study on reduction of cost overrun and time delay in building construction using six sigma

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Abstract - **There have been a lot of defects in recent years and errors may occur in a regular construction routine. In the construction of buildings, mistakes are very common. The time, complexity, budget and schedule of the proposed project can be affected by these major and some minor defects. The intent of this project is to identify and analyze the major and minor contributing problems and their corresponding defects happening in onsite construction work progress namely (Marking layout, Excavation, Foundation and Construction of brick walls) that they are responsible for causing cost overrun and time delay in construction management and also in this project six-sigma technique was implemented to rectify such defects and also the principle named as (DMAIC-Define, Measure, Analyze, Improve and Control) was incorporated to segregate and minimize such defects in each activities. And then the improve measures are recommended as well as the control plan was tabulated to control those defects and to secure the construction work progress from cost-overrun and time delay and control.**

keywords - **six- sigma, cost overrun, time delay, reducing defects, on-site activities.**

I. INTRODUCTION

To construct a building, it consists of some sequence to properly construct it. There were many issues during the construction of the building and the workers will face problems while the work is in progress, as a consequence of these issues and difficulties there were many errors that could cause and also affect the cost and time of the project. In an organization, respondents who are responsible for properly running the project with the main factor material quality, customer satisfaction, contractor responsibilities, labor and equipment availability, resource allocation, proper scheduling, proper estimation and planning of design and documentation and also include the external factors that all influence the project's efficiency, all of these factors must be taken into consideration when doing the work. Sometimes, these factors influencing major defects in projects that affects the projects time and cost. If in a construction industry the time and cost affected by these above factors it results in construction delays. The cost overrun and time delay affects the project's scope, quality and customer satisfaction. Since the building's problems in construction projects have increased, there is serious need to focus on the quality of building constructions industry.

Even though Six Sigma has been employed in the manufacturing and other industries, it is quite a fairly new impression in the construction project. Six Sigma's incorporation in the construction project has resulted in a gap in understanding of common problems in the construction industry that can serve as a guide for contractors and construction managers to help achieve a competitive quality level and a cost-effective project. The use of six sigma principles for the processes give a systematic approach to identify the defects, their root causes and gives a solution to improve them.

II. SIX-SIGMA EXPLANATION

Six Sigma is a series of process management methods and tools. A six-sigma method is one that it is theoretically predicted that 99.99 percent of all possibilities to manufacture any element of a component would be free from defects. By finding and eliminating the causes of errors, a six-sigma technique aims to increase the efficiency of the performance of a process. Six sigma is a possibility improvement theory informed by simple evidence that emphasizes defect avoidance over identification of defects. By trying to reduce variance, waste and cycle time while encouraging the use of job uniformity and flow, it drives consumer satisfaction and real issue outcomes, thereby contributing to sustainable development.

Six sigma provides tools and strategies for minimizing variance, removing defects and helping to recognize the root causes of mistakes, enabling companies to produce better consumer goods and services. Six Sigma is a definition which, in terms of defects, measures a mechanism. In the construction process, the motive for the use of six sigma principles is to reduce the variance in each process. Six Sigma is nothing but an average variance. The upper and bottom control limit range of ±6 sigma from the mean is allowed by Six Sigma. The defects beyond the acceptable limit are calculated by Six Sigma. The measured defects are then translated to defects per million possibilities, and also the quantitative levels of sigma are defined. Six sigma seems to have become the quality standard that is widely accepted. The word six sigma (6σ) emerged as a metric of efficiency or a quality measure. Six Sigma has now emerged as a customer performance management technology and then also focuses on quality, reduced costs and quality assurance.

III. DMAIC METHODOLOGY

The DMAIC method is used primarily for improving existing processes. **Figure.1** shows the flowchart for DMAIC methodology,

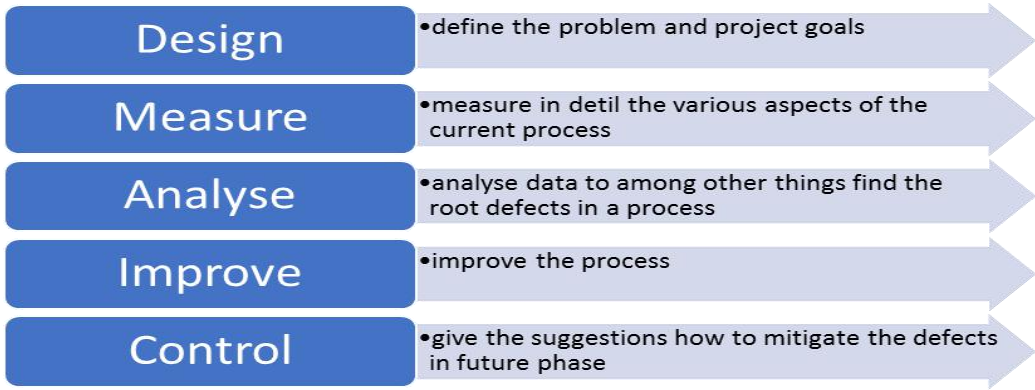

Fig.1 DMAIC methodology

IV. METHODOLOGY

The methodological framework of the study describes that the step-by-step procedure of the work to be carrying out in this paper. At the start of the project the site should be selected and identify the problems which contributing more in ongoing work of the building construction. Why means, these problems causing major defects in the construction buildings. In this paper, the problems are identified specifically from the selected activity in ongoing construction work such as (marking layout, excavation, foundation and construction of brick walls). After that, the questionnaire survey report is prepared based on the existing papers and existing construction defects, then the data collected from various construction companies and prepare the defect assessment table from that data collected. After that, the sigma level can be calculated from the method of DPMO (Defects per million opportunities). The entire process going to be done on the basis of one of the six-sigma methodology called DMAIC methodology. **Figure.2** shows the framing of methodological process.

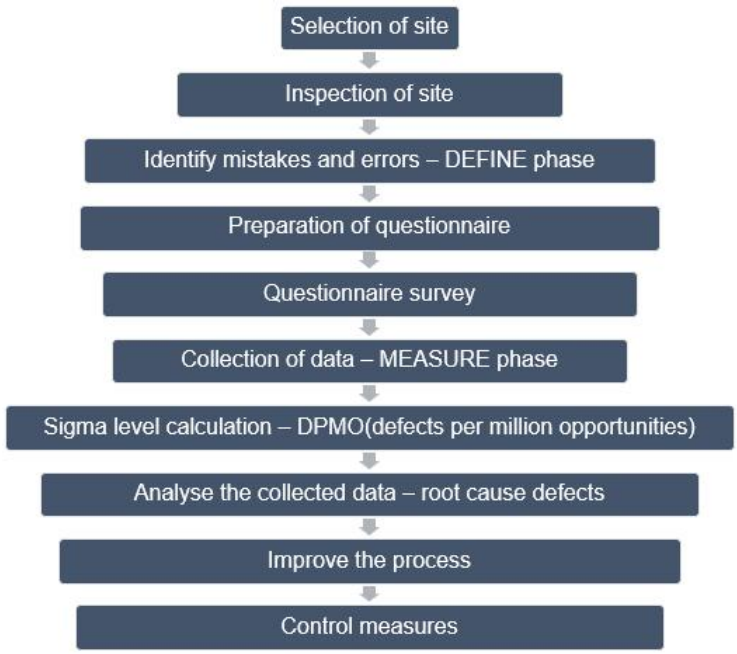

Fig.2 – Methodology flow chart

V. FACTORS EVALUATION

Three construction activities are used in this project to analyze flaws using the DMAIC approach. The three activities include layout and excavation, foundation work, and brick wall construction.

Defects per million opportunities (DPMO)

DPMO = (total number of defect occurrence/total number of defect possibilities)*1000000
Total number of occurrences = 309
Total number of defects possibilities = 30*19 = 570
DPMO = (309/570)*1000000 = 542105.26
Yield = 1-DPO
DPO = 542105.26/1000000 = 0.5421
Yield = 1-0.5421 = 0.4578
Yield % = 45.7%

By referring the sigma performance level table for this project from the detected data the result came as it closer to 2 σ level. So that there was need to suggest some improvement measures to control the defects and problems to reduce the cost overrun and time delay in building construction activities.

Table 1 Defects Assessment Table

S .No	Activity	Defects	No of occurrence of defects
1.	Marking layout and Excavation	Dewatering	23
		Inaccurate marking	20
		Manual dressing	18
		Soil sliding	21
2.	Foundation	Cracks in walls above affected section of building	15
		Cracks in foundation	24
		Displacement movement of building section	15
		Walls move out of plumb	6
		Expansion and deterioration of cement mortar and concrete below G.L	12
		Leakages	25
		Spalling of concrete	15
3.	Construction of brick walls	Cracks in walls	19
		Undulation	16
		Fall of plaster	18
		Moisture shrinkage	17
		Non- structural cracks	15
		Popping	6
		Moisture expansion	18
		Masonry cladding	6

DMAIC Principle

This step-by-step procedure of DMAIC methodology can be explain how the progress of the work is undertake in this project. In DMAIC methodology it consists of totally five step such as,

Fig. 3 Five step DMAIC method

This each step is the key matter to improve the quality of the project from the beginner stage of the project and also trying to neglecting the construction defects and finally help to increase the sigma level.

VI. ANALYSIS AND RESULT

Define phase

There are four basic types of faults that might develop throughout the marking, layout, and excavation processes. Dewatering, manual dressing, imprecise marking, and soil sliding are the flaws. These flaws could lead to poor construction quality and dissatisfied customers. As a result, additional time and cost are allocated owing to rework. As a result, determining existing performance levels and devising improvement strategies is crucial for significantly improving quality of service satisfaction.

Similarly, there are primarily seven categories of flaws that might contribute to common problems during foundation work. Cracks in the walls above the afflicted area of the structure, foundation cracks, and other flaws are on the list. Building section displacement, expansion and deterioration of cement mortar and concrete below G.L, walls moving out of plumb, concrete spalling and leakages. These flaws may have an impact on the project's cost and timeliness, as well as customer satisfaction. As a result, additional time and money are spent at this stage owing to rework.

The questionnaire study found eight categories of problems in the building of brick walls. Cracks in walls, moisture shrinkage, moisture expansion, masonry cladding, undulation, non-structural cracks, popping and collapse of plaster are among the problems identified. The survey detects various types of flaws in these actions. As a result of the flaw affecting the project's schedule and expense, there will be additional work in the form of rework. More time and money are allocated as a consequence of the rework. As a result, analyzing existing performance levels and identifying how to improve will lead to significant quality and customer experience improvements. As a result, there will be a need to strengthen the measures and decrease the flaws, necessitating my close supervision of the task. If we tolerate these types of little faults, the entire project will be harmed, and the project's lifespan will be shortened. What this means is that little flaws can result in significant damage. This is the stage where you define your project. The table below shows the flaws that were found.

Measure phase

The data from the activity is collected during the evaluation step. Evaluation also assists in identifying the most significant aspects, highlighting where efforts should be directed, and maximizing the use of limited resources to explore detected issues. The incidence of errors in marking layout and excavation activity, foundation work, and brick wall construction work are the issues that we are attempting to address here. The faults incidence table derived from a questionnaire survey in construction businesses for these three activities is listed below, with the number of occurrences filtered according to the number of occurrences.

A Pareto chart is a histogram, which is a combination of bar and line graphs. The purpose of this graph is to show a set of data in a bar graph format. The individual numbers are represented by the length of the bars, while the aggregate is represented by the line. The data is regarded from the largest to the smallest bar on the graph. These graphics are also created using Excel sheets. The pareto chart in this project follows the 80/20 rule, which states that only 20% of the causes are responsible for 80% of the occurrences. **Figure.4** shown below was a result, it is suggested that the 20% of problem categories that account for 80% of problems be identified.

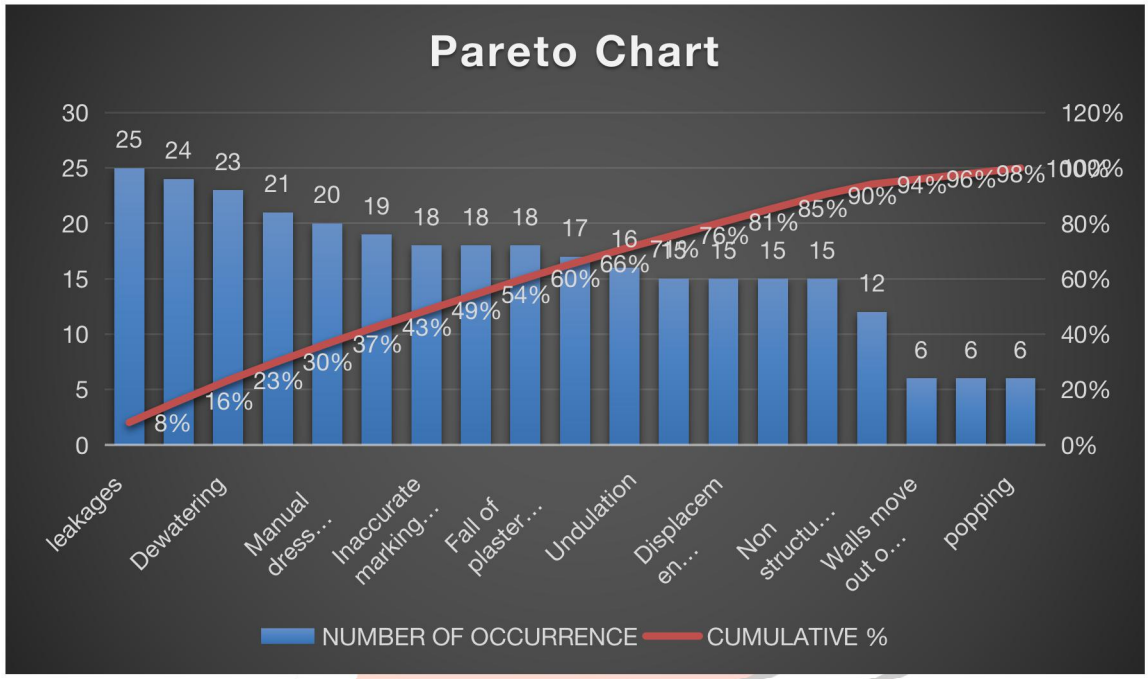

Fig.4– Pareto chart

According to the defects identified from the questionnaire survey for the above-mentioned activities such as marking layout and excavation work, foundation work, and brick wall construction work, 98 percent of foundation activity was indeed caused by leakages, and 94 percent of foundation activity was also caused by foundation cracks. Dewatering caused 90% of marking layout and excavation activity, 81 percent of marking layout and excavation activity was caused by soil sliding, 80 percent of marking layout and excavation activity was caused by manual dressing, and 76 percent of brick wall construction activity was caused by cracks in walls. Inaccurate marking, moisture expansion, and plaster collapse were responsible for 71% of marking layout and excavation activities, as well as building of brick walls. This was the project's measurement phase. During the measurement phase, we discovered that the number of occurrences of faults for the three activities described caused the highest proportion of defects. Furthermore, the top known flaws are enlisted from the pareto chart analysis, and the top most defects are taken towards the next phase of a project, known as the analysis phase, to study the sigma level and its defective percentage.

Analyze phase

In the analysis phase, the contributing factors of defects are analyzed, the defects per million opportunities are statistically calculated, and also the level of the defect's percentage can be calculated, which means how likely these defects are defective to the project. These kinds of things are analyzed statistically, graphically, and analyzed. Statistical calculation to find the sigma level and defective percentage of the defect,

The flaws per million opportunities, yield %, and sigma level for that particular activity were all discussed in the above table for layout and excavation. The entire number of defects occurrences was 82, the number of defects prioritized was 4, and the total number of defects possibilities for this activity was 120. The faults per million opportunities were estimated from this calculated data using the preceding DPMO formula, yielding a result of 683333.33. The flaws resulting from this action were 31.6 percent faulty. This action was closer to a 2-sigma level of performance. There is a lot of scope for development in this activity. Furthermore, the graph shows that the very first three flaws account for more than half of the overall cases.

Furthermore, the normal distribution curve for this marking scheme and excavation activity clearly demonstrated that modifications were required to eliminate faults and improve the process by reducing additional time and expense to avoid rework. The skewness value came close to +1 in descriptive analysis, so it is considered right tail skew. If the skewness comes close to this value, the graph indicates that the performance level would not be in a safe range, and that certain improvements

in that specific work, and there is a need to mitigate defects, will be made. These facts can be proven statistically and graphically.

For foundation activity it explained that the defects per million opportunities, yield percentage and the sigma level for that particular activity. From that table the total number of occurrence of defects detected was 112, number of defects shortlisted as 7, for this activity total number of defects possibilities detected was 210 from this calculated data the defects per million opportunities was calculated by using the above DPMO formula it resulted as 533333.3333. From this table the defects came under this activity was 46.6% defective. This particular activity was closer to 2 sigma performance level. The scope for improvement in this particular activity also was a huge. In addition, it is evident from the graph that the first two defect accounts for more than 50% of total cases.

The normal distribution curve for this foundation activity it clearly showed that there was need to put some improvements to reduce the defects and improve the process by reduce the additional time and cost in terms of rework. From the descriptive statistics, the skewness value came nearly +/- 0.1 so it is considered as normal curve no skew, if the skewness comes like this value the graph said that the performance level was in safe level. Because for this particular foundation work from seven kinds of defects two kinds of defects affects more than 50% so that there will be give some improvements in that particular work as well as need to mitigate the defects too. Why means the small errors or faults may also cause huge problems in further periods. These stuffs are statistically and graphically proved.

For construction of brick wall activity, it explained that the defects per million opportunities, yield percentage and the sigma level for that particular activity. From that table the total number of occurrence of defects detected was 115, number of defects shortlisted as 8, for this activity total number of defects possibilities detected was 240 from this calculated data the defects per million opportunities was calculated by using the above DPMO formula it resulted as 479166.6667. From this table the defects came under this activity was 52.08% defective. This particular activity was closer to 2 sigma performance level. The scope for improvement in this particular activity also was a huge. In addition, it is evident from the graph that the first five defect accounts for more than 50% of total cases.

The normal distribution curve for this construction of brick wall activity it clearly showed that there was need to put some improvements to reduce the defects and improve the process by reduce the additional time and cost in terms of rework. From the descriptive statistics, the skewness value came nearly -1.2 so it is considered as left tail skew, if the skewness comes like this value the graph said that the performance level was not in safe level. Because for this particular construction of brick wall work from eight kinds of defects first five kinds of defects affect more than 50% so that there will be give some improvements in that particular work as well as need to mitigate the defects too. Why means the small errors or faults may also cause huge problems in further periods. These stuffs are statistically and graphically proved.

Root cause analysis

Analyze is the step in which the root causes of the issues or defects are determined. The cause-and-effect diagram is used to analyze. By arranging possible reasons into separate groups, the cause-and-effect diagram examines why it all occurred or may even happen. **Figure.5** shown below was the root causes of defects.

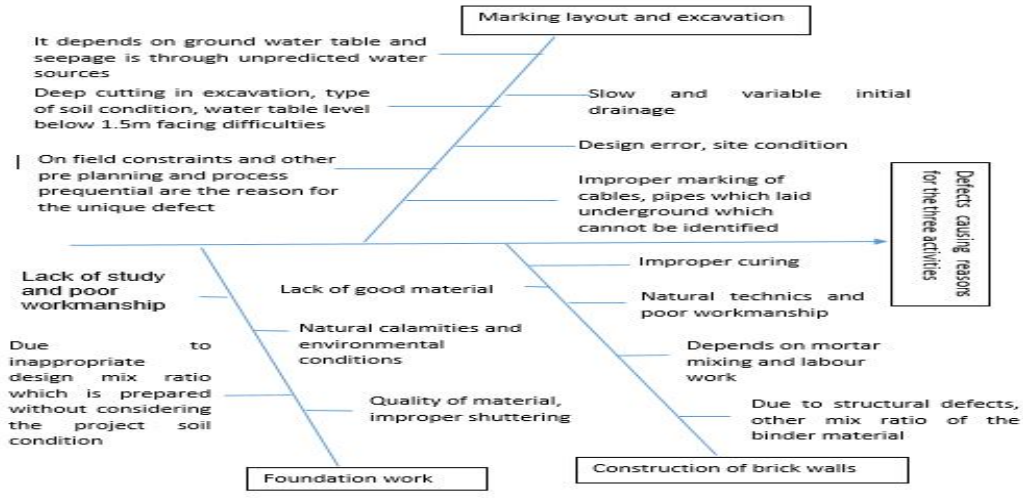

Fig.5 – Root cause analysis

By this analysis phase conclude that there was need some improvements in the specified activities why because the defects arising from those particular activities which contributing more to affect the time and cost of the building project work. The performance level of that specified activities came closer to 2-sigma and overall, 50% defective.

Improve phase

Improve is the process in which methods for removing flaws are found and a defect solution is developed. In this improve phase, providing the resolving ideas to mitigate the defects which affects the cost and time of the during. If in a project the cost and time plays a major and significant role in a construction management. If these two factors get affected means the entire project can be harmed. This cost and time of the project was majorly affecting because of some causes and problems happening are invisible to our naked eyes. In this project for that specified three activities (marking layout and excavation, foundation and construction of brick walls) by monitoring and surveying in each activity there was some kinds of defects were detected which also causing problems in further period. As well such problems may affect the quality of the entire building project and also reduces the customer satisfaction.

So that to reduce such further problems and to reduce cost and time of the building projects and to reduce the defects that causing major flaws, here in this improve phase given what are the main reason for causing those defects and how to mitigate them and improve the performance level of the activities are explained in this phase.
The root cause of this project explained that the main reason for the causes of the defects in those specified activities.

Firstly , for the marking layout and excavation activity the main root causes for the defects such as dewatering, soil sliding, manual dressing and inaccurate marking was design error, site condition, improper marking of cables, pipes which are laid underground not be identified, deep cutting in excavation, water table below 1.5m depth they facing difficulties and on field constraints, other pre planning and process prequential are the reason for unique defects happening on site work activities of marking layout and excavation. For those kinds of causes the results of defects facing in further periods such as dewatering of excess ground water, soil sliding at deep cuts, inaccurate marking as on field constraints. If these defects and problems are facing during this marking layout and excavation activity there was definitely additional rework process might take place. Those things may definitely affect the time at the same time cost of the project. To rectify those defects and problems to improve the quality of the process of work by the way of proper marking and indication to made on the ground level, pre-analyzing of the below soil before starting of work. If deep cutting was provided it should be broad enough. For soil sliding taking through report on geological soil profile test. For inaccurate marking and manual dressing advanced and prior planning and decisions on site variables will reduce the defects. For dewatering by using small motor by pumping reduces the additional time of the process.

Secondly, for foundation activity the main root cause for the defects such as leakages and cracks in foundation were occurred due to lack of study and poor workmanship, quality of material and improper shuttering, due to inappropriate design mix ratio which is prepared without considering the project soil condition and atmospheric and moisture content of the place, manual mistakes, improper mesh provision, poor material condition, natural calamities are the unique reason for the defects and problems happening on the site work activities of foundation. Further for those unique reasons the difficulties facing in further period was due to poor quality of material and improper shuttering there might be cracks are appearing on the columns, slabs and walls of the building, due to improper workmanship and design mix the pores are formed on the building it allows cracks and leakages on the building, due to improper mesh provision there might be deflection occurs on the building elements. Those difficulties may result in rework of the building construction and it definitely affects the cost and time of the building project. To mitigate those defects and problems improve the quality of the process of the work by the way of providing suitable concrete mixes and trial pits, proper inspection and monitoring of the work progress, prior planning and analyzing the required resources were the project will eradicate the mistakes, de-shuttering, proper soil testing, inspecting the quality of the materials and resources, skilled manpower providing proper training to them regarding site work activities periodically, proper placement of reinforcement, proper management.

For construction of brick wall activity, the main root cause for the defects namely cracks in walls, moisture expansion and fall of plaster in brick wall construction was occurred due to lack of good material, improper curing, natural tectonics, poor workmanship, depends on mortar mixing and labor work, improper mix ratio those are the unique reason for occurrence of defects and problems in site work activities of the construction of brick walls. Further for those unique reasons facing the difficulties in future period was due to improper curing there might be cracks on walls occur, due to improper mortar mixing and labor work there were fall of plaster along walls might be caused, due to improper mix ratio, environmental conditions, lack of good building materials there were moisture shrinkage and expansion might take place. Those difficulties definitely affect the life span of the building as well as affects the time and cost of the building project too. To resolve such kinds of mistakes during brick wall construction should strictly follow the improvement measures to mitigate the defects and their problems. The improvement measures to reduce the defects such as usage of materials as applicable through standards, proper curing time will be allotted, proper alignment along the walls to be marked clearly, properly inspecting the curing period of the specified work element, prior checking with all quality standards, proper usage of materials, skilled manpower should be required, monitoring the work by recording the day to day work activities on site it definitely eradicate most of the problems and defects occurring and happening during the work progress. This is the improve phase of this project it contains all the reasons for occurrence of defects and their problems as well as how to reduce the defects and problems by using the improvement measures are all things are described in this phase. The recommended improvement measures are used to reduce rework of the building projects at the same time saves the cost and time of the specified work activity by mitigating those defects.

Control phase

This is the last phase of the DMAIC principle. The preparation of a control plan is the step of control. The control plan will assist us in monitoring the numerous preventive actions that will assist us in achieving the intended outcome. In terms of specifications, marking, and effectiveness, a control plan is a description of the guidelines, checks, or scheduled activities. To keep track of all actions, a comprehensive checklist must be provided to ensure that the method is followed, and the contractor and supervisor must appropriately supervise their work. We can also control project completion delays by adhering to good project management guidelines. We may also reduce and control defects by implementing the following methods as a master production schedule.

Table 2 Control Plan

Control Plan	
By creating a flow of communication	There will be proper communication among the managing heads, supervisor, workers and co-workers.
By make a habit of continuous planning	Pre – planning of work should be properly designed as per the daily basis.

By inspecting and monitoring the daily work activities	The daily site work activities should be strictly inspected and monitored.
By following the standard specification norms	The design mix ratio and other things are should be strictly followed as per the IS standard code specification to avoid damages and rework.
Bu observing and asking questions to the workers and supervisors	Testing the skills of the workers and site supervisors who handling that specified project whether they have the capacity to do that particular work.
By budgeting the projects with work execution platform	Evaluating how much money spend for specified work process in daily basis and keep it as a report to avoid cost overruns in projects.
By issuing a written quality control document that is customized to each facility	Distribute this with everyone engaged in the project, from the designer to the contractors, to raise standards, define duties and time productively from the beginning.
By holding ore-activity meeting	As experts, we waste nearly two full business hours every week dealing with unnecessary problems and looking for relevant information. Meetings are not only a fantastic way for everyone to discuss specs together, but they are still a great way to clarify concerns and avoid misunderstandings.
By checking the quality of the materials and other resources	Checking the material and equipment which are used in the project work should be properly checked as per the quality standard norms.
By providing proper training to the labors	Before start of the every day of work explain the details of the today work as a training part to the workers and guide them properly.
By keeping the records of progress of the work done	Record the daily progress of work, money and time spend for that particular activity, production level those all things are recorded and keep it as a report to easily find the defects and resolve them side by side.

VII. CONCLUSION

In this project, it is seen that how many factors which contributing the occurrence of lots of defects in the building construction activities. Those problems and defects entirely affect the quality of the construction work as well as affects the cost and time of the construction. In this project for the randomly specified three activities named as marking layout and excavation activity, foundation work, brick wall construction work there was numerous occurrences of minor defects can be detected by the proper questionnaire survey regarding those three activities. The detected defects and problems are minor only but they causing and creating major problems in the further period. From the analysis part of this project the output resulted as the performance level of the three activities closer to 2-sigma range and overall, 50% defective taken from the yield percentage. The pareto chart in this project follows the 80/20 rule, which states that only 20% of the causes are responsible for 80% of the occurrences. As a result, it is suggested that the 20% of problem categories that account for 80% of problems be identified. The defects filtered from the pareto chart as per the 80/20 rule was dewatering, soil sliding, inaccurate marking, manual dressing, cracks in foundation, leakages, fall of plaster, cracks on walls, moisture shrinkage and expansion. Those defects are caused due to poor quality of material used, poor workmanship, deep cutting at excavation, design errors, atmospheric conditions were poor, improper design of mix ratio, improper curing, unskilled labors, improper marking of cables, pipes which laid underground which cannot be identified, improper soil testing these are analyzed from the root causes analysis (fish-borne diagram). From this analyzed result there were more improve measure ideas are suggested to reduce those occurrences of defects and also control plan also provided as a tabulation form to easily understand to control the defects causing ang improving the quality of the construction activities. In this project the DMAIC principle was implemented and then the result of this project was easily demonstrated through this principle.

REFERENCES

[1] Susmy Michael, Sahimol Eldhose (2014) - Defects Reduction in High Rise Residential Building using Six Sigma: A Case Study, International Journal of Scientific Engineering and Research (IJSER),Volume 4 Issue 3, March 2016.

[2] Meor Ibrahim Meor Hasan (2015) - MINIMIZING DEFECTS IN BUILDING CONSTRUCTION PROJECT, 78:5–2 (2016) 79–84.

[3] S. Sriram, A. Revathi (2016) - Implementation of Six Sigma Concepts in Construction Project for Ensuring Quality Improvements, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 4, April 2016.

[4] M. Subhi (2017) - A Review On Construction Defects, International Journal of Informative & Futuristic Research, Volume 4 Issue 8 April 2017.

[5] K Ullah (2017) - Theoretical framework of the causes of construction time and cost overruns, IOP Conference Series: Materials Science and Engineering:10.1088/1757-899X/271/1/012032.

[6] Maha Alkasisbeh (2018)- Implementation of Six Sigma Tools in Building Construction, International Conference on Industrial Engineering and Operations Management.

[7] Shaikh Mohammed Ayyaz (2018) - Quality Improvement by using Quality Control Indicators in High Rise Building, International Advanced Research Journal in Science, Engineering and Technology, Vol. 5, Special Issue 3, February 2018.
[8] Arif Hussain, Ashish Kumar Paharia (2018) - APPLICATION OF SIX SIGMA APPROACH FOR DELAY ANALYSIS IN CONSTRUCTION PROJECT, Issue 8, Vol.2 (February-March 2018).
[9] Nishaant Ha, Swethaa.B, Chris Anto.L (2018)- Concreting For Construction- Quality Control by Six Sigma Approach, International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-8 Issue-2S December, 2018.
[10] Sohail Khan (2019) - FACTORS INFLUENCING TIME AND COST OVERRUN IN CONSTRUCTION OF GOVERNMENT BUILDINGS: INDORE AS A CASE STUDY, CIKITUSI JOURNAL FOR MULTIDISCIPLINARY RESEARCH, Volume 6, Issue 4, April 2019.
[11] B. Kapre Varad, S.K. Sekar (2020) - QUALITY ANALYSIS AND QUALITY CONTROL IN BUILDING CONSTRUCTION WITH SIX SIGMA APPROACH, ISSN- 2394-5125 Vol 7, Issue 11, 2020.
[12] Akshata P Momaya (2020)- APPLICATION OF SIX-SIGMA FOR PROCESS & QUALITY IMPROVEMENT OF BUILDING CONSTRUCTION: A CASE STUDY, International Journal of Creative Research Thoughts (IJCRT), Volume 8, Issue 6 June 2020 | ISSN: 2320-2882.
[13] Ar. Priya Swami, Ar. Bhagyashree Kadiwal, (2020) - Implementation of Six Sigma Methodology in Construction Industry For Quality Process Improvement, International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 04 | Apr 2020.