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Review Article

Occupational Physical Stress Faced by Construction Workers & Painters and Improvement of their Work Activity; a Literature Review -

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ABSTRACT

Studies related to chemical exposure and organ cancer have been carried out with regards to construction workers across the countries. However, few studies include occupational physical stress faced by construction painters in finishing task. Similarly, a handful deals with product design and tool design that can be used to alleviate their occupational stress. The paper includes literature review of occupational stress experienced by construction workers, improvement of work quality, musculoskeletal disorders experienced by construction workers, health issues faced by construction painters, design interventions which include tools and equipment) and patents of products and tools designed for construction painters. Multiple combinations of keywords were used which comprised of; construction, physical stress, Musculoskeletal Disorders (MSDs), ergonomics, painter, worker, high-rise buildings. Several authors have focused on studies related to health issues which deals with effects of noise and fumes on the health of construction workers while others have discussed automation, and few have carried out experimental studies that consist of task analysis, impact of temperature & height on the occupational performance and health of the industrial and construction workers. The article will provide insightful information for medical practitioners, safety & health consultants and industrial designers alike.

Keywords: Construction; Equipment; Musculoskeletal disorders; Painters

ABBREVIATIONS

COPD: Chronic Pulmonary Disease; CWFIS: Construction Workers Federation of India; DOE: Design of Experiments; FEM: Finite Element Method; KPMG: Klynveld Peat Marwick Goerdeler; MSD: Musculo Skeletal Disorder; NSDC: National Skill Development Corporation; OSHA: Occupational Safety and Health Administration; TAMIR: Technion Autonomous Multipurpose Interior Robot; WEP: Water Based Paint

INTRODUCTION

Unskilled construction workers constitute 83.3% of the total construction manpower [1]. Construction workers face injuries, health issues and suffer death due to various reasons. Apart from exposure to solvents and chemicals in the paint mixing and application, painters experience musculoskeletal disorders in various regions of their body. Studies related to chemical exposure and organ cancer have been done with regards to construction workers across the countries. However, very few studies have been conducted on product designing of better tools and equipment that can alleviate the musculoskeletal disorders and increase efficiency as well. Workers who are employed by standalone contractors are high in number. There are about 120000 such contractors in the country [1]. 32 million workers are engaged in Construction activities in India. Out of these 22.2 million workers are not registered workers. Out of 15.2 million short-duration out-migrant workers, 36.2 % are employed in construction sector. Construction workers' job and social security is at a threat from companies in both private as well as public sector. Every year in public sector, the number of permanent workers is decreasing including the technicians, engineers and architects.

To understand efficiency, comfort of the painters needs to be studied. With rise in construction activity in India since last fifteen years, need of the informal unskilled workers have risen immensely. By 2022 there will be about one million construction and maintenance finishing workers employed in India (figure 1).

Painting is a part of finishing process. Due to weathering and washing of exterior paint due to constant exposure to rain and varied temperatures, the old construction need maintenance painting every five years. Therefore, the painting work is rather a continuous process which is carried all through the life of a building. The demand of painters and need to thus solve issues faced by the work force is significant to contribute to efficiency and productivity of the workers. The following content of the article deals with occupational stress and design interventions that have been carried out to improve the task of



construction and maintenance painters.

CONSTRUCTION ACTIVITY

Construction activity consists of various actions and processes. Some of these processes fall under the two heads; site preparation and site operations [2]. A construction project consists of various steps and processes. Each following the other and few are carried out simultaneously. Broadly a project starts with project brief which is more about planning and design followed by detailing and certain decisions pertaining to electrical, plumbing, HVAC (Heating Ventilation and Air conditioning), finishing, site design and detailing, marketing and sales and so on. The work is either in house or is done with outside contracts with contractors and consultants. Depending on the different processes and the capability of the firm to handle the tasks, the firm uses in house team or collaborates with other firms and consultants to carry out the different stages of construction and finishing.

Rise in population of construction workers

As indicated in the figure 2, there is a steady rise in the unskilled workers from 1995 to 2004. However, 2005 onwards the rate of increase has gone up. This was the time when construction activity in India had experienced a sharp rise and supply of construction projects was suddenly high due to increase in economic activity in the commercial and industrial systems.

The tasks of completing and completing construction works is predicted to be more than the other stages of activities that are part of a building construction activity. Therefore, demand of completion and finishing workers will increase over the next five years (figure 3).

Thus need to study the occupation health& safety becomes



Figure 2: Rise in population of Unskilled and skilled construction workers. Construction manpower by trades in civic and social infrastructure sector. Persons in thousands (cwfigs.org).

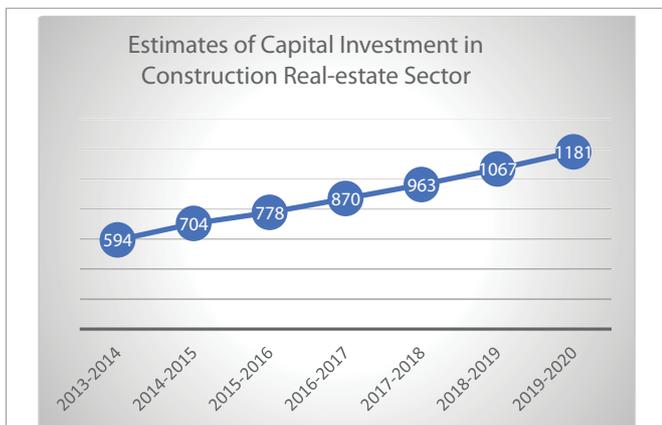


Figure 3: Estimate of capital investment (in billion US\$) in construction in India. Data source: report by National Skill Development Corporation, (2007) on Human Resource and skill requirement in building, construction real-estate sector in India.

essential for the efficiency of the workers engaged in completion and finishing of buildings. Construction workers experience several issues due to nature of their work, task performance with their equipment, safety issues, social and peer issues, exposure to chemicals and pollutants among others.

Issues faced by construction workers

Construction labour form around 7.8% of the world labour force. The fatal deaths of construction workers account to 16.4% of the total deaths across the globe [2]. After agriculture, construction is the second largest economic activity in India. The maximum number of deaths are resulted by falls followed by electrocution and then by fire. Any construction project includes preparation of site, building of sub-structure, superstructure and followed by finishing. These steps of building construction can be further integrated into smaller processes and sequences depending on the architectural design and chosen manufacturing process. Plastering, Painting, landscaping, electrical fittings and fixtures, paving is some of the activities that follow completion of the super structure of a building. The status of construction workers is largely uncertain as they consist mostly of

informal workforce. Most processes in the construction processes employ unskilled workers on large scale. As less number of studies have been done on construction workers and their occupational issues, the health and safety of the workers has been neglected. Issue faced by construction workers.

RELATIONSHIP OF WORKER WITH WORK AND WORKSTATION

Workers perform with their tools and equipment. The workstation and the immediate exterior activity area is the workstation of a construction worker. For construction finishers and painters, the job includes gathering teammates, expected extent of the surface to be painted, making of the paint mixture, procurement of harness and helmet, extension poles/sticks, material to fix one end of rope or support at the roof, smaller bucket to refill with paint mixture, rough cloth and brushes. His personal belongs which the painter and cleaner wears on himself includes, his attire, cell phone, lighter and bidi or cigarette, tobacco and calcium paste. Figure 04 shows interrelationship between a worker, work (task) and workstation (workspace) [3].

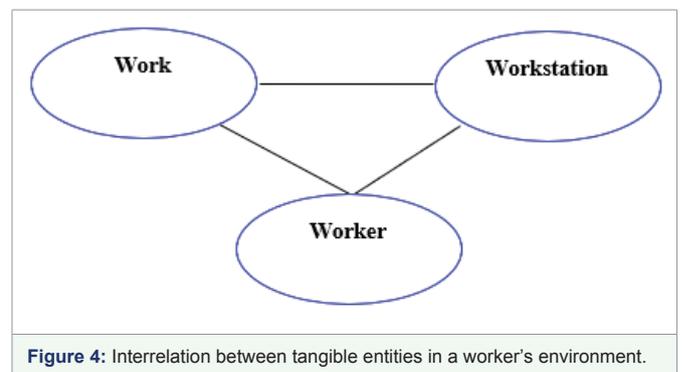


Figure 4: Interrelation between tangible entities in a worker's environment.

Worker performs the task in a specific space which is affected by surrounding physical, social and environmental factors. Work on the other hand is the task which is a defined set of actions that are carried out with the help of tools and equipment and required interaction with the environment, peers and cognitive abilities. Workspace is the area in which the task is performed which sometimes constitute to a portion of the task as well as is evident in case of construction painting task where the wall surface and whole access on scaffolding becomes the workspace.

The health hazards a painter experiences are of varying nature. There are risks of falling from the hanging rope, slipping from the scaffolding, ill functioning of the harness resulting in fall of the painters, maintaining balance and falling off, movement in precarious positions and postures resulting in loss of balance, muscle strain, breathing disorders due to inhalation of powder paint and fumes. Stressful weather conditions, conflict with peers and supervisor leading to mental stress. Such issues are pertinent to occupational efficiency and wellbeing of the building painters. Thus, to understand wellbeing of construction workers, it is important to closely review the role of tools and equipment which directly affects their work at hand at a given time.

LITERATURE REVIEW

Construction activities on site require workers to move arms

Table 1: Issues faced by construction painting workers.

Issues faced by construction workers in construction and painting task		
References		
[9-25]	<p>Construction and Maintenance Painters.</p> <p>Relationship between exposure, duration and frequency to mixed solvent, Similar effect with frequency and duration.</p> <p>Asthma, Chronic Bronchitis, No relation with Rhinitis and Conjunctivitis.</p> <p>Painters with 1-10 years experience has threefold risk of asthma than carpenters.</p> <p>Painting task related to COPD(Chronic Obstructive Pulmonary Disease).</p> <p>Dust and other impurities in ambient air affects respiratory health.</p> <p>Epoxy and Urethane has been less used in construction painting.</p> <p>Studies on respiratory health are rare in construction industry compared to others.</p> <p>Exposure to irritative and allergic substances.</p> <p>Water based paints (WBP) have replaced Solvent based paints.</p> <p>Skin disease, contact sensitivity, Neuropsychiatric disabilities- Moodiness, memory loss, slow response, decision making ability.</p>	<ul style="list-style-type: none"> • Solvent related health issues • Respiratory • Skin diseases • Contact sensitivity using water paint, glue, paints and putties • Long term exposure to fumes and solvents • Neurobehavioral and health related deficits • Bladder Cancer • Neurotoxicity • Skin Disease • Solvent mixture affects neuro-behaviour • Effects of chronic exposure to lead and solvents • Self -reported Asthma and bronchial hyperresponsiveness and lung function • Asthmatic symptoms and atopy among painters • Pharynx cancer and Oral cavity cancer • Haematological changes, respiratory symptoms • Respirator use • Attention and memory efficiency • Hand dermatitis • Solvent exposure index • Bladder cancer • Exposure to volatile organic compound • Behaviour aspect of solvent exposure • Cytogenic (how chromosomes relate to cell behaviour) damage
[26-35]	<p>Photocatalytic degradation of organic paint, Moss, Bacteria, soot and mould</p>	<ul style="list-style-type: none"> • Risk of accumulation of carbonyls in interior environment. • Low emitting photocatalytic material to be used in indoor painting and surfaces. • Photocatalytic material in surface coatings affects indoor air quality and air pollutants. • Use of photocatalytic material provides self-cleaning surface and mitigates pollutants • Nitrogen oxides can be removed effectively by use of photocatalytic materials in cement. • Efficiency of photocatalytic material is evident by the level of adsorption of the contaminants onto the active sites of cement toluene oxide composites.
[36,37]	<p>Lead in exterior wall paints, tap water, walls of old houses, ceramic cookware, house dust.</p>	<ul style="list-style-type: none"> • Lead content is highest in existing but earlier painted structures and parts including metallic structures, telephone kiosks, railings, yellow road line paints, public play grounds, playground and outdoor work out frames and members. • Old construction housing paints constitutes of lead. • Household tap water, old furniture, dust, ceramic cookware contained lead. • 20th century studies on children in United States resulted in highlighting lead related illnesses as the largest and longest running epidemic in the country.
[3], [38-41]	<p>Work related physical stress affects wellbeing of construction workers. Emergent properties give be used as one entity to be used for new inventions.</p> <p>Jugaad or make do innovations are more prevalent at local level of workers.</p> <p>User Centred design can be effectively used to design products of common use.</p> <p>Scope of ambidexterity is improved with proper job design of construction workers.</p>	<ul style="list-style-type: none"> • High productivity is supported by comfortable setup of work and workstation. • New innovations are possible by using existing knowledge of physicval world. • Painters use jugaad objects (make do innovations) like mild steel sheet and vegetable cutting pads. • User centred design interventions will be useful to solve the tool interaction issues similar to how butter separator tool discussed in the paper. • Finishing construction workers will have better opportunities when equipped with better job design and proper equipment
[42]	<p>MS (Multiple Sclerosis), BMI (Brain-Machine-Interface), HRQoL (Health Related Quality of Life)</p>	<ul style="list-style-type: none"> • BMI is proposed to significantly affect HRQoL of constructions workers suffering from Multiple Sclerosis (MS)

[43]	Monitoring of health using pulse rate.	<ul style="list-style-type: none"> Semiautomated method that involves non contact way of measurement of heart rate. Amount of sunlight is crucial for better result of readings.
[4], [44-48]	Causes of discomfort and problem areas in the regions of body of construction workers (Indian workers & South African workers).	<ul style="list-style-type: none"> Areas of improvements are Workshops, Mechanization, Constructability, Design of Equipment, Reengineering. Discomfort in work posture experienced by workers (20-50 years of age) is mainly due to Repetitive, Awkward posture, Fixed Posture for long duration, Heavy load, No breaks.

Table 2: Literature review of studies conducted about automation of painting by robots.

Painting Task		
References		
[50-61]	Wall painting Robot	<ul style="list-style-type: none"> Spray Wall Painting Robot. Safety robots that guard building and used for maintenance and cleaning. Spray painting robot, explored on car bumper to test application on contour surface. Locomotion and Adhesion based robots for wall painting. Designed TAMIR (Technion Autonomous Multipurpose Interior Robot)- adaptation of mobile carriage, material feeding system, robot radius with arm radius of 1.5 m. Wall maintenance robot with guide rail. Most important aspect if workspace analysis, degrees of freedom, ease of programming and arm configuration. autonomous spray painting robot could paint walls of interior spaces of a building. designed a painting robot that could paint only ceilings of a room. designed a very heavy robot for construction sites that could do four tasks which are painting, plastering, tiling and masonry. designed spray painting robot which was again very heavy. very small and handy robot that crawl on walls.

above shoulder while carrying out activities of carrying heavy and awkward load or performing a task. Hence tasks and activities of construction is an issue in ergonomics [4]. Materials may also be heavy and inconveniently sized and shaped, thus presenting manual materials-handling problems to the workers. Moreover numerous construction tasks pose significant ergonomic risks to workers [5]. Several studies in the past have focused on manual construction workers however no study has been conducted so far on occupational issues faced by construction and maintenance painters.

Search method

Research papers available online at various web sites including Science Direct, PubMed, Google Scholar and ProQuest were searched using sets of keywords. In multiple combinations research papers were searched using the following keywords: ergonomics, external wall, painting, construction, painting, and worker, high-rise housing [6]. Various authors have thus found to have focused on studies related to health issues related to noise and fumes that are faced by construction workers in general. While some authors discussed automation in construction industry in the world, few have carried experimental studies in the areas of impact of temperature, height and task analysis. Since 1998 some ergonomic studies have been carried out in the sector of building construction [7]. However, there is observed a lack of task studies and analysis of workers that are employed in jobs of finishing, painting, scaffolding and shuttering fastening among others.

Literature review of studies on issues faced by construction workers in painting task

Area of research being Health, Hazards, Tools, equipment pertaining to job of construction painters, the papers so found were screened further. Literature Review of issues faced by construction workers across the research studies done from.

Issues faced by construction workers in construction and painting task

Construction painters suffer from solvent related health issues, respiratory disease and skin disease [8,9]. According to Fiddler, construction painters are observed to have contact sensitivity issues which are related to solvent exposure in paints. Contact sensitivity is associated with usage of paint, glue and putties. Solvents affect neuro-behaviour and causes arm weakness [9,10] found that construction painters who are exposed to chronic solvents suffer from neuropsychiatric symptoms. Though, conjunctivitis is not found related to painting task by asthma, rhinitis and bronchitis is related to painting task. Painters with experience of 1-10 years and long working history has three-fold higher risk of developing asthma than other construction workers [15,18]. Construction painters are susceptible to develop Chronic Obstructive Pulmonary Disease (COPD) [14]. However, since past two decades epoxy and urethane has been used less in construction painting [24]. Dust and other impurities at construction painting site affects respiratory health of construction painters [14,18,19]. Studies on respiratory effects in construction painters is less than on other trades [20]. Water based paints have replaced solvent based paints in recent decades and User-friendly, low-emitting photocatalytic materials in the indoor wall painting [15,24,26]. Photocatalytic paint in indoor wall paints reduce air pollution [27-29]. Photocatalytic titania based surfaces can improve environment [34]. Lead was used in old constructed buildings. Lead content is highest in railings, metallic structure, yellow paint on road dividers, public play grounds [36].

Besides natural landscape features that lie next to construction site, weather and physical onsite machinery, physical entities related to job of construction painters can be integrated into three basic entities. 1) Individual; the construction painter’s physical self which is involved in tasks of repeated movements and load bearing along with cognitive abilities employed in sensing precision and

hand feet coordination in reaching out. In doing so the body of the painters experience various stress at different parts which leads to Musculoskeletal Disorders. Different body parts suffer physical stress differently depending on the expected intensity of work. 2) Essentials entities specific to Construction painting; this consist of task design, tool and equipment, aids that help the painter in performing the painting task with less stress and fatigue and costume which is immediately on his self. Costume thus plays an important role in giving comfort of movements and easy stretch of arms and legs in reaching and twisting movements. 3) External supporting elements essential to construction painters: these are the infrastructure tools and structures that give physical support and aid to move up and down the building façade and carry his paint and other equipment around his workspace (workstation (figure 4)).

Wall painting robots

Finishing task of newly constructed building as well as maintenance of old buildings require painting work. Several studies have shown design interventions to automate the painting task. Such studies deals mainly with robots that paint a wall surface. Specifications and limitations of these designs are highlighted in table

Automation of wall painting by wall painting robots

Spray painting robot was designed in 2013 that can be used to paint interior walls of a buildings [50]. This prototype robot moves on floor surface. A safety robot was designed that can be used for maintenance and cleaning work as well as for inspection of the buildings [51]. Asakawa and Takeuchi worked on control commands for robot to function without special knowledge. The robot was used to paint car bumper to test the functioning of command on a contoured surface. The painting activity resulted in uniform thickness of the paint coating on the contour surface of the bumper [52]. Moon

and his team worked on locomotion and adhesion based robot that can be used for painting walls [53]. TAMIR (Technion Autonomous Multipurpose Interior Robot) was designed by adaptation of mobile carriage which had attached working tools and fitted material feeding system. It had a painting arm with a radius of 1.5 m [54]. Moon and his team again built a prototype robot that had built-in guide rail. Moon’s robot could work for maintenance of building [55]. Koleka and his team studied various robot structures and their respective workspaces. He suggested that the most important aspects of design of robots are degrees of freedom, ease of programming, work accuracy, character of workspace and arm configuration for apt movement and reach [56]. Another robot was designed in which the distance of the reach of wall surface is fed by supervising worker and once paint other materials are set the robot starts to paint the wall autonomously [57]. A painting robot was developed that could paint only ceilings of a room. The size was a limitation as it could not be moved through narrow door openings and other spaces in residential buildings [58]. A multifunctional robot was designed for construction sites that could do four tasks which are painting, plastering, tiling and masonry [59]. It had limitations that due to its heavy weight it cannot climb and was cumbersome to be transported at the painting spots inside the buildings. A couple of spray painting robots were designed which was again very heavy [60, 61].

Design of tools and equipment

Physical interaction of workers with their tools play an important role in providing comfort in carrying out their task easily. Physical comfort of good grip and unwanted body posture due to absence of correct tool and equipment thus affects physical health of the construction workers. Table 3 shows the studies that deals with design intervention related to tasks of manual construction workers and improvement of tools and equipment.

Design of tools and equipment		
References		
[62-70]	Design of Shovel. Design of hand tool. Design of hollow-masonry concrete block. Preliminary helmet shell design. Participation of marketing team in product design. Hand tool Design considerations. Whole Body vibrations faced by operators in construction. Automation and Robotics. Automated robotic masonry system. Design of Personal protective device, Puncture resistance of protective clothing, Design of clothing. Protective clothing for aluminium Smelters, Protection Gloves. Automation and Robotics in Construction	<ul style="list-style-type: none"> Ergonomic efficiency has been neglected in design of many tools including shovel. Improvement of shovelling task is needed. Shovel design is required for better efficiency. Coal miner study; working posture data of normal erect, kneeling without ceiling restraint, kneeling in restricted height assessed. Heart rate and oxygen intake of experimental data compared well with actual coal miners engaged in shovelling activity. Optimization of posture, pattern of motion, working of gloves are suggested. Use of DOE (Design of Experiments) and FEM (Finite Element Method) ae used for optimization and test compression resistance of hollow cement blocks. Proposed semi parametric model-user feeds input of key parameters for custom design). Marketing team participation yields a better process to achieve better designs of products. Material, texture, repetitive force, special purpose tools required for flexible usability. User Centred design. Manufacturers role in identification of user needs. Aerosol deposition, puncture tests, bio-barrier properties of fabric measured. Minimum performance levels should be compared with field experience in the use of protective products. Improved work environment, work quality, uniformity is achieved by automation. Can be used to design engineering and maintenance of existing and future structures.
[71,72]	Design of equipment and aids. Design of material packaging in construction.	<ul style="list-style-type: none"> Design can reduce human cost, accidents, injuries. Scope for Design improvement exists; material packaging and delivery distribution can reduce accidents.
[73-79]	Design and Redesign of elements in the process of construction.	<ul style="list-style-type: none"> Redesign of kerbs. Most strenuous task of cement workers was laying bricks. Tested Usability of Trowels. Tested Usability of saws. Compared usability of random orbit sanders. Proposed brick laying device. Ergonomic quality of hand held tools

Table 4: Patents of tools and equipment used in carrying out painting task.

Existing patents of tools and equipment used by construction painters		
References		
[83-108]	Adjustable foldable horse for painters Improvement in painter's scaffold. Platform for Painters. Painter's roof bracket. Jack for roofers and carpenters. Improvement in holders for painter's use. Multiple roller corner painting tool. Adjustable holder assembly for painting tools. Painter's pouch. Multipurpose paint brush. Apparatus for carrying a spray paint. Painter's utility belt. Paint holder and delivery device. Multipurpose paint bucket. Painting machine and control unit for use in a painting booth. Wall finishing. Finishing of dry wall. Roof deck system. Modular Building blocks. Modular Construction. Dry Wall. Modular building Construction. Structure panels. Prefabricated Building sections. Transportable Structure Kit	<ul style="list-style-type: none"> • Staging support; foldable, base width is controlled with screws. • Platform of timber made up of longitudinal and transverse members; portable; to be fitted on base rods • Folder platform; fitted on metal ladder; for interior wall painting. • Used to support a platform for painters to stand; fixed on slant roofs; C shaped pair of brackets • Secured to roof; jack-scissor shaped. • Drainable tray occupying two sides of a case. Limitation of low capacity of containment of paint. Used for interior wall painting. • Case holder with housing to hold different sizes of paint brushes. • Two sets of rollers at right angle on the handle. Foldable. Used to paint corner of the walls. Short handle suitable for interior wall painting. • Adjustable arm used as a holder for painting accessory. Arm can be fixed to a round pipe. • Rigid box with paint container and other pouch to store paint accessories. Bag is carried with support on shoulder and back. Issues may arise for external wall painter to carry the (insufficient) load on body for hours. • Bucket with a short handle; can be hung on a bar/pole member. Meant for interior painting due to small size and absence of hanging feature. • Belt with a housing attached to hold spray cans. Not meant for wall painting. • Wearable belt with a pouch on one side. • Bucket with a spout; held in hand; no attachment feature. • Includes a main compartment along with smaller spaces for different paint in unequal quantity. Preferred use in interior wall painting; low paint capacity. • Painting booth; not usable for wall painting. • Fibrous Mat faced gypsum board exterior interior finishing system. • Gypsum board and finishing system. • Fibrous mat faced gypsum boards. • Modular pre- insulated, prefabricated building block. • Hybrid home construction technique. • Corner bead for dry wall construction. • Reinforced pre- formed building. • Reinforced synthetic resin structured panel (Prefabricated building sections made of gypsum. 'C','U' sections Used in partition walls.)

Design interventions of tools and equipment

Areas of improvements are design of equipment and re-engineering [44, 45, 47, 49]. Design of materials, packaging and delivery method can reduce accident more than third of all the risks at construction site [71]. Kerbs had been redesigned for better and easier edging of the surfaces [73]. Usability of trowels has been tested [75]. Stability of saws had been evaluated for better interaction and function [76]. A pilot investigation for comparison of usability of random orbit sanders and ergonomic evaluation had been conducted [77]. Brick laying device was designed [78]. Ergonomic quality of hand tools used at construction site which were used during construction process were studied [79]. Accidents are associated with design of equipment, support and tools that are used in material handling [80]. Construction safety is linked with barrier at construction sites that cordon potentially hazardous activities and site areas [81]. Parapet wall should be 42 inches high. Inappropriate installation of roofs and facades are hazardous for construction workers and that technical faults are caused by poor workmanship and not by quality of the material. 27% of OSHA (Occupational Safety and Health Administration) [82] reports are linked to Design of entities and system at construction sites.

Designs of painting tools and equipment

Several painting tools have been designed that help construction painters in their task. Table 4 highlights these studies. Some deals with platforms, organisers, buckets while others deal with belt, raised platform among others.

Product design patents for construction painters

William porter's 'Adjustable foldable horse for painters' is a foldable support, base width is controlled with screws. Willia Hoehm's 'Improvement in painter's scaffold' is a platform of timber made up of longitudinal and transverse members. It is portable and when in use can be fitted on base rods. Charles Sprague's 'Platform for painters' is a folder platform, fitted on metal ladder used only for interior wall painting. Martin Mattson's 'Painter's roof bracket' is used to support a platform for painters to stand. The platform is fixed on slant roofs supported by 'C' shaped pair of brackets. John Wright's 'Jack for roofers and carpenters' is secured to roof. It is a scissor shaped jack used to support a small plank or a platform. 'Carrying case for wet and dry painting booth' comprises of Drainable tray occupying two sides of a case. Limitation of low capacity of containment of paint and is used for interior wall painting (by Joseph Rocco). 'Brush Kit' is a case holder with housing to hold different sizes of paint brushes (by Oddo Charles). 'Multiple roller corner painting tool' is essentially a set of rollers at right angle on the handle additionally the product is foldable. Used to paint corner of the walls (by Hugo Rivadeneira) 'Adjustable holder assembly for painting tools' comprises of an adjustable arm used as a holder for painting accessory. Arm can be fixed to a round pipe (Chad Posser, Erick Rudnick). 'Painter's pouch' by Carl D. Robinson is a rigid box with paint container and other pouch to store paint accessories. Bag is carried with support on shoulder and back. Issues may arise for external wall painter to carry the (insufficient) load on body for hours. 'Multipurpose paint brush'

by Bert H Abbey consists of a bucket with a short handle; can be hung on a bar/pole member and is meant for interior painting due to small size and absence of hanging feature. 'Apparatus for carrying a spray paint' (Mark E. Devine) consists of a belt with a housing attached to hold spray cans. Not meant for wall painting. 'Painter's utility belt' (by Charles L. Byrd) is a wearable belt with a pouch on one side. Robert Scholl's 'Paint holder and delivery device' comprise of a bucket with a spout; held in hand; no attachment feature. 'Multipurpose paint bucket' includes a main compartment along with smaller spaces for different paint in unequal quantity. Preferred use in interior wall painting; low paint capacity (by Bert H Abbey). 'Painting machine and control unit for use in a painting booth' is a painting booth; not usable for wall painting (by Fujio Soshi, Masaharu Okuda, Koichizo Asami).

CONCLUSION

Causes of discomfort and problem areas in the regions of body of construction painters is mainly due to lack of improved design of tools and equipment, as has been established by Smallwood in his past studies. Hence to make the task less stressful, the physical strain in inconvenient body postures should be avoided. Design interventions that provide convenient working and less postural stress will thus lower the Musculoskeletal Disorders (MSDs) and intensity of the work for the construction and maintenance painters.

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