposure and providing personal protective equipment (PPE) such as masks and gloves. With the implementation of proper safety procedures, the negative impacts of chemicals in cement can be minimized, creating a safer, healthier, and more productive work environment. Finally, awareness and compliance with safety procedures by all workers and project management are essential to protecting workers' health.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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