EVALUATION OF WORKER PERFORMANCE IN CONSTRUCTION PROJECT USING SIX-SIGMA

Submitted in partial fulfilment of the requirements

for the degree of

MASTER OF ENGINEERING

in

CIVIL ENGINEERING

(With specialization in Construction Engineering and Management)

by

Tanwar Saif Muhammad Shakeel

(Registration Number: Anjuman-49)

Under the guidance of

Dr. R. B. Magar

Department of Civil Engineering

School of Engineering and Technology

Anjuman-I-Islam's Kalsekar Technical Campus

New Panvel, Navi Mumbai-410206

2018

A Report on

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CERTIFICATE

This is to certify that the project entitled **"Evaluation of Worker Performance in Construction Project using Six Sigma"** is a bonafide work of **Saif Tanwar (16CEM16)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of "Master of Engineering" in "Civil Engineering (With Specialization in Construction Engineering and Management)"

Dr. R. B. Magar
(Guide and Head of Department)

Dr. Abdul Razak Honnutagi
(Director, AIKTC)

APPROVAL SHEET

This dissertation report entitled "Evaluation of Worker Performance in Construction Project using Six Sigma" by Saif Tanwar (16CEM16) is approved for the degree of "Civil Engineering with Specialization in Construction Engineering and Management"

Examiners

1. ……
2. ……

Supervisors:

1. ……
2. ……

Date:

Place: Panvel

DECLARATION

I declare that this written submission represents my ideas in our own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Saif Tanwar
(16CEM16)

Date:

ABSTRACT

The main objective of this work is to evaluate worker performance index for improving construction productivity and provide practical solutions for construction performance improvement by applying the six-sigma technique. Construction productivity and performance improvement are vital focus areas in construction industry. Many researchers have experimented various measures such as lean principles, just in time, pull scheduling, last planner system etc. to improving project performance. However, it is being observed that construction industry has witnessed a considerable decline in productivity in terms of both labour and management issues. Based on site observation, questionnaire survey, interviews and examining existing worker performance system, the scenario for worker performance was analyzed. The finding shows that the management and supervisors play key roles in improvement of worker performance. Worker performance index (WPI) is used to evaluate the worker performance quantitatively for various purposes like assistance to managers in planning, supervisor's assessment and designing incentive scheme for rewarding best worker of any construction organization. Thus, with an improved worker productivity, overall performance of the construction project is envisaged. Further, six-sigma technique is used to validate and improve the construction performance and worker performance during construction execution phase. Managers and supervisors need to follow the management aspects, which is been recommended after the analyses done to improve the worker performance and productivity of construction projects. Thus, in this work, on basis of sigma level obtained, it can be concluded that WPI model proves to be successful for selecting a suitable worker according to their skills for desired work or a construction project with minimum defects with respect to their performance.

Keywords: Worker Performance Index; Labour Productivity; Construction Productivity, Performance Management.

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ABBREVIATION NOTATION AND NOMENCLATURE

WPI	Worker Performance Index
PMS	Project Management System
HRM	Human Resource Management
HR	Human Resource
CMT	Construction Management Team
DPMO	Defects Per Million Opportunities
COPQ	Cost of Poor Quality
CTQ	Critical to Quality
PBSRG	Performance Based Studies Research Group

Chapter 1

Introduction

1.1 General

The success of every organization depends on its employee behavior and their commitment. Human resources are of utmost importance to meet organizational goals. Human resources are one of the most prominent assets for any organization which differ from any other capital assets which require just a proper maintenance at regular intervals to be productive and profitable, whereas employee productivity entirely depends upon commitment level and job satisfaction. Construction is a labour intensive, project-based industry which operates in complex work conditions. Hence, it is observed that the employee turnover is very high in construction.

It is worthwhile to note here that Indian government has envisioned a plan to be a developed nation by 2022 through rapid economic and infrastructural growth. In this regard, the government has invested $ 1 Trillion in infrastructure segment which is expected to escalate the demand for productive and skilled labour in the real estate and construction sector. Hence, it has become imperative for construction entities to introduce or design a scientific technique to improve worker productivity and performance (India NSDC Report 2009).

Performance Management (PM) practices at any organization are the key management function of Human Resource Management (HRM) for motivating and developing the professionals and have a great impact on the employees. It is therefore essential to investigate the potential impact of PM practices on employee productivity and job satisfaction. The objective of this research is to discuss the role of comprehensive performance management system in improvement of the productivity of employee professional in construction Industry. Many managers in construction organizations are beginning to realize the importance of better management of their employees, an area of management now referred to as "human resource management (HRM)", in which one of the key experiments branded is discovering and recollecting suitable persons which forms foremost concern of any company as losing top employee can results in administration challenges, loss of human resources. Employee management is becoming difficult by the day and may also affect the productivity and job satisfaction. Moreover, one of the reasons that can be related to poor management of human resource is that good employees are not considered as asset. Failure to develop and retain the human assets can have a significant negative effect on a firm's bottom line it also affects the employees who falls under those good employees and organizations. Most construction company managers understand that they need to invest in regular maintenance for their machinery and equipment, but often neglect the need to invest in their human resources to keep them in good working environments. Above all, the best way to retain employees is to focus on the fact that one is dealing with people, not just numbers or statistics. Employees at every phase of the life cycle need to believe that the work they do is important and meaningful which is achieved through proper Performance management system (PMS). (Cleveland 1992)

Project management systems are very important and in this particular study a comprehensive analysis of PMS is envisaged. It starts right from setting of objectives, appraisal, giving the feedback to the employee, mentoring him/her in a right way, recommending him/her for training and development to giving incentives and rewards such that this entire system in a way contributes to job satisfaction. The quality of these practices would affect the quality of performance of employee as well as job satisfaction. So, the study is of the current status of these practices in construction industry and how much effect it has on performance of an employee. (Cleveland 1992)

In order to determine the independent attributes of PMS contributing to job satisfaction and to answer the research question through Literature Review, this work intends to define various critical points of Performance Management System which covers HR practices, employee

productivity and employee retention in the construction companies. (Deepa and Kuppusamy 2014)

1.2 Worker Performance Index

A Worker Performance Index (WPI) as a common evaluation method will help construction management team (CMT) to rank their worker in a fair and equal way. This will provide a basis to develop cohesive construction teams of the workers based on their performance levels and expected supervisory requirements. Systematically developed cohesive teams of workers significantly enhance the productivity compared to a randomly selected group (Gannoruwa and Ruwanpura 2008). Furthermore, these measurements will help to understand the cross section of the workers based on their current skills, personal traits and motivational levels. Developing a performance evaluation method is to continuously measure the performance and monitor personal improvements with time by adjusting the management process (i.e. providing them training, changing current foreman etc.). This will also help the construction planners to get an informed judgment about their workforce. The knowledge of WPI of a certain worker, will help the CMT to predict the performance of that worker before handing him a responsibility at the site. A rating system is also expected to create a competitive environment for workers which will lead to better performance. This can also be used as a basis for wage hikes, incentives, career progressions and training program recommendations. Moreover, this assessment shall provide future supervisors or foremen the pre-knowledge to take an informed judgment about his workforce before executing a task at site. (Tumla 2010).

1.3 Six Sigma as a Quality Management Technique

Six Sigma, it is a quality management technique that focuses on reducing variation in the process and preventing deficiencies in the product. This technique has been adapted by companies like Motorola, General Electric, Fords, Sun Microsystems etc. This technique is the arithmetical method to define how much difference occur in a set of data, a group of stuffs or a procedure. Sigma, which stands for standard deviation, is the most useful measure of dispersion. The six-sigma principle can be characterised on a ordinarily assigned product value distribution curve. When the mean is located at the centre of the normal distribution curve, the lower and upper limits are six times the standard deviation from the centre line. (Pande *et.al*; 2000)

One feature of Six Sigma is that it interprets the confusion of difference into a pure black or white measure of success: either a product or service meets customer requirements or it does not. Whatever that does not get together customer needs is called a 'defect'. Another approach to defining a sigma level is to analyse how many defects arise related to the amount of opportunities there are in the product or service for possessions to go incorrect. The outcome of this calculation is called 'Defects Per Million Opportunities' (DPMO). (Pyzdek, T.). The Six Sigma Handbook (2003)

1.4 Motivation

Construction industry today, is lacking a proper application of the Quality management techniques. Though several techniques are developed by the researchers, still their practical application, validation and reliability is not properly documented. Worker performance management is one of the biggest challenges today in construction industry. Improper management may lead to low quality construction, over-budgeting, delay in construction work and so on. Thus, a proper method needs to be devised in accordance to improve worker performance on site, such that the final output of the project is achieved as required within the stipulated time and the budgeted cost. Thus, the construction performance with quality product needs to achieved in the construction projects.

1.5 Aim and Objectives

The aim of this work is to suggest the ways to improve the worker performance in construction projects. Therefore, this study aims at selection of construction workers with recommendations about the suitable criteria for better productivity and job satisfaction. The objective of the study are as follows:

1. To measure and evaluate worker performance related to construction performance and productivity. (identify what are the different parameters involved in performance management)
2. To recognize the defects or factors affecting in workers performance in construction phases.
3. To improve workers performance using management techniques in construction project.
4. Introducing some recommendations for enhancing the worker's selection process.

1.6 Scope of the Proposed Work

In view of the aforementioned problem as specified from the literature review, following scope is outlined for the present investigation.

- The scope of the project is to improve worker performance in accordance to labour productivity and construction performance.
- Setting benchmarks for various management parameters for a worker and deciding the ranking based on the weightage calculated for various parameters.
- Selection of worker for selected job by following a proper methodology and validating the performance of the worker by six sigma technique.
- Preparing defect measurement sheets for evaluating performance of the worker and assigning the sigma level to the workers.
- Thus, the prediction of worker productivity and job satisfaction shall be done based on WPI (worker performance index) and six sigma technique.

Chapter 2

Literature Review

2.1 General

Appropriate HRM practices and positive employee behaviour including employee satisfaction, loyalty and productivity has been widely analysed. It is also being advised that considering employees as precious asset improves their self-confidence and loyalty which results in good quality and high performance (Al-Qudah, 2014)

Recent years have seen a need for greater emphasis on construction organizations to be more client and market oriented. However, while construction constitutes an important component of global economic activity and the very nature of the work is labour intensive, there has been a lack of attention given to the study of human resource management issues (Marchington and Wilkinson, 2012).

2.2 Performance Management Practices

Generic activities were most companies strive to improve it cost, speed, quality, flexibility and dependability (Slack *et al.,* 1998). These areas relate to the company's ability to compete and meet customer expectations; hey provide some insights into the overall performance of a company. Efficiency, on the other hand, is often described as "doing the right thing"; it refers to the extent to which customer requirements are met. Neely *et al*., (1995). Thus, effectiveness highlights the importance of reaching a desired objective, whereas efficiency focuses on the

process. Zannah *et al.* (2017) revealed that, five most significant causes of low-skilled workers' performance in the Nigerian construction industry. These are; low wages, lack of sufficient skill acquisition centres, lack of incentive schemes programmes, vulnerability to safety and health care services and lack of standard salary scales for skilled workers. Thus, here is the need to limit the listed causes of low-skilled workers' performance in order to improve by various motivational factors so as to achieve successful construction project delivery in the Nigerian Construction Industry. Poovitha *et al.* (2018) Concluded that the most significant factors affecting performance management and appraisal are Performance Factors, Behavioural Factors, Grading System, Personal Effectiveness and Social Factors. Employees should perform on these factors to enhance performance which ultimately can help to get higher profits from the projects.

2.3 Defining Employee Performance

Bernardin and Beatty (1984) define performance as the record of outcomes produced on a specified job function, activity or behaviour during a specified time period. Defining performance is considered to be a critical part of performance management system as identifying performance measures is required for appraisal which determines performance standards as levels of performance that correspond to pre-designed levels of individual and organizational effectiveness. It is important to keep in mind S.M.A.R.T. (Specific, Measurable, Achievable, Realistic, Time bound) technique to set objectives to the employees keeping in view point to be a fair, unbiased, and business-relevant basis for performance evaluation as pointed out by Borman (1991), Cardy and Dobbins (1994) and Heneman (1986).

Albanese (1991) To improve any firms effectiveness proper management practices is required and specially a well-trained employee human and team work practices is needed to improve any firm's effectiveness. To learn more about human-resources practices in the U.S. construction industry, a survey was conducted, and responses from the survey received from executives in 783 construction firms are reported. About one-third of the executives indicated their firm had a personnel department and a written human-resources philosophy statement. The survey was made in those firms who has a variety of employees working in those firms are more likely to engage in formalized strategic planning and human-resources planning and use a greater variety of selection, training, performance-evaluation, and promotion practices. Whether it is a current scenario or the past conditions construction industry faces a severe

shortage of technical, professional, and skilled labour. When there is a shortage of labours the cost of the labour also increases accordingly and the increasing cost of human resources make it overbearing that firms use the most effective, practical human-resources practices. Further research on such practices can contribute to helping the construction industry classify and instrument operative human-resources practices.

2.4 Application of Worker Performance Index

Cleveland and Murphy (1992) defined performance evaluation as a tool which reflects an employee's actual job performance levels in which accuracy should be the primary goal of appraisal system adopted. Fledman (1979) discussed the concept of accurate ratings seems to be rare in the present scenario due to presence of rating errors and judgement errors which are producing a difference between human judgement process and objectives of appraisal. Boice and Kleiner (1997) stated that frequency of appraisal varies from organization to organization; however, frequent appraisals are needed to give an accurate account of an individual's performance and make improvements in the future. They argued that a typical frequency of appraisal should be bi-monthly or quarterly as this practice would help to eliminate selective memory on the part of the supervisor or the employee and can help to reduce the appraisal rating errors. Poon (2004) stated that due to improper evaluation and employee's perceived performance ratings based on employer's personal bias and intent to punish subordinates, employees expressed reduced job satisfaction which, in turn, led to greater intentions to complete their work.

Kuppusamy (2014) discussed that a fair performance appraisal system additionally helps the organisations to motivate employees in two ways, i.e. financial or non-financial. Financially, by providing further incentives, it helps to motivate employees and makes them display an additional commitment within the organization and non-financially, by providing further roles and responsibilities; it helps the staff to own a good citizenship behaviour that helps them to give an additional input and extend their productivity.

Egan (1998) Set specific targets for improvement in terms of productivity, profit, quality, safety and efficiency of the project; He stressed the importance of the ambitious objectives and the role of evaluating the effectiveness in delivering improvements.

The main objective of a worker performance measurement tool is to improve the worker productivity by analyzing their current level of performance. A Worker Performance Index

(WPI) as a common evaluation method will help construction management team (CMT) to rank their worker in a fair and equal way. This will provide a basis to develop cohesive construction teams of the workers based on their performance levels and expected supervisory requirements. Systematically developed cohesive teams of workers significantly enhance the productivity compared to a randomly selected group Gannoruwa and Ruwanpura (2008). Furthermore, these measurements will help to understand the cross section of the workers based on their current skills, personal traits and motivational levels. Developing a performance evaluation method is to continuously measure the performance and monitor personal improvements with time by adjusting the management process (i.e. providing them training, changing current foreman etc.). This will also help the construction planners to get an informed judgment about their workforce. By knowing the WPI of a certain worker, will help the CMT to predict the performance of that worker before handing him a responsibility at the site. A rating system is also expected to create a competitive environment for workers which will lead to better performance. This can also use as a basis for wage hikes, incentives, carrier progressions and training program recommendations Tumla (2010) Moreover, this assessment is providing the future supervisors or foremen the pre-knowledge to take an informed judgment about his workforce before executing tasks at site.

2.5 Application of Six Sigma

Pheng and Hui (2004) examined the strategies and concepts of Six Sigma and to explore if Six Sigma can be applied to the construction industry to achieve the many benefits it has brought to the organizations that have implemented it successfully. A case study on the implementation process of a Six Sigma program by the Housing and Development Board (HDB) of Singapore was presented. An example of how Six Sigma was created, was presented to improve the quality of internal surfaces where improvement measures taken by Contractor A have helped to raise the Sigma from 2.66s to 3.95s. The principles of operation can be obtained even in this example can be equally by other design and/or construction firms.

Sawant and Pataskar (2014) explained that six-sigma is a Quality improvement technique that has being implemented in manufacturing and other industries, but in its nascent stage in the construction industry. They described the basic theory of six sigma, principles, methodology and various tools used. A case study of a residential building was taken in which the Six Sigma principles are applied for internal finishing work, the Six Sigma methodology has been adopted

to improve the quality and tested against the sigma level. The findings suggest that proper training and management support and minor changes in existing work procedure can help improve the quality and ultimately lead to customer satisfaction which is of prime importance. Desale and Deodhar (year) suggested process improvement methods used in the construction industry and analysis of features and principles of six sigma and there in to review of project manager, field engineers and the price of the same. Interview on Six Sigma is based on aspects of quality, performance, and control. This research protects and removes any doubt about the positive effects of Six Sigma on construction projects. In particular, Six Sigma can deliver a broader quality concept, detailed performance measurement, and coordination in repetitive process is and performance improvement. He produced a quality improvement directly / indirectly with a positive increase in production efficiency.

Han *et al.* (2008) explained that many researchers and project managers have attempted to improve project performance by applying new philosophies such as lean principle, just-in-time, pull scheduling, and last planner. However, very few studies conducted to establish specific quantitative targets to improve performance, while the frequency of errors in considering involved in the construction operations. They explored practical solutions for construction performance improvement by applying the six-sigma principle. This principle provides the metrics needed to establish the purpose of improving productivity and methodology of measurement and evaluation of improvement.

Where implementation is concerned, some of the key ideas can be drawn from the Six Sigma Roadmap Harry and Schroeder (2000); Pande *et al.* (2000) and the Business Process Management model Eckes (2001). The steps to an ideal roadmap for establishing the Six Sigma system and launching improvements are to:

1. Create and agree on strategic business objectives.
2. Identify key customers, core, key sub- and enabling processes, and owners of these processes.
3. Define customer requirements.
4. Measure current performance.
5. Prioritize, analyse, and implement improvements.
6. Expand and integrate the Six Sigma system.

2.6 Performance Feedback

The performance which is well monitored and controlled accordingly paysoff good value in return. Employees need feedback on how well they are doing and supportive feedback can lead to greater work motivation for employees. Feedback talks about pay and progress can lead to more employee satisfaction through performance management processes. They must in a way be able to accurately perceive the consequences of their efforts and be able to set goals on the basis of this feedback Latham and Wexley (1984). Pettijohn and D'Amico (2001) demonstrated that clear, specific, and full circle feedback, compared to evaluative inflated route of outcome feedback, resulted in more accurate evaluations of expectancy for success, ultimately contributing to fairness, and increased performance by allowing accurate attributions about past performance.

2.7 Construction Productivity Definition

In spite of many attempts, development of standard measuring scheme for construction productivity measurement has been a difficult task due to the complex and dynamic nature of the variables involved Park *et al*. (2005); Oglesby *et al.* (1989). Researchers and industry practitioners have developed several definitions to construction productivity based on their applications. The definition of productivity adapted in this paper is input to output ratio (input divided by output), where input is measured in labour hours and output is measured in work quantity. This is the common definition used for productivity at the activity level (labour productivity) Malisiovas, (2010); Hanna *et al.* (2009).

2.8 Factors Affecting Labour Productivity

Rojas and Aramvareekul (2003) identified 18 factors affecting labour productivity and classified them into four categories. They are in the in the order of importance of a) management systems and strategies; b) manpower; c) industry environment and d) external conditions. Manpower category includes worker experience, specific activity training, education, motivation, and seniority. Liberda *et al.* (2003) too identified 51 factors affecting productivity and classified them in to three main categories of human, Management and external. Under human category, they have listed several factors affecting the labour performance including

worker motivation, worker boredom and fatigue, worker attitude and morale, worker's physical limitations, worker absenteeism, worker learning curve, worker experience, worker skills and crew's team-spirit. Hewage and Ruwanpura (2006) conducted a study using the above factors Liberda *et al.* (2003) and clustered them in to nine groups according to their priority of importance. Out of the nine categories, six were directly related to labour performance and labour productivity. They are worker motivation, inadequate communication, worker skills, non-availability of information, congested work area and inadequate supervision.

Categorization of factors affecting labour productivity developed by both Rojas and Aramvareekul (2003) and Liberda *et al.* (2003) have Human, Management and External categories in common. Construction industry can make a larger influence on management and human categories than the external category. Pre-construction planning and workface planning are effective methods of influencing management and human categories. Tumla (2010) used 16 performance evaluation factors to develop a performance-based reward model for construction workers. The 16 factors were ranked based on the preference of workers, supervisors and the senior management. Factors that received highest preference were attendance, milestones, safety, quality, punctuality and teamwork to develop the performance-based reward model.

Productivity Alberta (2011) indicated that lack of upstream planning can cause significant negative consequences for downstream activities. In addition to that they have recognized lack of workface planning (detailed construction planning) as one of major issues in productivity. Merrow *et al.* (2009) highlighted the importance of detailed execution planning for achieving higher field productivity. Further they have found out that there was up to 6 percent improvement in efficiency (in terms of hours required) in work execution when workers participated in the planning the work which they perform. They have also mentioned that there is a clear relationship between productivity and involvement of the construction labour in pre-task planning.

2.9 Job Satisfaction

There is no universal definition of employee job satisfaction that covers all views of specific job factors, individual characteristics and group relationships with co-workers at the same time. However, there are some definitions that are widely accepted like job satisfaction as a match between what individuals perceive they need and what rewards they receive from their jobs Huber (2006). Job satisfaction is any contribution of an organization to employee in the form

of psychological, environmental, and work-related aspects that cause a person to truthfully say, "I am satisfied with my job" Glimmer (2005). Lu *et al.* (2005), outline worker satisfaction as a worldwide feeling concerning one's work or a connected cluster of attitudes concerning varied sides of the work setting. In literature, there are a large number of studies that analyse the term from many different perspectives and its relationship with various organizational variables.

Job satisfaction is a qualitative aspect and cannot be understood in strict quantitative terms but in order to boost employee satisfaction, it is vital to measure and establish the present levels of satisfaction initially, to do this, organizations in general do use rating scales in which employees are asked to express their inclination on several aspects of job satisfaction. Marketing and sales sector use the Big Five factor model of personality in job place. In general, exit interviews act as primary measurement tools in the construction industry Hosseini (2014). Once the current level of employee satisfaction is established, organizations can strategize to create motivated and committed workforce.

2.10 Employee Motivation

Intrinsic motivation relates to internal desires to perform a particular task or develop a certain skill, whereas extrinsic motivation refers to external factors which are unrelated to the task being performed but provide satisfaction that the task itself may not provide. The works of Maslow (1954), Herzberg *et al.* (1959), McGregor (1960), Vroom (1964), Lawler (1973), Ouchi (1981), and Locke and Latham (1990) remain the most notable, and thus have formed the basis for most previous motivational, performance, and productivity research studies.

Jenkins Jr. and Laufer (1982) mentioned that motivation has a direct impact on work performance. It can be positively influenced or managed by external to the worker. Evaluation methodology for motivation factor was developed based on the Vroom's expectancy theory (1964). This is evaluation is a modification of the work of Gannoruwa and Ruwanpura (2008) and Gannoruwa (2008). In Expectancy Theory, motivation is defined as a function of expectancy, instrumentality, and valence.

Petri, (1991) stated that an effecrive method of stimulating employees is to use effective motivation, which makes staff happier and committed to their jobs. Salary is not the sole rational motive for job satisfaction. There are different incentives and time unit policies which might conjointly function as motivators.

Motivation is essential to labour, as it gives site workers satisfaction such as achievement, sense of responsibility and pleasure of the work itself Enshassi *et al.* (2007). In supporting a similar view, Chase (1993) cited by Mohajed, (2005) believes made a combination of training, orientation for new employees, providing a safe and clean environment encouragement of two-way communication, employee participation in planning or decision making, and individual / team recognition may be utilised to achieve employee satisfaction. Herzberg argues that all too often management fails in its attempt to motivate employees because it puts all of the emphasis on removing dissatisfiers and neglects satisfiers that create motivation Oglesby *et al*. (1989) cited by Mohajed, (2005).

2.11 Impact of job satisfaction on employee Productivity

Once the employees are satisfied with their jobs, they will commit themselves automatically to their job. This makes the worker feel that they are the citizens of the organization and consequently each one of these factors can facilitate them to increase their productivity Kuppusamy, (2014). The following model has been derived from Kuppusamy's research work: PM practices and job satisfaction are studied widely in different parts of the world. It is believed that HR practices are closely linked to job satisfaction, Ting, (1997). Performance management being the crux of HRM, many scholars and practitioners believe that sound PM results in better level of job satisfaction which ultimately improves organizational performance Appelbaum *et al.* (2000). Ahmed and Hussain (2010) reported that a better performance appraisal (PA) system integrated with better HR practices will enhance performance appraisal satisfaction and also increase employee job satisfaction and reduce turnover intentions to bring effectiveness in the organizations. The above cited literature reviews the key elements of PM and summarizes the conceptual foundation of interlink between PM practices and job satisfaction, organizational commitment and individual behaviour, that affects the employee productivity.

2.12 Process Improvement Approach

Hammer and Champy (1993) Business process improvement (BPI) is a systematic approach to help an organization optimize its underlying processes to achieve more efficient results. The organization may be a for-profit business, a non-profit organization, a government agency, or any other ongoing concern. Most BPI techniques were developed and refined in the

manufacturing era, though many of the methodologies (like Six Sigma) have been successfully adapted to work in the predominantly service-based economy of today. While there are differences in the challenges that each type of industry poses, the fact remains that the core principles of BPI and how they apply to business improvement remain portable across industries and functions.

It should be noted that BPI focuses on "doing things right" more than it does on "doing the right thing". In essence, BPI attempts to reduce variation and/or waste in processes, so that the desired outcome can be achieved with better utilisation of resources.

BPI works by:

- Defining the organization's strategic goals and purposes (Who are we, what do we do, and why do we do it?)
- Determining the organization's customers (or stakeholders) (Who do we serve?)
- Aligning the business processes to realize the organization's goals (How do we do it better?)

The goal of BPI is a radical change in the performance of an organization, rather than a series of incremental changes (compare TQM). Michael Hammer and James Champy popularized this radical model in their book ''Reengineering the Corporation: A Manifesto for Business Revolution'' (1993). Hammer and Champy stated that the process was not meant to impose trivial changes, such as 10 percent improvements or 20 percent cost reductions, but was meant to be revolutionary. There are four roles within a business Management system: Business Leader, Process Owner, Operational Manager, and Process Operator. The responsibilities of each of these roles are unique, but work together as a system. Some employees in an organization may perform as many as all four of these roles over the course of a day, week, month, or year. The responsibilities of the business leaders follow the PDCA (plan, do, check, and act) cycle.

Plan: The business leaders create and own the business performance objectives of the organization. Senior leaders need to first understand the requirements of their customers, stockholders, workforce, suppliers, and communities. They need to understand their competition. They need to understand the environmental, economic, technological, social, legal, and political environments that they do business within. Senior leaders need to consider all of these elements as they design a Business model and business Strategy map that will meet the customer and business requirements. Business Leaders then translate these requirements and business environment issues into business performance objectives. Business Leaders then create business plans and associated resourcing plans that will cause the organization to achieve

these business objectives. The Business Leaders establish business performance metrics to measure the business's capability to meet these business objectives. Many organizations create a Balanced scorecard to organize and communicate business performance metrics.

Do: The Business Leaders are responsible to communicate to the organization their business plans. As the organization conducts business, the Business Leaders are responsible to build bridges and remove barriers that will allow the business performance objectives to be met. The business performance metric data is produced and collected as business is performed by the organization.

Check: The Business Leaders periodically analyze the business performance data and use it to visualize the business's capability to meet business objectives over time (performance trends), compare actual performance against performance targets, and identify performance issues.

Act: The Business Leaders are responsible to create improvement actions to address the performance issues that are identified during their analysis of the business performance data. These improvement actions are created to ensure the organization is able to achieve their business plans.

The process owner is the person who is responsible to design the processes necessary to achieve the objectives of the business plans that are created by the Business Leaders. The process owner is responsible for the creation, update and approval of documents (procedures, work instructions/protocols) to support the process. Many process owners are supported by a process improvement team. The process owner uses this team as a mechanism to help create a high-performance process. The process owner is the only person who has authority to make changes in the process and manages the entire process improvement cycle to ensure performance effectiveness. This person is the contact person for all information related to the process. The responsibilities of the process owner follow the PDCA (plan, do, check, and act) cycle.

Plan: The process owners create and own the process performance objectives of the organization. The process owner first needs to understand the external and internal customer requirements for the process. This person uses the business plans as a source to help understand the long term and short-term customer and business requirements. This person then translates these requirements into process performance objectives and establishes product (includes service) specifications. This person establishes process performance metrics to measure the process's capability to meet the product specifications and overall process objectives. The set of metrics that are to be reviewed by operational managers and process operators are called key performance indicators (KPIs). The process owner then designs process steps to describe work

that when performed will have the capability to produce product that meets the customer and business requirements.

Do: The process owner is responsible to communicate to the operational managers the details of the processes that the operational managers are responsible to execute. As the operational managers and process operators perform the processes, the process owner is responsible to build bridges and remove barriers that will allow the process performance objectives to be met. The process performance metric data is produced and collected as the process is performed by process operators. The process owner is continually involved with the operational managers and process operators as they use kaizen to continually improve the process as they are performing the work.

Check: The Process Owner periodically analyzes the process performance data and use it to visualize the process's capability to operate within control limits over time (performance trends), compare actual performance against performance targets, and identify performance issues.

Act: The Process Owner is responsible to create improvement actions to address the performance issues that are identified during their analysis of the process performance data. Improvement actions may include the initiation of Lean projects to reduce waste from the process or include the initiation of Six Sigma projects to reduce variation in the process. Improvement actions may include the use of problem-solving tools that would include risk assessment and root-cause analysis. Risk assessment is used to identify and reduce, eliminate, or mitigate risk within the process. This is the proactive approach to avoid problems being created from the process. Root-cause analysis is the reactive way to respond to problems that occur from the process. Root-cause analysis is used to identify the causes of problems within the process and identify and implement improvement actions that will ensure these problems do not occur again.

The process operator is responsible to learn and perform the processes (work) necessary to achieve the objectives of the business plans that are created by Business Leaders. The responsibilities of the process operator follow the PDCA (plan, do, check, and act) cycle.

Plan: The process operators - in collaboration with their Operational Manager, create and own their performance objectives. Process Operators are responsible to understand the performance objectives of the process they are to perform and the specifications of the product they are to produce.

Do: Process operators are responsible to learn the processes (work) that they are to perform. They ensure the processes are performed to meet the process performance objectives and produce product that meets specification. As the Process Operators perform the processes, they are responsible to communicate to their Operational Manager (supervisor) the bridges that need to be built and the barriers that need to be removed to allow the process and Process Operator performance objectives to be met. Process and Process Operator performance metric data is produced and collected as the process is performed.

Check: The process operator periodically reviews the Key performance indicators (KPI's). The Process Operator adjusts their work based on their actual performance compared to KPI targets. The Process Operator is responsible for identifying and reporting any performance issues and stopping production if necessary.

Act: Process operators practice kaizen to continually challenge the process and communicate improvement suggestions to their operational manager (supervisor).

Most resistance to BPI comes from within an organization. Managers often do not wish to change existing structures. The labor force may resist BPI because of fears of layoffs; however, an organization using BPI on a regular basis, argue many proponents, will already have the proper work force to meet existing business challenges.

Some organizations have implemented BPI on a smaller scale and reported success, by doing the following:

- Start with a small process that can be completed in a short time frame.
- Set clear timelines.
- Do not spread resources thinly and focus on the short-term payoff.
- Management and primary stakeholders must be involved, or else even a limited implementation will fail.

Processes need to align to business goals: An organization's strategic goals should provide the key direction for any Business Process Improvement exercise. This alignment can be brought about by integrating programs like Balanced Scorecard to the BPI initiative. e.g. When deploying Six Sigma, identification of projects can be done on the basis of how they fit into the Balanced Scorecard agenda of the organization.

Customer focus: Fast-changing customer needs underscore the importance of aligning business processes to achieve higher customer satisfaction. It is imperative in any BPI exercise that the "Voice of Customer" be known, and factored in, when reviewing or redesigning any process.

Importance of benchmarks: BPI tools place a lot of emphasis on "measurable results". Accordingly, benchmarks assume an important role in any BPI initiative. Depending on the lifecycle of the process in question, benchmarks may be internal (within the organization), external (from other competing / noncompeting organizations) or dictated by the senior management of the organization as an aspirational target.

Establish process owners: For any process to be controllable, it is essential that there be clarity on who is the process owners, and what constitutes success/failure of the process. These success/failure levels also help establish "control limits" for the process, and provide a healthy check on whether or not a process is meeting the desired customer objectives.

2.13 Quality Improvement Process

According to Juran (2000), The Quality improvement process should include the following. Zero defects planning: Proper planning is required for the concept of Zero Defect to become properly embedded in the company culture. It will have to start with a ZD commitment on the part of the top management.

Employee education: An investment in quality education can result in quantum leaps in improvement. A proper education system requires time and money, class work and assignments, explanatory videos and workshops, homework and team discussions in order to personalize the subject to the company concerned.

Zero defects day: He recommends a ZD day is planned to reward serious efforts, and is celebrated at least annually with speakers representing senior management, the customers, the unions and even the city or region. This will then act as a remainder of the importance of quality and as a demonstration of the commitment towards the ZD principle.

Goal setting: Goal setting is the immediate consequence of measurement. There is no point in measuring something unless there is a target to be met. When it comes to quality, the ultimate goal is that of zero defects, and all intermediate goals should move in that direction.

Error cause removal: The permanent removal of the causes of error requires a team effort. Adequate means of communication will ensure the sharing of the necessary information, which can help not only in the identification of the common sources of error and their permanent elimination, but also in the prevention of some problems arising in the future.

Juran (1992), The quality improvement process is never ending. The quality improvement process is never ending. To keep the momentum going, appropriate culture and attitude about quality have to be embedded throughout the organization.

Management Commitment: Senior management has to demonstrate a commitment to quality. This is the only way to convince the workers that management is not only serious about quality but also prepared to be involved in the process. A corporate policy on quality should be issued. The needs to be clear and unambiguous, and should be ideally based on the important promise of defect free delivery of products and services, on time.

Lowenthal, (2010), Voice of the customer is very important in the implementation of Six Sigma. Customers want products that fit their quality not just once in a while, but should be consistently. The customer's desire for quality in a product actually amounts to specifications for that product. The specifications may not be drawn up in a set of blue prints or a formal request. The customer's desire for reliability is the demand that those specifications be fulfilled consistently is the bottom line of the customer. Many of the companies realize that pleasing their customers and doing it consistently has a direct correlation to their profitability. The voice of the customer has four aspects. In essence he feels that Six Sigma involves understanding the customer's specifications for a product and customers desire for reliability, understanding fully the processes that are involved in producing that product and reducing variation in those processes to increase reliability.

Ram (2011), Six Sigma is a powerful methodology to improve business process. It is a structured approach to problem solving that can be applied any process, manufacturing, construction, production, HR etc. All processes have variation, and these variations are the reason for defects and customer dissatisfaction. Six Sigma methodologies can be used to reduce variation from any source and it improves Quality and customer satisfaction. DMAIC is the best methodology to reduce the defects and deviations.

2.14 Observed Research Gap

From literature survey following research gaps are observed and discussed here as:

- The construction industry mainly focuses on amount of productivity. But the need of the time is to focus on the quality management program which is performance-based.

- Though WPI (Worker Performance Index) was introduced as performance-based model but its major application was observed in construction process. Limited research has been observed in application of WPI model for worker selection for a construction project.
- The construction industry has witnessed the low productivity and job satisfaction due to varying reasons such as poor performance, financial problems, or poor pre-construction planning and poor management arising from the lack of adequate safety considerations on construction sites. Also, the current trend observed in the construction industry is to focus on the selection of worker not on the basis of their performance but on amount they work for and age, skill and experience of worker is not considered.
- There is less research work carried out for validation of the performance management techniques applied in construction industry.
- Even Six sigma analysis technique is rarely used in construction industry to rate the workers for the construction work carried out.

Chapter 3

Methods and Methodology

3.1 Worker Performance Index

Worker Performance Index (WPI) is a relatively new conceptual model developed by Centre for Project Management Excellence at University of Calgary. In this approach it is not the price but the quality of the performance that is given importance. WPI approach is specifically intended to get labour productivity and construction productivity with best performance of worker.

3.1.1 WPI Process

Initial list of all factors affecting labour performance was created using literature review. Based on site observations carried out in two building construction sites in Calgary, interviews conducted with project personnel and examinations of current worker rating systems were used to identify the initial list of factors. The identified critical factors to be used in the evaluation methodology are motivation, technical skills and management. Supervisors overall assessment of the worker is also considered as a critical input. Supervisor's evaluation gives the overall evaluation of the worker from an external point of view. Each performance factor consists of a

multitude of sub factors. When selecting the correct group of sub factors for the evaluation methodology the WPI tool has considered measurability and controllability as the selection criteria. Measurability is the ability to measure the particular sub factor using suitable scale (i.e. Likert), hence the factor is quantifiable. Controllability is defined as the ability to have control over the sub factor in order to improve it. (Chandana&Janaka2012)

a) Management Factors: This evaluates the worker records related to management procedures. It consists of the workers attendance, punctuality and safety records which are general to all of the workers.

b) Supervisor's Assessment: Immediate foremen use their experience to evaluate each worker based on qualities such achieving targets, workers attitude and morale, quality of work, leadership potential, learning potential (ability to learn and ability towork on own), oral communication skills, team spirit and finally supervisor overall recommendation about the worker. This assessment will give a feedback to the next supervisor who is taking over the site about the worker's current performance. To minimize personal influences, to reduce subjective judgments, and to keep the fairness to all the workers, immediate superiors have to re-confirm the assessment made by the foreman. The supervisor's assessment criteria must also be available to the workers to ensure fair and transparent assessment.

c) Motivation Level Factors: Jenkins Jr. and Laufer (1982) mentioned that motivation has a direct impact on work performance. It can be positively influenced or managed by external to the worker. Evaluation methodology for motivation factor was developed based on the Vroom's expectancy theory (1964). This is evaluation is a modification of the work of Gannoruwa and Ruwanpura (2008). In Expectancy Theory, motivation is defined as a function of expectancy, instrumentality, and valence.

Expectancy (EP) - expectancy is the worker's belief that effort leads to performance. Instrumentality (PO) is the belief that better performance leads to more outcome or output. Valence (V) - Valence describes how strongly the workers appreciate the outcomes or outputs of their personal performances.

3.2 Six Sigma Methodology

Six Sigma is measured in defects per million opportunities (DPMO). Six-sigma is an overall business improvement methodology that focuses an organization on

- Understanding and managing customer requirements.

- Aligning key business process to achieve these requirements.
- Utilizing rigorous data analysis to minimize variation in these processes.
- Driving rapid and sustainable improvement in the business process by reducing defects, sequence time, effect to the environment and other unwanted deviations.

Procedure development mentions to a strategy of discovering solutions to remove the basis causes of performance problems in processes. Process improvement efforts seek to fix problems by eradicating the origins of difference in the process whereas leaving the fundamental process together. In Six sigma terms, Process Improvement teams find the critical X's (i.e. causes) that creates the unwanted Y's (i.e defects) produced by the process.

Thus, process improvement teams use DMAIC; a popular six sigma analytic tool. The DMAIC process distinguishes five steps and has problematic problem solving and statistical tools. Each step has key goals and essential agent groups.

DMAIC stands for the following:

- Define Opportunities
- Measure Performance
- Analyze Opportunities
- Improve Performance
- Control Performance

This tool can be applied at various stages of construction projects. For instance,

1. **Detailed design stage:** To improve coordination method to reduce duplication of work.
2. **Construction stage:** Arranging the employer's table drawing and mating designs, as it needs much coordination among different trades.
3. **Scheduling stage:** Preparation of contractor's construction schedule.
4. **Execution of works:** Executing the contracting work.

3.3 Define Opportunities

What is Important?

The objective of this stage is to identify and / or validate improvement opportunities that will achieve the organization's objectives and provide greater reward and development of the business process, identify critical customer requirements, and prepare to act as the actual project team.

The key deliverables in this phase include:

- Team Character
- Action Plan
- Quick Win Opportunities

1. **Define the problem:** Problem should be based on measurable data and specific.
2. **Identify the customer:** Identification of the customer includes the analyses of problem impacts and a detailed analysis of COPQ (Cost of poor quality).
3. **Identify CTQ characteristics:** Identification of CTQ (Critical to quality) is the determination of the important issues for customers.
4. **Map the process:** A visual representation of the existing process should be prepared in order to look beyond functional activities and core process.
5. **Scoping the project:** Determination of specific project issues, a problem statement and brainstorm session are the purposes of scoping the project.

3.4 Measure Performance

How are we doing?

The objective of this phase is to identify critical measures that are necessary to evaluate success and failure, meeting critical needs of customers and starting developing a methodology effectively collect data to measure process performance. Also, to understand the elements of the Six sigma calculation laid the baseline for the operations analyzed by the team.

The key deliverables in this phase include:

- Input, process and output indicators
- Operational definitions
- Data Collection format and plans
- Baseline performance
- Productive team atmosphere

1. **Identify measurement and variation:** Types, sources, causes and detailed impacts of variation on process should be defined by the establishment of measurement.
2. **Determine data type:** Six Sigma team should define data types that will be collected. The main focus is to decide what kind of data and knowledge required for process improvement.
3. **Develop a data collection plan:** Data collection plan provides data collection responsible and data displaying formats.

4. **Perform measurement system analysis:** Graphical and baseline analysis should be performed through MSA (Measurement System Analysis) to ensure that the data collection plan works accurately and data is collected is confidential.
5. **Collect the data:** Collected data should be proper and provide enough information to Six Sigma team to identify the root causes of the problem.

3.5 Analyze Opportunities

***What is Wrong*?**

The objective of this phase is to stratify and analyze the opportunity to identify a specific problem. Also, to identify and validate the root causes that the team can thus focus on. To determine true sources of variation and potential failure modes that leads to customer dissatisfaction.

The key deliverables in this phase include:

- Data Analysis
- Validated root causes
- Sources of variation
- Problem statement
- Potential solutions

1. **Perform capability analysis:** Baseline capability should be realized in order to understand performance level of the process.
2. **Select analysis tools:** Six Sigma team should control the graphical analysis and decide which tools will be used in order to find the details of variation and performance.
3. **Apply graphical analysis tools:** A visual performance indications should be realized through graphical analysis techniques.
4. **Identify sources of variation:** Statistical tools are used in order to define the variations sources. The main focus in this step is to find and repair significant variations.

3.6 Improve Performance

What needs to be done?

The objective of this phase is to identify, evaluate and select the right improvement solutions. Also, to develop a change management approach to assist the organisation in adapting to the changes introduced through solution implementation.

The key deliverables in this phase include:

- Solutions
- Process maps and documentation
- Pilot Result
- Implementation milestones
- Improvement impacts and benefits
- Storyboard
- Change plans

1. **Generate improvement alternatives:** Focus of this step is to define, generate and evaluate the possible improvements.
2. **Create a "should be" process map:** Mapping of best improvement opportunities should be realized by Six Sigma team.
3. **Conduct FMEA (Failure Mode and Effect Analysis):** This analysis is used in order to make the situation analysis of “before the failure”.
4. **Perform a cost/benefit analysis:** Cost/Benefit analysis is the comparison between expected benefits and improvements costs.
5. **Conduct a pilot implementation:** The implementation of planned improvements should be conducted on a small scale.
6. **Validate improvement:** Sigma values before and after “Improve Stage” should be compared in order to understand the effect of process improvement.

3.7 Control Performance

How do we guarantee performance?

The objective of this phase is to understand the importance of planning and executing against the plan and determine the approach to be taken to ensure that the targeted results are achieved.

Also, to understand how to disseminate lessons learned, identify replication and standardization opportunities/processes and develop related plans.

The key deliverables in this phase include:

- Process control systems
- Standard Operating Procedures
- Training
- Team Evaluation
- Change Implementation plans
- Potential Problem Analysis
- Solution results
- Success stories
- Trained associates
- Replication Opportunities
- Standardization Opportunities

1. **Mistake-proofing:** Remove the error possibilities is the main focus of this step. It is important to remove errors before provoking defects in the process.
2. **Long-term MSA (Measurement System Analysis):** Data collection should be distributed over the long-term in order to measure and monitor inputs/outputs of process improvements through Measurement System Analysis.
3. **Appropriate and applicable charts (statistical process control):** Graphical representation of process should be realized in order to control processes with lower and upper limits.
4. **Reaction plan:** That is a detailed plan of controlling issues and necessary actions if the revised process is no longer under control.
5. **The new or revised SOPs (standard operating procedures):** Six Sigma team should periodically revise the existing documents and procedures in order to reflect improvements results.

3.8 Research Design

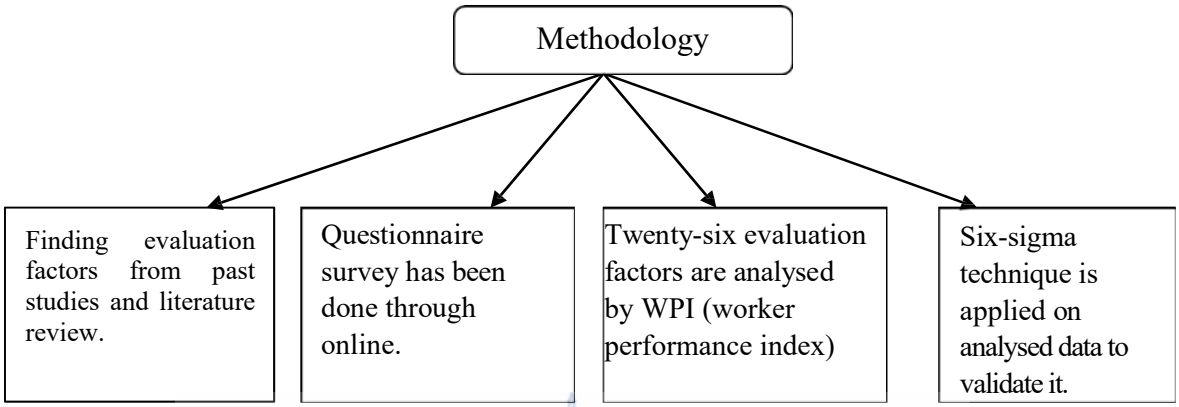

Figure 3.1 Process flow chart

This chapter comprises of the method and the design that was used to conduct the research. It was a quantitative research in which the data was collected using questionnaires. The population was made of clients, contractors, engineers and consultants who were selected by random sampling and convenience sampling technique. There was collection of both primary and secondary data. The primary data were obtained by means of questionnaires, while the secondary data were collected from the literature. In addition, this chapter also presents the questionnaire design, different sections of the questionnaire scale, as well as experimental work done as conducted to ascertain the reliability of the questionnaire. The research methodology chosen for this study comprised of intensive literature review, mail questionnaire, a conceptual model of WPI (worker performance index) and also to measure the performance of the same using six sigma technique.

Research design refers to the plan, which will be followed by the scientific research aimed at guiding the process of data collection and analysis.

This research consists of seven phases:

1. The first phase of the research is the proposal includes identifying importance of study, definition problems of the study; identify objectives of the study and development of study plan.
2. The second phase of the research is literature review including literatures and studies related to the worker performance in construction projects were reviewed.
3. The third phase of the research includes the questionnaire design through Google form and distribution, making interviews with engineers, managers, academics and others to know the management factors affecting worker performance in construction projects.

4. The fourth phase of the research was distributing questionnaire, through social media about 65 questionnaires were distributed among local contractors, engineering consultants, engineers and clients to collect the necessary information and data that will help in achieving the objective of the study.
5. The sixth phase of the research includes analysis of data and discussion of it by using WPI model.
6. Defect were calculated in worker performance using six sigma technique.
7. The last phase of the research includes the conclusions and recommendations.

3.9 WPI Development Process

Initial list of all factors affecting labour performance was created using literature review. Based on site observations carried out in two building construction sites in Calgary, interviews conducted with project personnel and examinations of current worker rating systems were used to identify the initial list of factors. The identified critical factors to be used in the evaluation methodology are motivation, and management. Supervisors overall assessment of the worker is also considered as a critical input. Supervisor's evaluation gives the overall evaluation of the worker from an external point of view. Each performance factor consists of a multitude of sub factors. When selecting the correct group of sub factors for the evaluation methodology the WPI tool has considered measurability and controllability as the selection criteria. Measurability is the ability to measure the particular sub factor using suitable scale (i.e. Likert), hence the factor is quantifiable. Controllability is defined as the ability to have control over the sub factor in order to improve it.

a) **Management Factors:** This evaluates the worker records related to management procedures. It consists of the workers attendance, punctuality and safety records which are general to all of the workers.

Factor score for management (FSmgmt) is obtained after totalling subcomponent. Likert values under that factor.as shown in Table 3.1.

Table 3.1 Management Factors evaluation (Siriwardana, & Ruwanpura, 2012)

Sr no.	Management Factors (FSmgmt)
1	Attendance
2	Punctuality
3	Safety Record

$$FS_{Mgmt} = \sum(SC_{Mgmt1} + SC_{Mgmt2} + SC_{Mgmt3}) \quad (1)$$

b) **Supervisor's Assessment:** Immediate foremen use their experience to evaluate each worker based on qualities such achieving targets, workers attitude and morale, quality of work, leadership potential, learning potential (ability to learn and ability to work on own), oral communication skills, team spirit and finally supervisor's overall recommendation about the worker. This assessment will give a feedback to the next supervisor who is taking over the site about the worker's current performance. To minimize personal influences, to reduce subjective judgments, and to keep the fairness to all the workers, immediate superiors have to re-confirm the assessment made by the foreman. The supervisor's assessment criteria must also be available to the workers to ensure fair and transparent assessment.

In a similar process factor score for Supervisors Assessment (FSsup) is obtained after totalling subcomponent Likert values under that factor.as shown in Table 3.2.

Table 3.2 Supervisor's Assessment evaluation (Siriwardana, & Ruwanpura, 2012)

Sr no.	Supervisor's Assessment (FSsup)
1	Achieving targets
2	Quality of work
3	Attitude and morale
4	Leadership potential
5	Learning potential
6	Oral communication skills
7	Team work
8	Overall recommendation

$$FS_{Sup} = \sum(SC_{Sup1} + SC_{Sup2} + \cdots + SC_{Sup8}) \quad (2)$$

c) **Motivation Level Factors:** Jenkins Jr. and Laufer (1982) mentioned that motivation has a direct impact on work performance. It can be positively influenced or controlled from outside the employee. Evaluation methodology for motivation factor was developed based on the Vroom's expectancy theory (1964). This evaluation is a modification of the work of Gannoruwa and Ruwanpura (2008) and Gannoruwa (2008). In Expectancy Theory, motivation is defined as a function of expectancy, instrumentality, and valence.

Expectancy (EP) - expectancy is the worker's belief that effort leads to performance. Instrumentality (PO) is the belief that better performance leads to more outcome or output. Valence (V) - Valence describes how strongly the workers appreciate the outcomes or outputs of their personal performances.

Factor score for motivation (FSMo) is calculated by the theory developed by Vroom (1964). Effort to Performance (EP) - Value is obtained by taking the average Likert value of the subcomponents under Effort to Performance category under Motivation Factor in Table 3.3.

Table 3.3 Management factors evaluation (modified from Hewage et al. 2011)

Sr no.	Motivational Level Factors (FSmo)
1	**Effort to Performance (SAep)**
1.1	Fairness in treating
1.2	Justice
1.3	Language styles
1.4	Feeling of in-group
1.5	Availability of instruction
1.6	Group attachment
2	**Performance to Outcome (SApo)**
2.1	Fairness (in reward setting)
2.2	Group construction
2.3	Gang work
2.4	Work performance link with outcome
2.5	Emotional strength of foremen
3	**Valence (SAv)**
3.1	Equality of reward (extrinsic and intrinsic)
3.2	Earning more money
3.3	Importance of incentives
3.4	Performance according to outcome

In a similar process Performance to Outcome (PO) and Valence (V) was obtained by taking the average Likert value of the subcomponents under Performance to Outcome category and Valence category Motivation Factor in table 3.3.

Total score for Motivation Factors (FSmo) is given by,

$$FS_{mo} = \sum\left(SA_{Ep} + SA_{Po} + SA_{v}\right) \quad (3)$$

Worker Performance Index (WPI) is calculated by totaling all factor scores values.

$$WPI = FS_{Mgmt} + FS_{Sup} + FS_{Mo} \quad (4)$$

3.10 Validation Using Six Sigma Technique

The next process is to validate the work of the worker performance index using Six Sigma Analysis. The worker performance is filtered from initial three filtration steps is termed as worker performance index. To verify and set a standard WPI for the workers to perform well, six sigma technique would be applied on his previous similar kind of performance. Defect measurement sheet would be generated in which the observed defects of the project would be marked. The defect also includes the time parameters. These defects would be quantified using

six sigma equations and tables. On the observed data collected, Defect per Million Opportunity (DPMO) is calculated using Eq. 4 (Han et al. 2008).

$$DPMO = \frac{(No.of\ Defects\ in\ data\ assessment\ sheet)}{No.of\ Opportunities\ of\ defects \times\ No.of\ Units} \times 1{,}000{,}000 \quad (4)$$

Based on $DPMO$, using sigma conversion as shown in Table 3.4, the sigma level is calculated for the contractor.

Table 3.4 Overview of Sigma Levels & DPMO

Yield	DPMO	Sigma Level
69.2	3,08,000	2
93.3	66,800	3
99.4	6,210	4
99.98	320	5
99.9997	3.4	6

On the Basis of Sigma Level attained by the worker, the worker performance would be verified using WPI. A relationship can be obtained between both the Performance Management Techniques using the Validation process.

Chapter 4

Results and Discussions

4.1 General

The results were calculated and discussed on the basis of in assessing overall employee productivity and job satisfaction where respondents were asked to indicate their degree of responses on varying from 5 (Strongly Agree) to 1 (Strongly Disagree) with equal weightages assigned to each 26 sub components of management factor, and a score less than or equal of 2 are considered to be not satisfied. Further the same was validated using six-sigma.

4.2 Findings from WPI

From 54 responses received back, the worker performance was evaluated. On the basis of average rating for each worker performance was calculated. On the basis of Likert scale, WPI was allotted to worker and as per Weighted Scale, relative weight was set for each worker. Thus, it can be stated as higher the WPI value of worker, higher will be the performance. The successful distribution of WPI can be studied from Table 4.1. Average WPI of 54 workers according to management factors and average overall WPI of 54 workers is shown in Table4.2. Fig. 4.1 shows the average WPI.

Table 4.1 WPI (Worker performance index)

Worker's	Average Management Factor WPI	Average Supervisors Assessment WPI	Average Motivational Level Factor WPI
W1	1.3	2	2.1
W2	1.0	1.25	2.5
W3	3.7	4.125	3.9
W4	3.0	3.0	1.7
W5	1.0	2.4	2.0
W6	5.0	4.3	3.9
W7	4.7	4.5	4.5
W8	3.0	2.5	2.3
W9	3.7	4.1	3.5
W10	1.0	1.0	1.1
W11	3.0	4.9	4.0
W12	3.3	3.8	4.2
W13	4.3	4.4	4.6
W14	2.7	4.4	4.1
W15	2.7	2.0	2.0
W16	1.0	2.0	1.8
W17	3.0	3.9	3.9
W18	3.0	4.5	4.5
W19	4.3	3.8	3.7
W20	3.3	4.3	3.5
W21	2.0	3.3	3.1
W22	5.0	4.8	4.2
W23	3.3	4.4	4.0
W24	1.0	1.0	1.0
W25	3.0	4.6	4.8
W26	3.0	2.1	2.2
W27	3.7	3.5	3.6
W28	3.3	3.0	3.6
W29	4.7	5.0	4.6
W30	4.0	3.3	3.9
W31	3.3	2.4	3.3
W32	5.0	4.6	4.7
W33	5.0	4.0	3.9
W34	4.0	3.6	3.6
W35	4.7	4.3	3.6
W36	2.7	3.9	3.9
W37	4.0	2.9	4.3
W38	4.0	3.8	3.5
W39	3.0	2.1	2.3
W40	4.0	4.4	3.6
W41	5.0	2.9	4.7
W42	1.7	2.3	1.5
W43	1.0	1.0	1.5
W44	1.0	1.1	1.3
W45	2.7	4.6	4.3
W46	3.3	2.6	3.2
W47	3.7	4.1	3.9
W48	3.7	3.0	2.1
W49	4.3	4.0	4.5
W50	3.0	3.3	3.0
W51	4.0	4.9	4.4
W52	1.3	1.4	1.3
W53	2.0	1.5	3.1
W54	3.7	2.4	3.7

Table 4.2 Average WPI Of Workers

Sr no.	Evaluation factors	Attributes	WPI of each worker	Overall WPI
1	Management factor	Attendance	3.1	3.3
2		Punctuality		
3		Safety Record		
4	Supervisor's Assessment evaluation	Achieving targets	3.3	
5		Quality of work		
6		Attitude and morale		
7		Leadership potential		
8		Learning potential		
9		Oral communication skills		
10		Team work		
11		Overall recommendation		
A	Motivational Level Factors	**Effort to Performance (SAEp)**	3.3	
12		Fairness in treating		
13		Justice		
14		Language styles		
15		Feeling of in-group		
16		Availability of instruction		
17		Group attachment		
B		**Performance to Outcome (SAPo)**		
18		Fairness (in reward setting)		
19		Group construction		
20		Gang work		
21		Work performance link with outcome		
22		Emotional strength of foremen		
C		**Valence (SAv)**		
23		Equality of reward (extrinsic and intrinsic)		
24		Earning more money		
25		Importance of incentives		
26		Performance according to outcome		

The above table 4.2 shows the average employee performance index of 54 workers where WPI based on the management factors was 3.1 and that the supervisor weighting factors and motivational factors was 3.3 & 3.3.

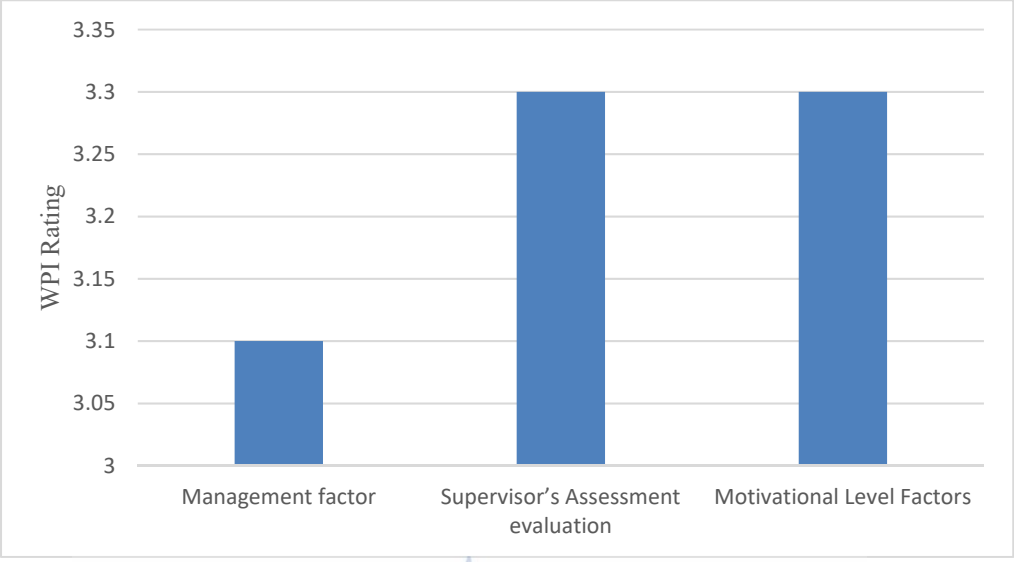

Figure 4.1 Average WPI of worker

Table 4.2 and Figure 4.1, shows the average worker performance index of 54 workers where, WPI on the basis of management factors was 3.1 and that of supervisor's assessment factors and motivational level factors was 3.3 & 3.3 respectively. The success of every organization depends on its employee productivity and their performance. There was need to quantify the performance of the worker.

4.3 Findings from Six Sigma Model

The defects in performance of workers was validated on the basis of Likert scale rating with respect to the worker performance index scored by worker. The data assessment sheet as shown in appendix-I was prepared wherein data were collected. The worker scored rating 1 and 2 on Likert scale was considered as defects, where 1 stands for very poor performance, 2 stands for poor performance, 7where 3,4 and 5 stands for average, good and excellent. The defect measurement observed were converted into DPMO as shown in Table 5.3. The Sigma Level observed based on DPMO was **4.88.** Since this defect calculation also included time delays parameter while assessment, hence it is also observed that the project execution was completed within the stipulated time. Thus, WPI is also capable of overcoming management issues in construction projects.

Table 4.3 Sigma Level Calculation

Sr no.	Evaluation factors	No. of Units Observed	Defects observed in Assessment Sheet	Opportunities	DPMO	Six-sigma
1	Management factor	Attendance	12	54	986.193	4.88
2		Punctuality	15	54		
3		Safety Record	15	54		
4	Supervisor's Assessment evaluation	Achieving targets	17	54		
5		Quality of work	13	54		
6		Attitude and morale	15	54		
7		Leadership potential	16	54		
8		Learning potential	17	54		
9		Oral communication skills	19	54		
10		Team work	14	54		
11		Overall recommendation	15	54		
A	Motivational Level Factors	**Effort to Performance (SAEp)**				
12		Fairness in treating	15	54		
13		Justice	14	54		
14		Language styles	17	54		
15		Feeling of in-group	12	54		
16		Availability of instruction	16	54		
17		Group attachment	16	54		
B		**Performance to Outcome (SAPo)**				
18		Fairness (in reward setting)	14	54		
19		Group construction	14	54		
20		Gang work	14	54		
21		Work performance link with outcome	8	54		
22		Emotional strength of foremen	18	54		
C		**Valence (SAv)**		54		
23		Equality of reward (extrinsic and intrinsic)	15			
24		Earning more money	13	54		

25		Importance of incentives	11	54		
26		Performance according to outcome	15	54		
Total		26	360	1404		

Thus, from above Table 4.3, it can validate the result obtained by WPI. The workers selected on basis scores high sigma level value. Hence the worker performance could be predicted for construction projects based on the sigma assessment sheets. Many studies have been conducted on WPI but yet no margin or minimum acceptable value of WPI was established. Thus, there was need to implement six sigma technique to set an acceptable value of WPI. Table 4.3 shows the defects in the worker performance with respect to their opportunity's factors and subcomponent of the factors. Using equation 4, DPMO was calculated as shown in Table 4.3. Thus, using the DPMO value & Table 3.4 sigma level was obtained as 4.88, which indicates the WPI rating is not acceptable.

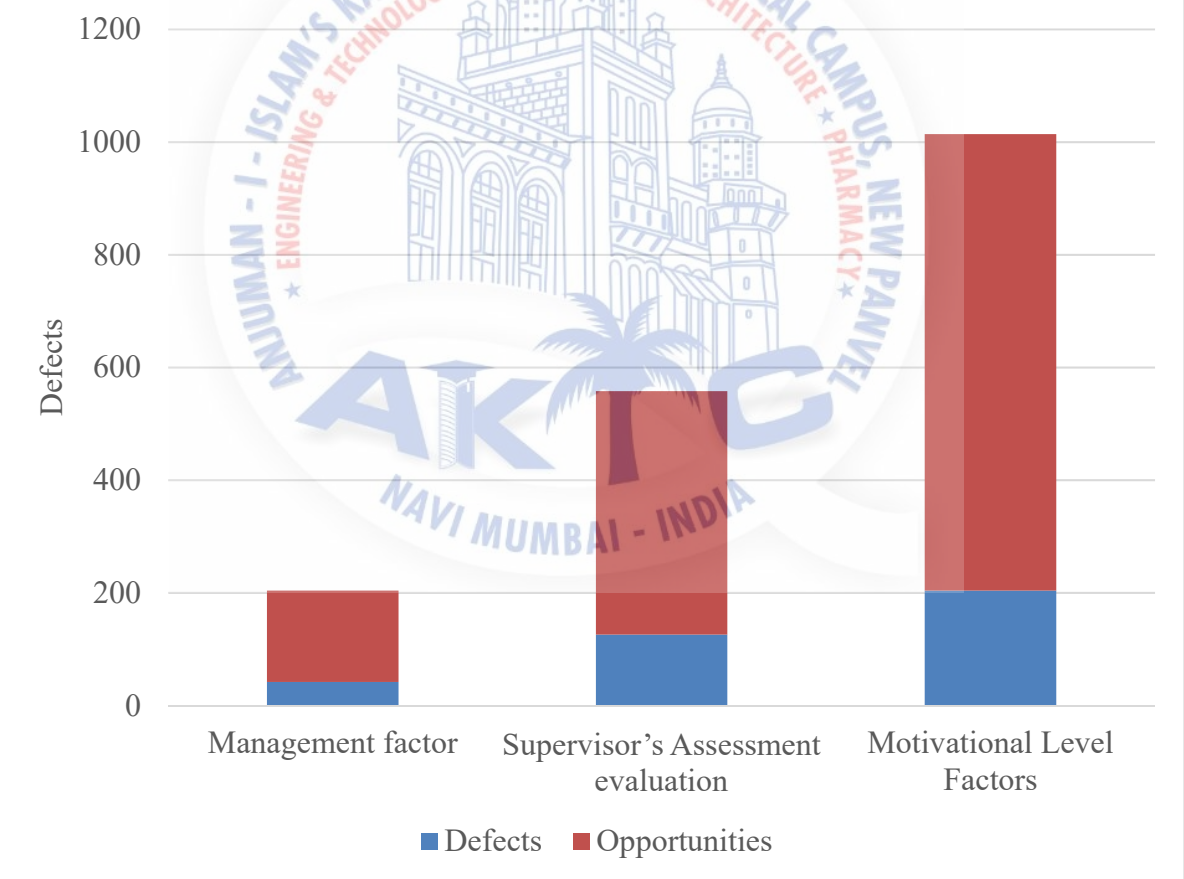

Figure 4.2 Defects vs Opportunities

Figure4.2 shows the defects with respect to opportunities where, bar in blue denotes the defects from the total opportunities of their respected factors. Management factors shows the good performance of worker whereas supervisors assessment factor and motivational factors have

very high defects which shows that these two factors affect the worker performance and construction performance. The figure also shows that the supervisor's factor and motivational factor has high effect on the performance of the worker which may also affect the job satisfaction and construction productivity.

Chapter 5

Summary and Conclusions

5.1 Summary

The entire study is about improving worker productivity and performance in construction project in terms of quality, productivity, job satisfaction etc. This can be brought about by selecting the appropriate the project managers and supervisors. The study shows that low-cost worker is given preference for project execution, which often effects project schedule and quality. Thus, this study examines the worker's performance by focusing on choosing appropriate workers by best WPI model, so that the project execution can be carried out appropriately considering effective productivity and economic construction. Also, this study is accompanied with the validation of the WPI model by using Six Sigma Analysis. Thus, using Six Sigma analysis, the sigma level of the workers could be predicted, and on basis of this prediction the performance of workers can be improved for the future project tasks. On basis of these techniques, through complete analysis, each worker performance was evaluated and selected and based on the sigma level, conclusion of the research work was made.

5.2 Conclusion of the experimental program

Worker performance index has been evaluated in this paper considering management, supervisor assessment and motivation to assess the workers. Proposed evaluation format of WPI is capable of acquiring data based on multitude of indicators of worker performance. Therefore, this information can used to perform an in-depth analysis and to compare and contrast different categories of workers. The evaluation successfully assisted to test the concept of WPI in identifying different structured groups. Furthermore, this concept can be extended to represent worker group performance levels. This method can be used as a basis for creating worker crews with predictable performance or outcomes. In addition to planning, this methodology can also be applied to monitor workers individually as well as in groups in order to identify critical changes in performance and take corrective actions as necessary. Potential limitations of this methodology include opposition by labour unions and difficulty when applying to large working groups.

Even from Six sigma model results, it is found that each worker has minimum number of defects in his project works carried out. thus, on the basis of no. of defects assessed and no. of opportunities to assess the defects, the sigma level of workers could be achieved. This sigma level can also give prediction of the reliability of the worker performance in the future projects to be carried out. Thus, in this research work, on basis of sigma level obtained, it can be concluded that WPI model proves to be successful for obtaining the suitable worker for a construction project with minimum defects with respect construction performance.

5.3 Future Scope

- The above studied model proved to be reasonable and feasible, and showed a satisfactory performance. It also demonstrated its ability to predict the suitable candidates.
- Future work will include incorporating remaining factors such as technical skills factor to develop a comprehensive analysis of construction workers performance indices using a soft computed generalised project-based model, which will carry a complete regional database of workers.
- This worker can be defined by the sigma levels on basis of their performance certificates and validation of previous works.

- Also, the weighted scale can be developed by Analytic Hierarchy Model, Multi-criteria model and compared with the current system of WPI.

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APPENDIX-I

Defects of Management Factors

WORKER'S	Management factors evaluation form [Attendance]	Management factors evaluation form [Punctuality]	Table 1: Management factors evaluation form [Safety Record]
W1	1	1	2
W2	1	1	1
W3	3	4	4
W4	3	3	3
W5	1	1	1
W6	5	5	5
W7	5	5	4
W8	3	3	3
W9	4	4	3
W10	1	1	1
W11	3	3	3
W12	3	4	3
W13	5	4	4
W14	2	3	3
W15	3	3	2
W16	1	1	1
W17	4	4	1
W18	3	3	3
W19	5	4	4
W20	3	3	4
W21	2	2	2
W22	5	5	5
W23	3	3	4
W24	1	1	1
W25	3	3	3
W26	3	2	4
W27	3	4	4
W28	3	3	4
W29	4	5	5
W30	4	4	4
W31	3	3	4
W32	5	5	5
W33	5	5	5
W34	4	4	4
W35	5	5	4

W36	3	2	3
W37	4	3	5
W38	5	4	3
W39	3	3	3
W40	4	4	4
W41	5	5	5
W42	2	1	2
W43	1	1	1
W44	1	1	1
W45	2	3	3
W46	5	2	3
W47	4	4	3
W48	5	5	1
W49	4	4	5
W50	3	3	3
W51	4	4	4
W52	1	2	1
W53	3	2	1
W54	4	3	4
No. of defects	12	15	15
No. checks	162		

Defects of Supervisor's Assessment Factors

WORKER'S	Supervisor's Assessment [Achieving targets]	Supervisor's Assessment [Quality of work]	Supervisor's Assessment [BAttitude and Morale]	Supervisor's Assessment [Leadership potential]	Supervisor's Assessment [Learning potential]	Supervisor's Assessment [Oral communication skills]	Supervisor's Assessment [Team work]	Supervisor's Assessment [Overall recommendation]
W1	2	3	1	3	1	2	1	3
W2	1	1	1	1	2	2	1	1
W3	4	4	3	4	5	4	5	4
W4	3	3	3	3	3	3	3	3
W5	1	1	2	2	3	3	3	4
W6	4	5	3	4	4	5	5	4
W7	4	4	4	4	5	5	5	5
W8	2	3	3	2	2	3	3	2
W9	5	5	5	3	4	3	3	5
W10	1	1	1	1	1	1	1	1
W11	4	5	5	5	5	5	5	5
W12	3	4	4	4	5	4	3	3
W13	4	5	5	4	4	5	4	4
W14	4	5	3	5	5	4	5	4
W15	2	2	2	2	2	2	2	2
W16	2	2	1	2	2	3	2	2
W17	5	5	3	4	4	4	4	2
W18	4	5	4	4	4	5	5	5
W19	4	3	3	5	3	2	5	5
W20	4	5	4	4	5	3	5	4
W21	3	4	4	3	3	2	4	3
W22	4	5	5	5	5	5	4	5
W23	4	5	4	5	4	4	5	4
W24	1	1	1	1	1	1	1	1
W25	4	4	4	5	5	5	5	5

W26	2	3	2	3	2	3	1	1
W27	3	3	4	4	4	3	4	3
W28	4	4	3	3	3	2	2	3
W29	5	5	5	5	5	5	5	5
W30	4	3	3	3	3	3	3	4
W31	2	2	3	2	3	2	3	2
W32	4	5	4	4	5	5	5	5
W33	5	5	3	5	4	2	5	3
W34	3	4	4	3	3	4	4	4
W35	4	4	4	4	4	5	4	5
W36	3	4	3	4	5	5	4	3
W37	4	3	3	2	2	3	3	3
W38	4	3	4	3	4	4	4	4
W39	2	3	1	2	3	3	2	1
W40	4	4	4	5	4	5	5	4
W41	3	3	3	3	3	2	3	3
W42	2	2	2	2	2	2	3	3
W43	1	1	1	1	1	1	1	1
W44	1	1	1	1	1	2	1	1
W45	5	5	4	4	5	5	4	5
W46	4	3	3	2	2	2	3	2
W47	4	4	4	3	5	4	5	4
W48	1	5	1	5	1	1	5	5
W49	3	4	4	5	4	4	4	4
W50	3	3	3	3	3	3	5	3
W51	5	5	5	4	5	5	5	5
W52	1	1	1	1	2	2	2	1
W53	2	2	1	2	1	1	1	2
W54	3	2	3	3	1	2	2	3
NO. OF DEFECTS	17	13	15	16	17	19	14	15
NO. OF CHECKS	432							

Defects of Motivational Level Factors

WORKER'S	Effort to Performance (EP) [Fairness in treating]	Effort to Performance (EP) [Justice]	Effort to Performance (EP) [Language styles]	Effort to Performance (EP) [Feeling of in-group]	Effort to Performance (EP) [Availability of instruction]	Effort to Performance (EP) [Group attachment]	Performance to Outcome (PO) [Fairness (in reward setting)]	Performance to Outcome (PO) [Group construction]	Performance to Outcome (PO) [Gang work]	Performance to Outcome (PO) [Work performance link with outcome]	Performance to Outcome (PO) [Emotional strength of foreman]	Valence (V) [Equality of rewards (Extrinsic and intrinsic)]	Valence (V) [Earning more money]	Valence (V) [Importance of incentives]	Valence (V) [Performance according to outcome]
W1	2	1	3	3	2	1	1	1	2	3	3	1	3	3	3
W2	3	4	2	3	1	5	2	3	1	3	2	1	3	4	1
W3	4	3	4	4	4	4	4	5	5	4	4	4	4	3	3
W4	2	1	1	2	1	1	2	2	2	3	2	1	1	3	2
W5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
W6	3	5	3	4	4	4	4	5	3	3	3	4	5	5	3
W7	4	5	5	5	5	5	4	5	5	5	5	3	3	4	4
W8	3	2	3	2	2	3	2	2	3	2	2	3	2	2	2
W9	2	3	4	4	4	4	4	3	3	4	5	1	5	5	1
W10	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
W11	4	5	4	2	4	1	5	5	3	4	5	5	4	5	4
W12	4	4	3	4	5	4	4	4	5	4	4	4	4	5	5
W13	5	5	4	4	5	5	4	5	5	5	5	5	4	4	4
W14	4	4	5	4	4	5	4	3	5	4	4	3	4	4	5
W15	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
W16	2	2	2	3	2	2	1	1	3	3	2	1	1	1	1
W17	5	4	3	3	4	3	5	4	3	3	2	4	5	5	5
W18	4	4	4	4	5	5	5	5	4	5	4	5	4	5	4
W19	4	3	3	4	4	3	3	4	5	5	3	2	4	5	4
W20	4	3	3	3	3	3	3	4	4	3	3	4	4	4	4
W21	2	3	2	3	3	4	3	4	3	4	4	3	3	3	3
W22	5	5	5	5	5	5	3	3	2	3	3	4	5	5	5
W23	4	5	4	4	4	5	4	3	4	4	5	4	3	4	3

W24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
W25	4	4	5	5	5	5	5	5	5	5	5	5	4	5	5
W26	2	3	1	3	3	2	1	3	2	3	2	3	2	1	2
W27	3	3	4	4	3	4	4	4	4	4	3	4	3	4	3
W28	4	3	3	3	3	3	3	4	4	4	4	3	5	4	4
W29	4	5	3	4	5	5	5	5	5	5	4	5	5	5	4
W30	3	4	3	3	3	4	4	4	4	5	4	3	5	5	5
W31	3	3	3	3	4	4	3	4	3	3	3	3	4	4	3
W32	5	5	4	5	4	5	5	5	4	4	4	5	5	5	5
W33	5	5	1	2	3	5	5	5	5	4	1	4	4	5	5
W34	3	4	3	4	4	4	4	4	4	4	4	3	3	3	3
W35	4	3	4	3	4	4	3	3	4	4	3	3	4	4	4
W36	4	5	3	3	4	4	3	4	4	4	4	3	4	4	5
W37	5	5	4	3	5	4	5	3	3	5	3	5	5	5	5
W38	4	3	4	3	4	3	4	3	4	4	3	3	4	3	4
W39	1	2	3	3	2	1	3	2	3	3	2	2	2	2	3
W40	4	4	4	4	4	4	4	3	1	3	4	3	4	4	4
W41	4	5	5	5	4	4	4	5	5	5	5	5	5	4	5
W42	1	1	2	1	1	1	1	1	2	2	2	2	2	2	2
W43	2	1	1	3	1	2	1	2	1	3	1	1	1	1	1
W44	1	1	1	1	1	1	1	1	1	3	2	1	1	3	1
W45	5	5	5	4	4	4	5	4	4	4	4	4	4	4	4
W46	3	4	2	3	2	2	3	2	3	4	4	3	5	4	4
W47	4	4	4	4	4	5	4	5	5	4	4	3	3	3	3
W48	3	1	1	1	1	3	3	3	3	3	1	1	3	3	1
W49	4	4	5	3	4	5	5	5	5	4	4	4	5	5	5
W50	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
W51	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4
W52	1	1	1	2	1	1	2	2	1	1	2	1	1	1	2
W53	4	4	2	3	3	2	3	3	3	2	2	3	5	5	3
W54	4	3	5	4	4	4	4	4	4	3	3	3	4	4	3
No. of defects	15	14	17	12	16	16	14	14	14	8	18	15	13	11	15
No. of checks	810														

LIST OF PUBLICATIONS

"Evaluation of Worker performance in Construction Project Using Six Sigma", Proceedings of National Conference "Advanced Structures, Materials and Methodology in Civil Engineering" (ASMMCE 2018), NIT Jalandhar.

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