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A Study of Human Factors and Risk Related To the Construction Industry

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ABSTRACT: *The purpose of this project is to overview the ergonomics risk factors in construction industry. The study will include the ergonomics risk factors in relation of human and their nature of work. Various organized and unorganized behaviours in construction are studied. Construction industry is one of the important occupants under the unorganized sector. Safety and comfort is always an issue in construction sites. Various ergonomics risk factors affecting adversely on workers. The objective is to list out all the major ergonomic factors and prioritize them based on its severity and consequences. To accomplish that, Likert scale questionnaire is prepared for the survey work and FMEA (Failure Mode and Effect Analysis) methodology is chosen. Failure mode and effect analysis (FMEA) is a step-by step approach for identifying various potential failure modes and estimating their corresponding failure effects. Followed by FMEA, Risk Priority Number (RPN) is computed for prioritizing the factors. Actions will be taken according to the priority given to the failure. Analyse the various ergonomics risk factor based on its priority and give a result based on the analysis.*

***Keywords*:** Ergonomics, Construction, Risk, Factor, Priority, Workers.

I. INTRODUCTION

Introduction to Informal Sectors

It is well known that a major part of the workforce in India and other developing countries work in informal sector. Informal sector has become an increasingly popular subject of study, not just in economics, but also in sociology and anthropology. Keith Hart was the first person to introduce the term "Informal Sector . The ILO evolved a conceptual framework and guidelines for the collection of statistics on informal sector and presented the same in the Fifteenth International Conference of Labor Statisticians (ICLS) held in February, 1993 in the form of a resolution. In India, the different organizations like National Sample Survey Organization (NSSO), Directorate General of Employment and Training (DGET), National Commission for Enterprises in the Unorganized Sector (NCEUS) set-up a definitions of informal/unorganized sector employment and informal/unorganized employment.

TABLE-1
Industry-wise growth rate of unorganized workforce in India

INDUSTRY	1983 to 1987-88	1987to 1993-94	1983 to 1994	1993-94 to 1999-2000
Agriculture, hunting, forestry and fishing	.65	2.14	1.5	.02
Mining and quarrying	11.29	3.74	6.1	-4.56
Manufacturing	3.42	1.86	2.53	2.17
Electricity, gas and water.	38.1	4.18	17.6	-9.05
Construction				

	16.58	-.05	6.76	8.32
Trade, hotels and restaurants	4.72	3.49	4.02	7.45
Transport, storage and communication	5.01	4.63	4.79	8.93
Other services	5.57	5.98	5.81	-1.98

Type of industrial sector

[1] Organized sector: Organized sector is a sector which has its own fixed rules, safe operational procedures and Policies. Example: Manufacturing industry

[2] Unorganized sector: Unorganized sector there are no health and safety regulations and policies for the workers.

Unorganized/Informal sector: The unorganized sector consists of all unincorporated private enterprises owned by individuals or households engaged in the sale and production of goods and services operated on a proprietary or partnership basis and with less than ten total workers.

Unorganized/Informal employment: Unorganized workers consist of those working in the unorganized enterprises or households, excluding regular workers with social security Benefits, and the workers in the formal sector without any employment/ social security benefits provided by the employers.

In India, about 93% of the workers working in unorganized sector, it has been made by the National Commission for Enterprises in the Unorganized Sector (NCEUS). About 44% of all unorganized urban workers now work for India's booming construction industry Example: Construction site and agriculture field.

II. CONSTRUCTION SECTOR

Construction Industry is an unorganized sector and it is the least researched industries even today. The system of reporting data about internal working and safety is also minimal. The manpower driven industry is facing regular accidents in daily working, which cause heavy losses in terms of men, money and time. The Construction sector in India is the second largest economic activity after agriculture and provides employment to about 33 million people. The Construction sector has strong linkages with various industries such as cement, steel, chemicals, paints, tiles, fixtures and fittings. In India, nearly two-thirds of the contribution to the net domestic product is by the unorganized sector. The largest numbers of informal workers are in agriculture. In fact, 98.84 percent of the employment in agriculture is informal. Other than agricultural sector, the highest numbers of informal employees are in retail trade, construction, land transport, textiles etc.

Construction workers:

A large portion of construction workers are unskilled labourers. They perform a variety of jobs. Each of these jobs has unique risks, sometimes these jobs are deadly.

ERGONOMICS RISK FACTORS RELATED TO CONSTRUCTION INDUSTRY:

Ergonomics is the study of improving the fit between the worker and the physical demands of the workplace. Ergonomics can be used to reduce injuries, improve productivity and reduce the costs of doing business. The construction industry suffers from debilitating and costly occupational injuries primarily to workers backs, necks, shoulders, hands and arms. These types of injuries or traumas are commonly called repetitive motion injuries (RMIs) and are caused by activities that are repeated on a regular basis. Symptoms of RMIs may include chronic pain, numbness, tingling, weakness and limited range of motion. RMI symptoms may not be noticeable for months or even years after exposures or may appear to be acute after a sudden and severe onset.

The Ergonomics Risk Factors (ERF) are listed below:
[1] Awkward Posture
[2] Force
[3] Repetition
[4] Vibration
[5] Static Loading
[6] Contact Stress
[7] Extreme temperature

Awkward Posture

Posture refers to the position of different parts of your body. Muscles, tendons, and ligaments must work harder and can be stressed when you are in an awkward posture. Awkward posture occurs when any joint of your body bends or twists excessively, outside a comfortable range of motion .Various work activities can result in awkward postures:
[1] Leaning sideways, such as when reaching into a low drawer to one side (awkward back posture)
[2] Bending down to work at a low level (awkward back posture)
[3] Reaching overhead (awkward shoulder posture)
[4] "Flaring" the elbows out to the side (awkward shoulder posture)
[5] Bending the wrist when moving objects or keyboarding (awkward wrist posture)
[6] Bending the neck down, such as looking at small components in poor lighting conditions (awkward Neck posture)
[7] Twisting part of the body, such as twisting the neck to view documents while keyboarding for a Long time (awkward neck posture)

Force

Force is the mechanical or physical effort to accomplish a specific movement or exertion. Force can be defined as the amount of physical effort required to perform a task (such as lifting) or to maintain control of equipment or tools. Exerting a force on a person or object may overload our muscles and tendons. The force may come from gripping, lifting, pushing or pulling. The force that a worker exerts on an object is a primary risk factor. Muscles and tendons can be overloaded when you apply a strong force against an object. Holding a lighter object (such as a mouse) for long periods can also expose workers to a risk of MSI. There are three types of activity that require force such as force involved in lifting, lowering, or carrying, force involved in pushing or pulling and grip force. In other word, force is the amount of physical effort required by a person to do a task or maintain control of tools or equipment.The amount of force depends on the type of grip, the weight of an object, body posture, the type of activity and the duration of the task. The amount of force required by an activity can sometimes be magnified causing even more muscular fatigue.

Repetition

Repetition rate is defined as the average number of movements or exertions performed by a joint or a body link within a unit of time or performing similar motions with the same body part with little rest or recovery. Repetition could also be defined as performing the same motion or group of motions excessively. Repetition involves doing a task that uses the same muscles over and over with little chance for rest or recovery. Repetition also is the time quantification of a similar exertion performed during a task.eg. A warehouse worker may lift and place on the floor three boxes per minute; an assembly worker may produce 20 units per hour. Repetitive motion has been associated with injury and worker discomfort. Generally, the greater the number of repetitions, the greater the degree of risk. However, the relationship between repetition and degree of injury risk is modified by other risk factors such as force, posture, duration, and recovery time.

Vibration

Vibrations occur when an object oscillates or rapidly moves back and forth about its stationary point, like a swinging pendulum. Vibrations are defined by the frequency (how fast the object is moving) and the magnitude or amplitude (the distance of the movement). Vibration may be defined simply as any movement which a body makes about a fixed point. This movement can be regular, like the motion of a weight on the end of a spring, or it can be random. Vibration has been found to be an etiological factor in work environments

utilizing tools vibrating in the frequency band of 20 to 80 Hz. For example, use of a chain saw or powered wood working tools for extended periods of time.
Vibration applied to the hand can cause a vascular insufficiency of the hands/fingers (Raynaud's disease or

vibration white finger

[1] Hand-arm vibration (HAV) is typically associated with operating power tools. Exposure occurs when the tool vibrations are transmitted to the hand and arm.
[2] Whole-body vibration (WBV) is typically associated with standing or sitting on a vibrating surface.
[3] WBV exposure occurs when vibrations are transmitted usually through the feet if standing, or the legs and hips if seated. WBV can affect the entire body, including internal organs. Exposure of the whole body to vibration (usually through the feet/buttocks when riding in a vehicle) has some support as a risk for injury.

Static Loading

Our body is built to move about, not to remain still. It is uncomfortable and tiresome having to maintain body position without change over extended periods. We experience this discomfort while driving a motor vehicle where the location of the trunk on the seat, of the head in order to see, and of the hands and feet on controls constrains us to a nearly immobile posture. Although define in a variety of ways, static loading generally means the performance of a task from one postural position for an extended duration. The condition is a combination of force, posture, and duration. The degree of risk is in proportion to the combination of the magnitude of the external resistance, awkwardness of the posture, and duration.

Contact Stress

Contact stresses are defined as impingement or injury by hard, sharp objects, equipment or instruments when grasping, balancing or manipulating. Contact stresses are encountered when working with forearms or wrists against the edge of a desk or work counter. The muscles and tendons are impinged when pressed into the sharp edge. Using the hand as a hammer to close a lid securely also creates mechanical stresses, especially if the lid has raised surfaces or sharp edges. Local contact stress occurs when a hard or sharp object comes in contact with the skin. The nerves and the tissues beneath the skin can be injured by the pressure. Here are some examples of activities that can result in local contact stress:

[1] Ridges and hard edges on tool handles digging into the hand
[2] Edges of work surfaces digging into the forearm or wrist
[3] Striking objects sharply with the hand, foot, or knee (such as striking the carpet stretcher with the area above the knee when laying carpet)

The effects of local contact stress can be made worse if the hard object contacts an area without much protective tissue, such as the wrist, palm, or fingers and also when pressure is applied repeatedly or held for a long time.

Extreme Temperature

Extreme temperature can be classified into two that are extremely cold and extremely hot. Cold temperature can be define as a low temperature reduces manual dexterity and accentuate the symptoms of nerve-end impairment. Cold stress is the exposure of the body to cold such that there is a lowering of the body's deep core temperature. Systemic symptoms that a worker can present when exposed to cold include shivering, clouded consciousness, extremity pain, dilated pupils, and ventricular fibrillation. Heat stress is the total load the body must accommodate. It is generated externally from environment temperature and internally from human metabolism. Excessive heat can cause heat stroke, a condition that can be life threatening or result in irreversible damage. However, in Malaysia there is only hot weather and the construction sites workers only expose to hot temperature.

Hazards in the construction occupation

The following below is a list of hazards in the construction occupation

- Hazards from scaffolds.
- Power access equipment.
- Ladder hazard.

- Roof work hazard.
- Manual handling.
- Plant and machinery.
- Excavations.
- Lifting and body straining.
- Fire and emergency.
- Hazardous substance.
- Noise.
- Without use of protective clothing.
- Hazard to general public.
- Unsafe working area.

TABLE-II
Human illness with construction worker

Occupations	**Hazards**
Brick masons	Awkward postures and heavy loads
Stonemasons	Awkward postures and heavy loads
Hard tile setters	Awkward postures
Carpenters	Heavy loads, Repetitive motion
Drywall installers	Walking, heavy loads, awkward postures.
Electricians	Heavy loads, awkward postures, asbestos dust.
Electrical power installers and repairers	Heavy metals in solder fumes, heavy loads, asbestos dust.
Painters	Solvent vapours.
Paperhangers	Awkward postures
Plasterers	Dermatitis, awkward postures
Plumbers	Lead fumes and particles
Pipefitters	Lead fumes and particle, welding fumes.
Steamfitters	Welding fumes, asbestos dust
Carpet layers	Knee trauma, awkward postures, glue and glue vapour.
Soft tile fitters	Bonding agents
Concrete and terrazzo finishers	Awkward postures
Glaciers	Awkward posture
Insulation workers	Asbestos, synthetic fibres, awkward postures
Surfacing equipment operators	Gasoline and diesel engine exhaust
Roofers	Roofing tar, heat, working at height
Sheet metal installers	Awkward postures, heavy load, noise
Wielders	Welding emissions.
Solders	Metal fumes, lead, cadmium.
Drillers	Silica dust, whole-body vibration
Hammer operator	Noise, whole body vibration.
Pile drivers	Noise, whole body vibration
Hoist and winch operators	Noise, lubricating oil.
Crane tower operators	Stress, isolation
Excavating and loading machine operators	Silica dust, heat stress, noise, whole body vibration.

Grader and scraper workers	Silica dust, stress, noise, whole body vibration
Steel construction workers	Asphalt emissions, heat.
Truck and tractor	Whole body vibration
Demolition workers	Asbestos, lead, dust, noise
Hazardous waste workers	Heat, stress

III. RISK PRIORITY NUMBER

RPN is a measure of the risk of failures; it can be used to rank failures and to prioritize actions. Actions will be taken according to the priority given to the failure that is ranked by RPN. On the basis of risk priority numbers calculated from occurrence, severity and detection of potential risks are graded and their levels of acceptability are determined. An important index in the FMEA is Risk Priority Number (RPN), which is the product .of occurrence (O), severity (S) and detection (D) ratings as shown in equation

RPN = S*O*D

[1] Severity

[2] S is the "severity", an assessment of the seriousness of the effect of the potential failure mode. Determine all failure modes based on the functional requirements and their effects. Severity rating: It is depend on the rank the seriousness of the effect of the potential failures.

[3] The severity score (S) is an integer between 1 and 10, where the most severe is a 10

[4] Occurrence

[5] Where O is the "occurrence of failure" indicating the probability that the failure mode will occur as a result of a specific cause. In this, it is necessary to look at the cause of a failure and how many times it occurs. All the potential causes for a failure mode should be identified and documented.

[6] Occurrence rating: It is depend on the estimation of the frequency for a potential cause of failures. The probability score (P) is an integer between 1 and 10, where the highest probability is a 10.

[7] Detection

[8] Where "D is the probability that a potential failure will be detected. It rates the likelihood that the problem will be detected before it reaches the end-user/customer.

[9] Detection rating: It is depend on the likelihood of the process control to detect a specific root cause of a failure. The detectability score (D) is an integer between 1 and 10 where most difficult to detect is a 10.

[10] Likert scale

[11] A Likert scale is a psychometric scale commonly involved in research that employs questionnaire. it is the most widely used approach to scaling responses in survey research, such that the term is often used interchangeably with rating scale or more accurately the Likert-type scale.The scale is name after its inventor, physiologist Rensis Likert. Likert scale is bipolar scaling method, measuring either positive or negative response to a statement.

IV. CONCLUSION

The construction industry has more possibility of accident than any other industries, and when the accident occurs, it can cause serious and deadly damage. The accident is repetitive, occurring at same progress of work. Therefore, it is necessary that a system is to be formulated which prevents and manages the accident in advance, and it requires scientific and formulated safety management system, for that assessment of risk is important in construction sector. And it is also important to analyse the various ergonomics factors. For finding out these important factors a questionnaire on Likert scale is being made. The work was completed by taking a survey using the questionnaires in the construction company and the hazard factors are identified and prioritized. Analysis is carried out by using SPSS software. From analysis, the result is to minimizing the ergonomics risk factor or hazardous work in the construction industries.

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