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Occupational Risk in Construction Sites With Reference To Chemical Hazards

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***Abstract**: Worldwide around 120 million accidents occur at workplaces out of which 210,000 are fatal accidents. More than 500 men and women killed every day at work places because of various reasons; this phenomenon needs urgent attention in order to find out remedial measures to save precious lives of our workforce. In construction industry particularly on projects sites workers are very often prone to accidents associated with their work because of inadequate safety provisions. The major health hazards with reference to construction sector may be Physical, Chemical, Mechanical, Ergonomic and Psychological hazards. Amongst them Chemical hazards are extremely dangerous for human because of their long term effect and frequency of occurrence. Safety of workers at construction sites is a grey area which is not addressed adequately. This paper addresses the issue of construction worker's safety with reference to chemical hazards.*
***Keywords**: Chemical, Cadmium, accidents, welding, Painting*

I. Introduction

Accidents are unplanned sudden occurrences which result in injuries, fatalities, loss of production or damage to property and assets. It is very difficult to find out the causes of accidents as they cannot be predicted. Notion of safety culture is a complex phenomenon since culture is not a visible entity. Safety culture is an important concept for understanding the possibilities of prevention. There is a need to identification of potential hazards and to institute appropriate action before occurrence of a likely hazard. In last century a remarkable progress noticed in the area of safety form accidents particularly after occurrence of major catastrophes, such as Bhopal and Chernobyl. Many advanced countries like Sweden, Finland, Japan and the Federal Republic of Germany have made safety analysis mandatory and reduced fatal occupational accidents by 60 to 70% in last 50 years or so. This phenomenon is not adequately addressed in developing countries like India which

II. Occupational Accidents

Occupational accidents are more common in construction, manufacturing, as well as food and beverage industries

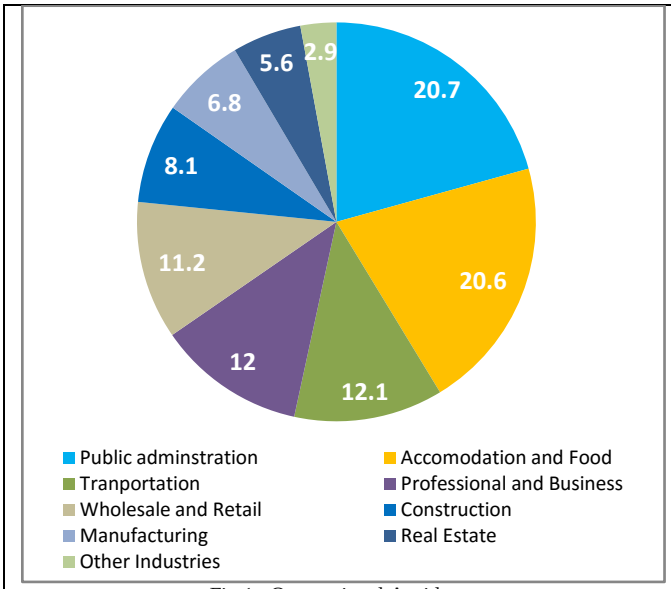

Fig.1 . Occupational Accidents

.A work accident, workplace accident, occupational accident, or accident at work is a "discrete occurrence in the course of work" leading to physical or mental occupational injury. According to the International Labour Organization (ILO), more than 337 million accidents happen on the job each year, resulting, together with occupational diseases, in more than 2.3 million deaths annually.
Construction and manufacturing sectors which are perceived as high risk industries ranked the sixth (8.1%) and the seventh (6.8%) respectively. (Fig 1)

III. Exposure Sources And Their Effect

Exposure to external agents may result in an injury in the form of a disease-like condition which may be of the following type:

- Chemical exposures (solvents, cleaning agents, degreasing agents, etc.)
- Physical exposures (noise, radiation, heat, cold, inadequate lighting, lack of oxygen, etc.)
- Physiological exposures (heavy loads, bad work postures or repetitive work)
- Biological exposures (viruses, bacteria, flour, animal blood or leather, etc.)
- Psychological exposures (work in isolation, threat of violence, changing working hours, unusual job demands, etc.).

IV. Chemical Hazards In Construction Industry

Construction workers are largely prone to exposure to hazardous chemicals which adversely affect their health and well being. Chemicals hazards are generally in the form of dusts, fumes, gases and vapors. The exposure to chemicals may result in severe health disorders, such as poisoning, asphyxiation and cancer. In addition there may be other injuries which include severe burns, disfigurement, internal organ damage, neurological injury, birth defects, and respiratory problems.

V. Effect Of Chemicals On Human Body

The way in which chemical affect human body is depends on its form. They enter into the body by inhalation or breathing in, ingestion or swallowing and absorption through the skin where inhalation or breathing in is the most important route of entry (Fig 2). Some toxic gases and vapors which are present in construction site cause irritation in the nose and throat and give warning of their presence. Others, however, do not and penetrate deep into the lungs or blood stream. There is a possibility of ingestion or swallowing where chemicals such as lead-based paints are handled and the handler eats something or smokes without first washing his/her hands. Toxic vapors contaminate utensils used for drinking or eating, or when meals are eaten onsite. Toxic fumes from welding and soldering, and electrical shock can cause bodily injury, illness, or death as there is the possibility of no oxygen particularly in confined spaces. In confined workspaces workers may be exposed to two types of hazards:

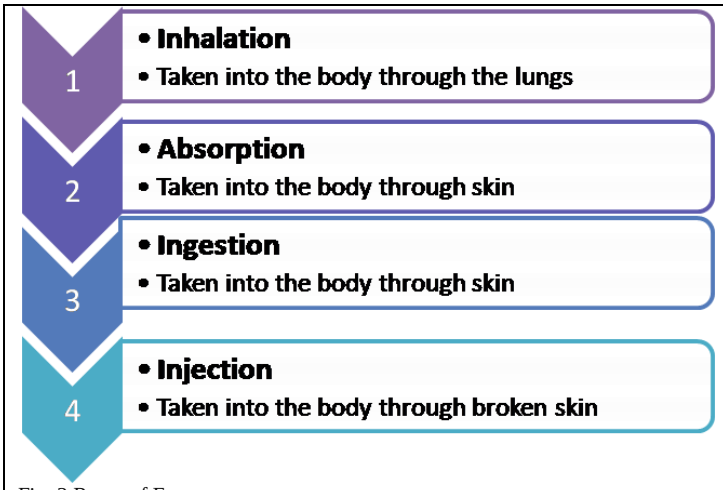

Fig. 2 Route of Entry

Inherent hazards: They include electrical, chemical, or mechanical hazards associated with specific types of equipment and the interactions among them.

Induced hazards: Such hazards are induced from incorrect decisions and actions that occur during the construction process.

VI. Hazardous Chemical Agents

Presence of hazardous chemical in construction site is a matter of serious concern. Some of such agents and their effect on human body are as follows:

Cadmium: About 70,000 employees in the construction industry have been exposed to Cadmium which is used as a rust-preventive coating on steel and as an alloying element. The acute exposures of cadmium can produce severe lung irritation, pulmonary edema, and even there is chance of death. Its long-term exposure can result in emphysema and can damage the kidneys. (OSHA)

Zinc: Used in the manufacture of brass, galvanized metals, and various other alloys. In the process of welding or cutting zinc-coated metals there is a possibility of inhalation of fumes which can cause metal fume fever.

Beryllium: Beryllium is largely used as an alloying element with copper and other base metals. Its acute exposure can result in chemical pneumonia and its long-term exposure can result in shortness of breath, chronic cough, and significant weight loss, accompanied with fatigue and general weakness.

Iron Oxide: Iron is the principal alloying element in steel manufacture. Construction workers are often exposed to iron oxide toxic fumes arise from both the base metal and the electrode during the welding process. The primary acute effect of this exposure is irritation of nasal passages, throat, and lungs.

Mercury: Compounds used to coat metals to prevent rust or inhibit foliage growth (marine paints). Mercury vapors produced under the intense heat of the arc or gas flame. The exposure of which may produce stomach pain, diarrhoea, kidney damage, or respiratory failure while its long-term exposure may produce tremors, emotional instability, and hearing damage.

Lead: Lead oxide fumes generate in the process of welding and cutting of lead-bearing alloys or metals whose surfaces have been painted with lead-based paint. Lead adversely affects the brain, central nervous system, circulatory system, reproductive system, kidneys, and muscles. Its Inhalation and ingestion can cause lead poisoning.

Fluorides: Several types of fluxes used in welding are coated with fluoride compounds. Construction workers often exposed to these fluxes which may irritate the eyes, nose, and throat. Repeated exposure in air over a long period may cause pulmonary edema (fluid in the lungs) and bone damage.

Chlorinated Hydrocarbon Solvents: Various chlorinated hydrocarbons are used in degreasing or other cleaning operations in construction activities. In welding and cutting operation the heat and ultraviolet radiation from the arc may decompose the vapors and form highly toxic and irritating phosgene gas.

Phosgene: The proximity of chlorinated solvents with welding operation result in formation of phosgene formed by decomposition of chlorinated hydrocarbon solvents by ultraviolet radiation. It reacts with moisture in the lungs to produce hydrogen chloride, which in turn destroys lung tissue

Carbon Monoxide : The incomplete combustion of various fuels result in formation of Carbon Monoxide. Welding and cutting on site also produce significant amounts of carbon monoxide. In addition, welding operations that use carbon dioxide as the inert gas shield may produce hazardous chemical concentrations of carbon monoxide in poorly ventilated areas caused by a "breakdown" of shielding gas.

Ozone: Ozone (O3) is produced by ultraviolet light from the welding arc. Gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc), and plasma arc cutting produce Ozone in greater quantities . Ozone is a highly active form of oxygen and can cause irritation to all mucous membranes. Both nitrogen dioxide and ozone may have long-term effects on the lungs.

Nitrogen Oxides: The ultraviolet light of the arc can produce nitrogen oxides (NO, NO2), from the nitrogen (N) and oxygen (O2) in the air. Nitrogen oxides are produced by gas metal arc welding (GMAW or short-arc), gas tungsten arc welding (GTAW or heli-arc), and plasma arc cutting. Its high concentrations can cause shortness of breath, chest pain, and fluid in the lungs (pulmonary edema).

Workers in construction sites have to work with various chemicals such as solvents, resins, glues, pesticides, cement. In the presence of cement there is a great possibility of occurrence of chemical hazards. In loading unloading of cement dust can get stuck everywhere and in contact with water or sweat can cause chemical burns.

Woodwork: Wood is largely used in various forms in building construction. In woodwork chemicals are used during various operations, such as wood machining, treatment and gluing. It has been observed that the accidents occur during preventive treatment of wood, near dipping tanks or spray devices, wood gluing, near roll or curtain spreaders (glue, formol). The chemicals which are used are as follows:

- **Chlorinated pesticides:** phenol, lindane
- **Solvents:** ethylic, butylic, acetone, perchloroethylene, trichloroethylene, polyvinyl chloride, tetrahydrofuran
- **Glues:** resorcine, neoprene, phenolic, amine hardeners, formol, formaldehyde

Terracing: Terraces are required to be made waterproof which need adequate measures for terrace sealing which generally done with use of chemicals. Inadequate handling and of such chemical may adversely affect for example if cold coating is applied using solvents and thinners (toluene, xylene) may prove disastrous.

Insulation: For Insulation various products are used such as urea formaldehyde resin, polyurethane resin, chlorinated solvents, neoprene glues, glues and resins, binders, pigments etc. The risk to uman health occurs when Urea formaldehyde foam is used with one component containing an acid hardening solution (phosphoric acid or hydrochloric acid). There is also a splash hazard during equipment cleaning, especially using chlorinated solvents.

Painting : Painting is another important activity which involve large scale use of chemicals for surface preparation as well as painting process. Various chemical which are used are as follows:

- **Alkaline paint removers:** sodium carbonate, calcium carbonate, caustic soda, potash.
- **Chlorinated solvents:** perchloroethylene, trichloroethylene, acetone, methylene chloride, etc…

- **Thinners:** butylglycol, ethylglycol, methylglycol, acetate, etc…
- **Resins:** polyols, amines
- **Mineral pigments**

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Use of lyes, solvents and alkaline strippers pose risk to workers there are also risks during cleaning of old paint, metal part degreasing, stopping and plastering (solvents).

In wall and floor covering Use of solvents and resin-based glues during plastic covering operation causes accidents.

Welding and Fabrication : Welding and metal fabrication presents both obvious and hidden issues of industrial hygiene. There are many safety issues beyond the obvious dangers of heat, molten metal, and the combustible gases in Oxy-acetylene welding and electrical dangers. Welding fumes contain noxious gases including ozone, nitrogen oxides and carbon monoxide which are harmful to human health. Exposure to the metals found in welding fumes like zinc, copper, magnesium and cadmium can cause frequent acute respiratory complaints.

VII. Prohibited Materials

The 'Red List' of materials that are not to be used in construction as specified by "The International Living Building Institute, a US-based sustainable building certification programme is presented in table1 :

Table1. Prohibited Materials

S.N.	Chemical	Use
1	Alkylphenol	Alkylphenols are a component in phenolic resins, but they can also be found in adhesives, paints and coatings and high performance rubber products
2	Asbestos	Used in various forms in roofing, partitions etc.
3	Bisphenol	Bisphenol A is used as a hardener in making polycarbonate plastics and epoxy resins. Common BPA products include water bottles, baby bottles, food storage containers, household electronics, plastic lenses and DVDs.
4	Cadmium	Most commonly used in the production of nickel-cadmium (Ni-Cd) rechargeable batteries and as a sacrificial corrosion-protection coating for iron and steel. Other uses include alloys, coatings (electroplating), solar cells, plastic stabilisers, and pigments.
5	Chlorinated Polyethylene (CPE)	CPE is a versatile material that when compounded with other materials, achieves different properties and products. It is widely used as a thermoplastic elastomer (TPE), rubber and modifier for resins (PVC, PE and ABS)
6	Chlorobenzene	Chlorobenzene's most high-profile application was in the production of the pesticide DDT. Modern uses are as a solvent in the manufacture of adhesives, paints, paint removers, polishes, dyes, and drugs.
7	Chlorofluorocarbons (CFCs)	CR is used mainly in the rubber industry but is also important as a raw material for adhesives and has different latex applications such as moulded foam, rubber sheeting, sound insulation and gaskets.
8	Chlorosulfonated polyethylene (CSPE)	CSPE's weatherability, UV stability and adhesion capability have made this material very popular as a commercial roofing material. Other applications include wire and cable sheathing and paint.
9	Formaldehyde	Formaldehyde is used in a wide spectrum of products. In construction, formaldehyde is still widely used as a binder in insulation products as well as commonly as an adhesive in wood panel products.
10	Halogenated flame retardants	Flame retardants (FR) are compounds that when added to manufactured materials, such as plastics and textiles, and surface finishes and coatings that inhibit, suppress, or delay the production of flames to prevent the spread of fire.
11	Lead	Lead comes with a long history of use, but in recent times we have become aware of its potential to render harm to humans. However, it still plays a role in the construction industry, primarily in roofing applications.
12	Mercury	Though previously applied to a wide spectrum of products and processes, mercury's toxicity has become highly restrictive of general useage.
13	Perfluorinated Compounds (PFCs)	PFCs are used to make stain, heat and water-resistant products including fire protection agents, floor polishes and paints. They are also used to manufacture non-stick coatings.
14	Polychlorinated Biphenyls (PCBs)	PCBs are synthetic organic chemicals that were manufactured for use in various industrial and commercial applications - including oil in electrical and hydraulic equipment, and plasticisers in paints, plastics and rubber products. Useage has become severley restricted in recent years.
15	Polyvinyl chloride (PVC)	Such is the height of the PVC industry's economic profile, that critiicism from GreenPeace and others has provoked the producers of PVC into a series of intense and acrimonius confrontations
16	Polyvinylidene Chloride (PVDC)	Polyvinylidene Chloride is synthesised from ethylene dichloride. Introduced by DOW Chemicals in 1939, the PVDC monomer is used in the manufacture of barrier coatings, fibres and plastics.
17	Pthalates	Phthalates are esters of phthalic acid and are most commonly found in plastics, and primarily, in PVC as plasticisers to increase their flexibility, transparency, durability and longevity.

Source: https://en.wikipedia.org/wiki/**Red_List**_building_**materials**

VIII. Diseases Resulting From Chemical Hazards

Chemical hazards stem from smoke, fog, vapour and odour which are communicated by air. Chemicals affect human body via inhaling or dermal contact (organic solvents and pesticides). A large number of liquid-semi-liquid chemicals like glue, gum, adhesive, asphalt, tar and cement powder which are largely used in construction sites are dangerous to the workers as they may cause diseases some of which are as follows:

- **Silicosis:** It is a disease caused by inhaling tiny bits of silica and contact. It is seen among workers who blende sand, use rock drilling machines and dig a tunnel.
- **Asbestosis:** It is a lung disease caused by inhaling asbestos fibres. It is often seen among workers who work with asbestos.
- **Bronchitis:** It is common among welders.
- **Skin allergies:** It is widespread among workers and masons working with cement.
- **Neurological (nervous system) disorders**: It is seen among workers and painters who work with organic solvents and leads.
- **Lung cancer:** It is mostly observed among workers working with asbestos particularly for roofing, workers of woodwork and welders.
- **Lead poisoning:** It is seen among workers working for bridge repair and painters.

IX. Prevention Of Chemical Hazards :

Research suggests that both psychological and social factors are important in determining the way people perceive and respond to risks (Fischoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, 1987; Rayner, 1992; Douglas & Wildavsky, 1982). Perceptions and understandings of risk are important influences on the conceptualization of risk control strategies (Tesh, 1981). Risk management is defined as a threestaged process (Ridley, 1990; Viner, 1996). First, hazards in the work environment are identified; second, the risk posed by these hazards is assessed; and finally, appropriate controls for risks are selected according to a risk control hierarchy (Mathews, 1993). For reducing construction site related chemical hazards it is important to control exposures to chemicals and toxic substances. A hierarchy of controls is used as a means of determining how to implement feasible and effective controls. Prevention process include four steps as shown in fig.3

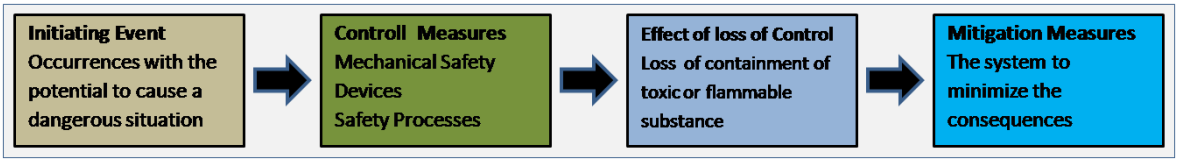

Fig.3

OSHA's longstanding policy engineering and work practice controls are the primary means used to reduce workers exposure to toxic chemicals, as far as feasible, and that respiratory protection is required to be used when engineering or work practice controls are infeasible or while they are being implemented. Where possible, elimination or substitution is the most desirable followed by engineering controls. Administrative or work practice controls may be appropriate in some cases where engineering controls cannot be implemented or when different procedures are needed after implementation of the new engineering controls. Personal protection equipment is the least desirable but may still be effective.

X. Conclusion

The belief that accidents are caused and can be prevented makes it imperative to consider those factors which are likely to favour the occurrence of accidents. By studying and analyzing such factors, the root causes of accidents can be isolated and necessary steps can be taken to prevent the recurrence of the accidents. These root causes of accidents can be grouped as "immediate" and "contributing". The immediate causes are unsafe acts of the worker and unsafe working conditions. The contributing causes could be management-related factors, the environment and the physical and mental condition of the worker. As per Buildings are likely to be affected by number of hazards like fire settlement, internal or external explosion caused by gas, petrol vapour or sabotage differential movement or conditions of elastic instability for which they are not designed (Blake 1989) In construction industry particularly on projects sites workers are very often prone to accidents associated with their work because of inadequate safety provisions. The major health hazards with reference to construction sector may be Physical, Chemical, Mechanical, Ergonomic and Psychological hazards. Amongst them Chemical hazards are extremely dangerous for human because of their long term effect and frequency of occurrence.

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