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Enhancing the Quality Improvement through Six Sigma Using DMAIC methodology in construction

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Abstract: **Although Six Sigma has been carried out within side the production and different services industries. This look at defined the Six Sigma idea as a first-class initiative that may be carried out in the constructing enterprise. The concepts, method, and metrics of Six Sigma are first mentioned. The software of Six Sigma for enhancing the first-class of inner finishes at some stage in creation is likewise explained. For that a case of residential complicated which include one hundred residences is carried out to discover the defects in plastering. These defects are then evaluated through making use of DMAIC method of six sigma. Before making use of DMAIC, the sigma degree is calculated through defects consistent with million possibilities (DPMO). In case look at miles determined that the defects determined in completingpaintings (plastering) of residential complicated are cracks on plastered floor, mistaken vertical edges of column, window and door, horizontal edges of column, window and door, air hole in plastered floor, choppy plastered floor, and plastered floor broken at some stage in sporting out different sports. Further those defects areevaluated the use of DMAIC method.**

Keywords: **Six Sigma, Defects, Construction, Quality Improvement, DMAIC.**

1. INTRODUCTION

Construction enterprise performs a main position in monetary growth of any nation. Construction enterprise is the maximum booming enterprise within side the complete world. Construction region is viewed as a service enterprise which generates substantial employment and offer growth impetus to different production sectors. Also, creation control and technology are the two key elements influencing the improvement of the development region. Now a daysthe vital goal of creation enterprise is to finish the mission in time and in the scheduled prices and budget. Along with this want for enhancing first-class and client pleasure has acquired good sized interest in recent years, so the one method which can fulfil all the necessities of creation enterprise is the use of six sigma standards in creation enterprise. The six sigma is a first-class development approach of products in order to ensure client pleasure. The end result of six sigma maybe an elevated efficiency, development in overall performance and the manager of overall performance troubles hence minimizing defects, dangers and deviation. Six sigma is a first-class development approach primarily based totally on facts changed intofirst off utilized by Motorola in Nineteen Eighties through Bill Smith of Motorola to lower cost, boom first-class through enhancing procedure and lessen production time. It acquired little exposure till past due 1990s. Six Sigma effectsthe software of a new form of control approach to creation. Essential features of Six Sigma include a clear set of targets for the transport procedure, geared toward maximizing overall performance for the client at the mission degree, concurrent layout, creation and the software of mission manage at some stage in the existence cycle of the mission from layout to transport. Six sigma is a quantitative method for development with the purpose of restricting defects from any procedure, specifically a numerical purpose of three. Four defects consistent with million possibilities (DPMO). Six sigma is reportedly less difficult to apply than many different first-class control packages as it gives records approximately the

extrude wanted and the packages to execute the extrade. DMAIC is a record pushed approach of six sigma used to enhance processes. It brings shape to the development procedure and assist teams discover capacity solutions, makes a decision a path of motion and enforce procedure manage.

- **Six Sigma: -**

The Greek word, "σ" used to indicate the usual deviation of set of data. The popular version is related to calculation of common price for a specific set of data. Sigma is not anything however a deviation from mean. Six Sigma derived from statistical distribution called "popular regular distribution". Six Sigma recall the variety of decrease and top restriction disorder is +/- 6 sigma from the mean. Six Sigma is a data primarily based totally technique primarily based totally on medical technique to the discount in disorder prices described via way of means of consumer for put off defects from each product process. Following graph illustrates the charge of defects in line with million possibilities in one-of-a-kind sigma's levels.

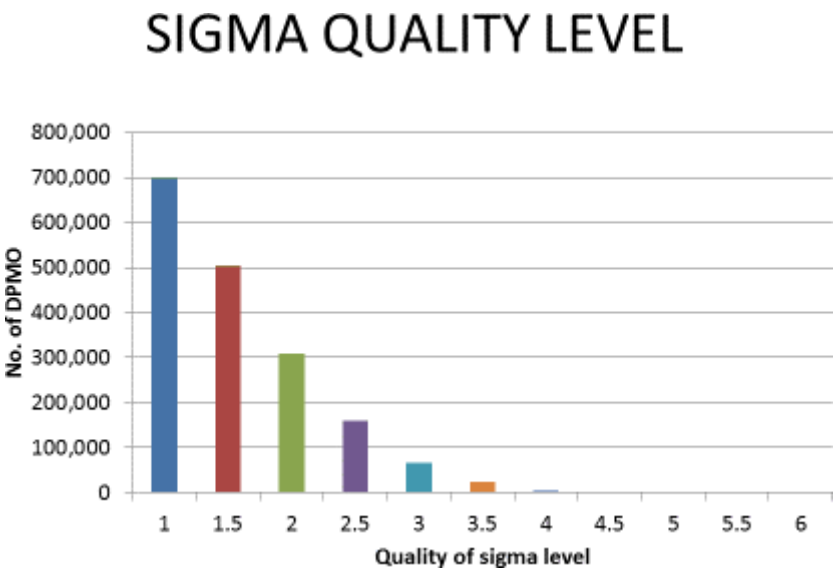

Fig 1: Overview of Sigma Level and DMPO (Google search)

Six sigma effort's goal 3 foremost areas: -

- Improving consumer satisfaction.
- Reducing cycle time.
- Reducing defects.

Three key traits separate six sigma from nice packages of the past: -

- Six Sigma is a consumer focused.
- Six sigma initiatives produce principal returns on investments.

Six sigma modifications how control operates: -

This is actually the origin of the name Six sigma. Statisticians have used the Greek letter sigma to seek advice from commonplace deviation. Six sigma is just six standard deviations. What it really means that is that a process is extremely capable that client specifications are literally six standard deviations aloof from the method center Fig.1. Six Sigma as a defect rate matrix Since aproduct can solely be thought-about defective if it's created outside of customer specifications, a process with such a high capability will nearly manufacture no defect. The mathematical calculation of 3.4 DPMO is predicated on two assumptions: the method output follows {a normal a traditional commonplace} distribution, and also the process mean might shift up to 1.5 standard deviations within the long term. within the extreme things once the process mean has shifted 1.5 standard deviations a technique or the other, the foremost range of defects the process can manufacture may be calculated as P (Z > 4.5) + P (Z > 7.5) Since P(Z>7.5) is nearly zero, six sigma is technically P (Z > 4.5), that is 3.4 per million [3]. scheming defect per million opportunities for 6 sigma Six sigma equates 3.4 defects for

each million components created or method transactions carried out. This quality equates to 99.99966. fact free product or transactions.

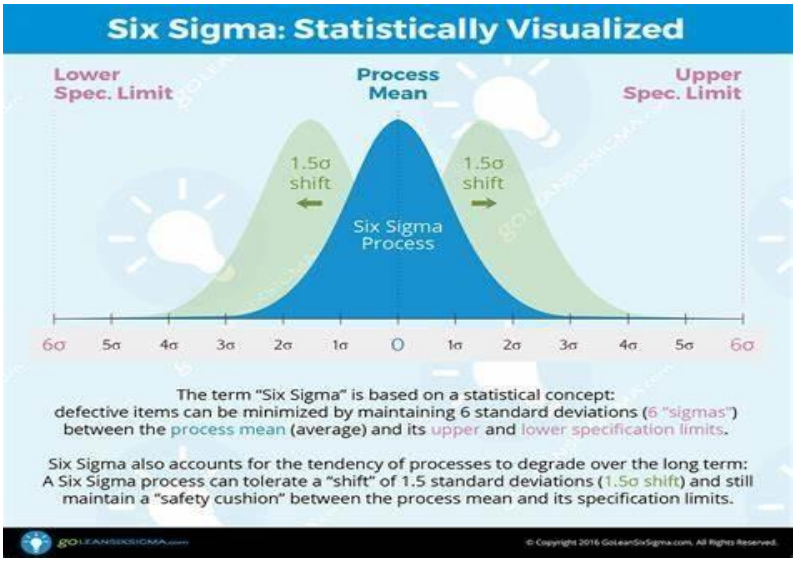

Fig 2: Six sigma statically Visualized(google search)

1.1 Formation of Constructs and Vital Components: -

1. Constructs: - Important parts

2. Leadership and management follow: - Leadership commitment to 6 sigmahigher management commitment to quality. Leadership and upper management support of a Six sigma budget.

3. Linking Six sigma to human resources: - Six sigma coaching throughout the hiring method providing rewards and recognition for 6 sigma project staff. Open in progress communication between management and workerson Six sigma project. Providing employee training on Six sigma belts (Green Belt, Black Belt, Master Black Belt, and Champion) worker training on project management, applied math tools, quality commitment, teamwork, and DMAIC/DFSS Overall, training on Six sigma to scale backturnover.

4. Linking Six sigma to client: - Victimization customer issues and feedbackto boost quality

1.2. Problem Statement: -

 Rahul construction Co. has launched Rahul Eastview I, a residential housing development settled in Pune at Hadapsar. The living accommodations are terribly spacious and also the size starts from 681.03 sq ft. Rahul Eastview I is in shut proximity to several supposed faculties and hospitals. Pune District could be a prime area, with many attractions work and recreational choices simply a drive away. The project offers many amenities adore

 The company has been producing a lot of defects. Measured over the last 6 months, year the defective rate of quality products has increased by 40%resulting in a loss of 100000/- for 4 months cumulative. Clint is not happywith the delay in project. Training programmers are not accessible

1.3 Objective: -

 Identify and eliminate waste by using different assorted tools.

 Review the essential principles of Six Sigma and DMAIC ideas.

 Improve the standard of the ongoing method (internal plastering work) ofa building project by eliminating deficiencies and meet the quality. standards and customer satisfaction.

1.4. Limitation: -

 The reason why this is considered to be a limitation on the part of the Six Sigma System approach is because the guidelines provided by the Six Sigma approach are relatively broad, causing it to be vulnerable to subjective interpretation. This would eventually lead to the possibility of various interpretations of the guidelines being provided by

the Six Sigma approach bymembers of management from different departments. As a result, this subjective interpretation would pave the way for friction between divisions and departments to occur.

 In this look at six sigma concepts will be carried out for inner completing paintings (Plastering) of residential mission (one hundred-one hundred twenty Flats) and the sigma degree for the equal may be calculated from the received records. The DMAIC method will be followed to enhance the first-class of thepresent procedure

1.5. Scope of study: -

 The basic theory of Six Sigma, its principles, methodology and various toolsused was studied in detail.

 Six Sigma principles was applied for internal finishing work of a project and the sigma level for the same was calculated from the data obtained.

 DMAIC (Define, Measure, Analyze, Improve, Control) was adopted toimprove the quality of the existing process.

1.6. Organization of Thiess: -

Chapter 1:

It Includes the introduction of project work. It describes - Six sigmaMethod, kinds of Six Sigma, Construction Process, downside Statement ofDefects that are all-too-common sight and scope of the project work. • [1.1] Chapter 2:

Includes LITERATURE REVIEW. consistent with one survey of the Six sigma, Defects caused 1.35 million issues in globally. conjointly mentioned papers that presents review of existing geometry: [2.1]

 Susmy Michael and Sahimol Eldhose, (2016)

 Francisco Ribes Garcia, (2014)

 Muharrem Firat Yilmaz, (2014)

 Sunil V. Desale and Dr. S. V. Deodhar, (2013)

 Mehmet Tolga Taner, (2013)

 Abdulaziz Ali Banawi, (2013)

 Raid-Al-Aomer, (2012)

 Thomas Rydzek – The Six Sigma Revolution (2000)

 Low Sui Pheng & Mok Sze Hui (2004)

 Sneha P. Sawant, Smita V. Pataskar (2014)

 S. Sriram, A. Revathi. (2016)

 Shantanu Sathe, Dr. Satish B. Allmpallewar (2017)

 Seung Heon Han, Myung Jin Chae, Keon before long Im, and metal DongRyu, (2008)

 Maryam Dabbaghi Tehrani, (2010)Chapter 3:

It includes analysis methodology with: [3.1]: -

 Preliminary Survey [1]

 Six sigma Studies and Demographic of selected Section [2]

 mensuration of Defects at site [3]

 Analysis of knowledge and Corrective Measures [4]

 Applying DMIAC studies of selected section [5]

Designing Schedule for Completion of Project and Expected Outcome.Chapter 4:

It contains site choice of the roots that are hand-picked for surveying. wherever it's been determined sorts of Defects which weren't as perthe Six sigma dimension. activity of numbers of Defects on the positioning and their size. [4.1]

Chapter 5:

It embodies experimental investigation mistreatment instrument for survey, the way to take activity of defects. to live variety of defects in site.what's the Procedure for Survey, however style construction process? [5.1] Chapter 6:

It is nothing however results and discussion. Survey was done on the locationintervals were taken. Observations were taken for sort Defects in entire survey.

Construction defects details are ascertained and also the benefits are notedown. [6.1]

2. LITERATURE REVIEW

After that, literature regarding six sigma all told the sectors are collected. The implementation of six sigma or the appliance of six sigma in producing and different business units additionally the} success rate of six sigma for other units have been studied out. Once that, the data analogous with the application of six sigma in construction sector has been patterned out. The papers related to quality management, industrial sectors, industrial buildings, residential comes, infrastructure projects have been spelled out. The information was alsocollected from previous researches administered on six sigma.

2.1. Review of previous researches paper: -

Suhas Vijay Patil and Balakrishna Rao K (2022) (16) This paper presents aseries of tests applied to recycled coarse concrete (RCA) and recycled coarse aggregate concrete (RCAC), and the test results are compared to NCA and original NCA-derived concrete. In addition, the results revealed at-a-glance the deficiencies in recycled aggregates and helped identify the area where concentration is important to advance the DMAIC 6-letter methodology standard of victimization of recycled aggregates. A total of twelve deficiencies were identified within the process and raw material. Applied mathematical analysis was used to measure the performance of all combinations created withRCA.

Susmy Michael and Sahimol Eldhose, (2016) [1] This paper presents in multi-storied buildings, quantity of defects throughout the development worksare most common. it's necessary to search out the defects that resulting, caliberwithin the construction projects. This paper describes the viable ways for the development of quality in the construction processes and operations with the six-sigma principle. during this paper factors touching quality of building recognized that are embody schedule delay, ow quality of materials, low quality of machinery, deficiency of data in labors and safety precautions. letter of the alphabet level of the multi storied residential buildings is calculated. The success rate for the building lies in between 85-90%, while considering each activity this shows that to succeed in sigma level, reduction in defects doing each item of labor is necessary.

Francisco Ribes Garcia, (2014) [2] This paper presents Six sigma may be a methodology that is principally improve the standard and time management ofthe projects. The Six sigma system increased the time, quality and value management within the projects. within the construction industry, every and each building is sort of an example for the data technology industry, which means up time and quality in the industry will be complicated. Aim of this study is to presents that Six sigma will make a comeback time and quality management inside the arena of building construction. As per the Six sigma principle, the goal is to observe the defects in fields. This principle will cut back the defects, minimize accidents and minimize wastage of money, by suggests that of that specialize in management of quality. This analysis completes that Six sigma is in a position to optimize and improve common anddefinite comes in time and quality.

Muharrem Firat Yilmaz, (2014) [3] Six sigma provide the advantages of method improvement that are important for the performance improvement. Toimplement the Six sigma principle doesn't necessitate longer time than traditional project period not like different process and quality improvement methods. Six sigma provides qualitative & quantitative approach and processimprovement tools, to live performance of processes and consequently improve it. From this paper it's concludes that, DMAIC methodology of Six sigma will be useful to boost quality and quantity, at the same time it'll have a control on technical and money success of project. research worker conjointly said, Six sigma has provided AN correct system, uninterrupted knowledge assortment system and conjointly activity techniques for performance and method measurement. the mix of Six letter system to the prevailing techniqueof Project management department makes the cluster efforts of website and workplace department a lot of competent.

Sunil V. Desale and Dr. S. V. Deodhar, (2013) [4] In construction industry to realize the growth, an unbroken effort desires to be taken. Such a growth possibilities is inflated by adapting the varied management principals and toolsof lean and six sigma for minimizes or zero wastage. Delays are wide-rangingin construction and prices additionally too high for

quality that's specified. As increasing competition from national and international construction corporations, modernization growth up for the implementations of Lean concepts. This paper places of interest the important problems contrastive construction companies and also explores the consequences of Lean and six sigma construction ideas in construction sector in India. A Lean Constructionand six sigma constructs have been with success accepted by industry in several countries. however still it's to not be employed in construction industry. This paper target this rising concept, "Lean Construction", that relieson the essential principles of management.

Mehmet Tolga Taner, (2013) [5] This paper identifies the importance of important Success Factors for the victorious starting of the Six sigma to construction companies. Participation and dedication of high managers, regarding quality initiative of suppliers and customers was supported the foremost important factors to the success of construction companies. Leadership and dedication of top managers, cooperation and dedication of middle management was also founded the CSFs for victorious beginning of the Six Sigma, whereas deficiency of information concerning the tactic to initiate is additionally found to be poignant its implementation. great deal of waste and high prices is founded to lesser the development firm's performance. Six sigma is incredibly helpful for merchandise with minor rates of defects and waste, low-cost costs, higher satisfaction of customers.

Abdulaziz Ali Banawi, (2013) [6] Ineffective and badly managed comes are often produces high amount waste and conjointly consumes resources, power,time and cash in high quantity, this makes issue in construction sector. This study aims towards the advance of performance and therefore the effectiveness of processes earlier and through the part of construction. They were implemented 3 systems that are Lean, Green, Six Sigma. These systems can be facilitated to achieve the foremost wished benefits, if the dedication of the highest management and the efforts of individuals participated obtained and also if implementation of the improvement actions planned carefully. while not any support of high management and people's involvement it's uphill to urge the required improvements. rigorously implementation also will want time and efforts, although it is terribly essential for precise results.

Raid-Al-Aomer, (2012) [7] Lean construction uses the ideas of lean principles and lean thinking to regulate construction projects. The intention of this scientist is to analyze the prevailing lean construction processes and to develop a sensible framework to implement lean techniques and live the lean construction performance. during this paper investigation and categorization in dire straits the various waste within the construction industry. They analyzed around 27different wastes occur in construction. Defects are the overall kind of waste in construction was based from the survey of assorted companies. The second general type of waste in construction is over processing. scientist acknowledged the impacts of waste on comes quality, speed and cost. They counseled the LC-KPIs set that live and directs to improvement in terms of cost, quality, speed and waste. Incentives for employee within the style of reward system additionally urged for achieving objectives of lean construction.

Thomas Rydzek – The Six Sigma Revolution (2000) [8] this research paperexplains the basic concept of six sigma and DMAIC method. It additionally explains approximately the six sigma extrade retailers which might be leadership, champions and sponsors, grasp black belt, black belt, inexperienced belt. The creator concludes that despite the fact that the methodis simple, it's miles through no way easy. But the effects justify the efforts expended. It additionally explains the firms that successfully enforce six sigma perform higher in virtually every business category, including return to sales, return on investment, employment growth & percentage rate boom.

Low Sui Pheng & Mok Sze Hui (2004) [9]– Implementing & making useof sixsigma in creation describes the six-sigma idea as a first-class initiative that canbe carried out withinside the constructing enterprise. The concepts, method, andmetricsof Six Sigma are first mentioned. The implementation phases as well as the education packages required are explained. A case looks at of ways sixsigma changed into pioneered in a company withinside the constructing enterprise is provided on this studies paper. The locating shows that control projects and aid, relevant education, appropriate selection of pilot projects, and commitment through team individuals are critical for a success implementation of six sigma withinside the company. The software of six sigma for enhancing the first-class of inner finishes at some stage in creation is likewise explained.

Sneha P. Sawant, Smita V. Pataskar (2014) [10]- Applying Six Sigma Principles in Construction Industry for Quality Improvements This paper describes the basic concept of Six Sigma, concepts, method and numerous equipment used. A case looks at of a residential constructing is taken in which the Six Sigma concepts arecarried out for inner completing paintings, the Six Sigma method's DMAIC idea has been followed to enhance the first-class and is checked towards the sigma degree. Thefindings endorse that right educationand control aid and minor modifications in cutting-edge paintings

method canassist enhance the first-class and in the end client pleasure that's of top importance. Various equipment is gift at every step of DMAIC method relyingupon the issue degree.

S. Sriram, A. Revathi. (2016) [11] - Implementation of six sigma standardsin creation mission for ensuring first-class development paper describes the implementation of Six Sigma standards in Construction mission to meet the first-classstandards and client pleasure. The simple concept of Six Sigma, Six Sigma concepts, DMAIC (Define, Measure, Analyze, Improve, Control) method and equipment utilizedin every level of DMAIC method has been mentioned on this paper. A case looks at changed into carried out in a residential constructing to which Six Sigma concepts hadbeen carried out for inner completing paintings (tiling paintings). The findings endorsethat right education, control aid and minor modifications that is required in cutting-edge paintings method which might assist to enhance the first-class and, in the end, improving the client pleasure that's of top importance.

Shantanu Sathe, Dr. Satish B. Allmpallewar (2017).[12] -Application of sixsigma in creation, this paper describes the Six sigma principle and framework as a high-quality improvement strategy through the triple-crown business. during this paper we tendto projected the Six alphabetic character may be a applied math methodology that gives astructured framework to prepare and implement strategic method improvement initiativesto achieve reductions in process variability or defects. the fundamental theory of six sigma, DMAIC (Define, Measure, Analyze, Improve & Control) methodology is been mentioned in this paper. A case study on a billboard building was conducted to those sixsigma principles were applied for few internal finishing works. This thesis aims at understanding the wants of housing industry from method improvement perspective andmatches these needs with the expected outcomes of Six sigma.

Seung Heon Han, Myung Jin Chae, Keon before long Im, and metal DongRyu, (2008) [13] This paper provides the manner for improvement of construction performance through the applying of the six sigma. This Six sigma principle gives the metrics essential to line up the goal of performance improvement and a system for activity this improvement. With the mix of the lean construction plan and six sigma this study presents the strategy to boost the development operations and method es. They terminated that six sigma issocial control tool used not just for quality improvement and productivity however conjointly used for process and quality control. Quality error or defects in processes will be controlled with the assistance of this principle, inadditional realistic ways in which to realize the fascinating vary

Maryam Dabbaghi Tehrani, (2010) [14] This paper describes the Six sigma principle, Systems and structures in industry. The core focus of report is on acceptive the Six sigma principle in construction sector. Six sigma is latest construct in construction sector. the thought of application of this principle onconstruction comes was additionally studied during this paper. additionally, this paper also identifies the benefits of DMAIC methodology and their impactto realize the standard level of the construction. Study has been demonstratingthe DMAIC methodologies flexibility in construction and prompt the way to apply each stage taking into thought the indices of construction.

2.2. Gap Research:-

Situated in jap Pune, Hadapsar is a advanced locality comprising a combination of residential complexes, IT parks and commercial areas. 57% residences on the market in Rahul Eastview lies in variety of ₹40Lac - ₹60Lac.

2 Bhk is the maximum not unusualplace room configuration on this undertaking and bills for approximate 65% of all of the residences on sale. The enterprise is presently generating plenty of defects in production. The software of Six Sigma for enhancing the fine of inner finishes at some stage in production is likewise explained. For that a case of the residential complicated such as one hundred residences is achieved to discover the defects in plastering. These defects are then evaluated via way of means of making use of the DMAIC technique of six sigma.

2.3. Summary: -

To maintain the enhancements, it's necessary to rewrite the SOPs, and make sure that the employees are properly trained within the new techniques. one in every of the key parts to six sigma is that not only ought to the corporate improve processes, however that those improvements should be replicable. the sole manner that's doable is that if everybody concerned in the method is awarethat the process has changed, and is capable of execution the new process. DMAIC part five is control, that is that the means by which the new process isformed replicable

3. METHODOLOGY

In look at the records is accumulated from secondary reasserts which include studies paperand internet to look at the Six sigma concepts, simple standards of DMAIC method and numerous equipment utilized in DMAIC. A case looks at of

residential complicated whichinclude one hundred residences is carried out to discover the defects in plastering. For thata tick list is ready and the disorder evaluation sheet is ready wherein the feasible defects that may occur in plastering paintings changed into listed. After accumulating number, one records from the case look at, the sigma degree is calculated through the use of DPMO afterwhich determined out defects are mitigated through making use of DMAIC idea of six sigma method for growing sigma degree and minimizing the defects. After enforcing DMAIC and locating out the foundation reasons of plastering defects, treatments are advised for their manage and development of plastering process.

3.1. Definition: -

3.1.1.Difference between QC & QA: -

Quality Control-QC:	Quality Assurance-QA:
It mainly focuses and Concent rates on the outputs, which deals with the final outcome of the products. Controls carried out throughout cycle.	Focused on Process and its improvement. Concent rates on various stages of the process like concept, design, production, performance and conformance.
Reactive in nature. It identifies the defects and variations in all stages and rectifications are carried out immediately.	It is always Proactive in nature and its approach will be assuring the quality atall stages.
Mainly work as a Line function. Activitysupervision is carried out by all concerned in different locations.	It works as a staff function. OnlyQualityassurance people are involved in the process of achieving quality.
It finds and identifies the defects andThen apply various procedures to eliminate them.	Prevent defects to occur sit is carried outduring the development stage.
Testing procedures are followed to sort out defects in the outputs throughout the life cycle. Defects and deviations arerectified on the spot, so that further process is streamlined and without errors.	Quality audits are carried out to check the conformance of the product with respect to concept and design. Quality Manuals and specifications are strictly followed in assuring quality to all processes.

3.1.2. TQM: -

This is a management approach towards Quality started in the year 1950 and hascontinuously improved its popularity by the early 1980s. Total quality management is a union of the culture, attitude, and structure of a company thattries to provide products and also services that satisfy the irrequirements. Theculture aims for superior quality in allotsactivities, with all activities done forthe first time, and with the elimination of defects and deviations. The two basicprinciple of TQM are as follows.

- Doing right things at the first time, and every time, and maintain it throughout.

- There is no point in making rectifications or modifications for any kind of defects and deviations. The design and planning should be carried out carefully with all available trial and error methods. The models should be prepared and should work exactly as the output. By maintaining consistency, products should be produced. We have to do the correct thingsat the first time.

- Continuous improvement in all processes, procedures, actions and activities in a systematic way.

- There should be an attitude for improvement in all activities and it should be done continuously, and carried out till optimum results are evolved. Asthere are changes happening in technology, organization shave to update continuously.

- TQM is an improvement to the traditional and systematic way of doing business. It is approved and established technique to guarantee existence of organization in the world class competition. By slight changes in the thought process, in its philosophy and actionsof management, the culture of organization can be changed.

 TQM is an art of controlling the entire organization to achieve world class quality in all the activities. The Golden principle of TQM says to "do to others as you would do to you".Total Quality Management is based on a philosophy and a group of principles, that makes the basics of a continuously and every improving organization. It is also the application of statistical methods and human potential to improve the process in an organization to exceed customer needs.

3.1.3. Five Ingredients of TQM: -

TQM combines fundamental management and engineering principles and tools under a systematic way and with a scientific approach. The TQM cycle is a combination of five major attributes dealing with customers and processes.The five attributes and principles in the cycle which are shown in the TQM model are as follows: -

- Organizational focus will be always on the customer or user.
- Continuous process improvement in all activities.
- Correct monitoring and continuous evaluation in all activities.
- Involvement of all employees and stakeholders always in the organization.
- Improvement in Quality, the major agenda of the organization.

3.1.4. Six sigma: -

Six Sigma is a union of tools and a mixture of various techniques for process improvement. It is a philosophy for improvement on any processes in a projectby way ofeliminating the defects and deviations. The methodology is designedto achieve financialgains through continuous improvements in the process andachieve high degree of quality.It is considered as an advanced management tool that can be used in an organization, to improve all the processes in areas of manufacturing, services, construction and sales etc.

Six Sigma is a management philosophyconcentrateson identification ofdefects,deviation sand variations in a process. It is a process improvement methodology works for creatinga world class quality in products and services. Its orientations are based on facts and dataand are focused on finance by saving money and is a result-based methodology.

Six Sigma is working on the major philosophic belief and thinking that, the finest qualityprovider is the lowest cost owner. The root cause of poor quality of the product or serviceis due to variation in the process involved. The highestexpectation in applying Six Sigmais to have happy and satisfied customers. By the application of Six Sigma the defects and errors are reduced to 3.4 in number.

Six Sigma is a methodology to change the culture of the organization with continual improvement. A process which is working with Six Sigma methodology is treated as of highest quality and known as World Class. Six Sigma is measurement oriented and aims for highest perfection and accuracy in all aspects of the organization dealing with quality. Six Sigma is also a measure, which is equal to a limit of 3.4 defects in one million times.

DMAIC Procedure: - As per paper publish by Miroslav RUSKO named "Application of Six Sigma method of EMS design". Six sigma is based mainlyon understanding the customer needs and expectations, improving and establishing new process, manufacturing and service process. Six sigma is a continuous improvement methodology by using DMAIC. For implementationof six sigma method to improve the quality of products and processes base toolis DMAIC (Define, Measure, Analyze, Improve, Control). DMAIC framework gives some techniques such as DOE (Design of Experiments), FMEA (failure mode and effect analysis), control chart, QFD (Quality Function Deployment) in a logical direction. This methodology offers structured framework in following steps to establish systematic continuous improvement.

Define: To define customer requirements and any things that do not meet thoserequirements are defects. Identify problems which affect quality. To define project, aim and need.

Measure: Construction activity is a set of various dependent activities. Identify the performance requirements of the process with respect to its defect's characteristics.

Analyze: To study and analyse the data collected in previous step and find outthe root causes of defects.

Improve: Improve for eliminate the defects. Identify the ways to destroy the existing defects. Develop the solution.

Control: Measure the performance of the new process under a controlled planto control the quality level of the process. For increase the sigma level.

FIG 3: DMIAC Cycle(google search)

The **Six Sigma** system allows the employees throughout the organization to be classifiedinto levels according to the required training and experience. Thestaffs form teams and work together to achieve the goals and results. The hierarchy of training includes 5 different grades known as belts.

1. **Master Black Belts:** The highest position in the SS system having 2 yearsof working experience and can teach on the subject of Six Sigma.
2. **Black Belts:** Working as full-time project leader and associated with implementation of SS in an organization.
3. **Green Belts:** Mainly focuses on usage of DMAIC who works under the guidance of a Black Belt.
4. **White Belts:** A new entry into SS system. After completing the course work, he can register for green belt certification.
5. **Yellow Belts:** The lowest position in SS. The employers give this kind of training to their employees. By introducing Quality Management in the organization, it formsa major group of people in the industry who are leaders in their fields. It includes a sequence of modes toward an ultimate goal that can be measured and is achieved through statistical methods. Many other goals are also worked towards throughout including reduction of cycle time, improving profit margins, reducing costs, and making sure of customer satisfaction.

Fig 4: Six sigma belts(google search)

3.2. Formula: -

The checklist is prepared for various components. The one which meets standard requirements is marked as '0' else it is marked as '1' and NA showsthat item not applicable. The total number of defects and total number of opportunities for defects in each checklist is calculated as follows.

$$\text{DPMO} = \frac{\text{(No. of "1" in checklist * 1000000)}}{\text{(No. of Opportunities of defects*No of units.)}}$$

Flow diagram: -

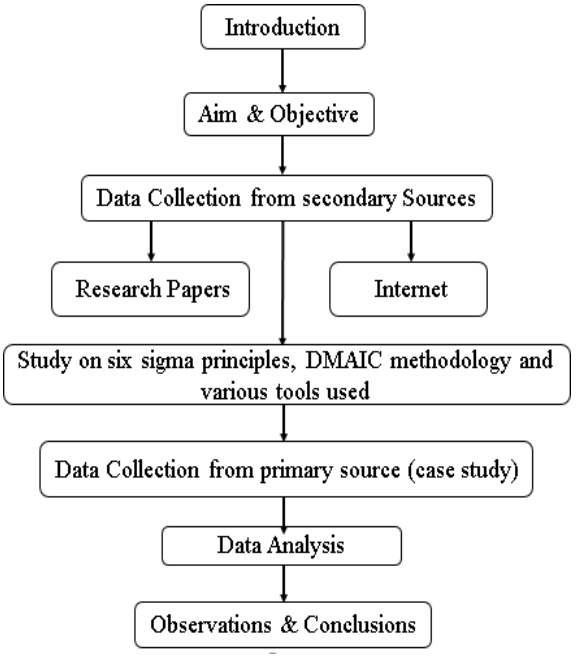

Fig 5: flow diagram (google search)

3.3. Tools Tools & Technician: -

In this paper the following tools are used in each stage of DMAICmethodology:

Define: SIPOC (Suppliers inputs process outputs customer)Measure: Pie chart

Analyze: Cause and effect diagram Improve: Remedies for corrective actionControl: Control plan.

4. CASE STUDY

4.1. Introduction of Site: -

The residential complicated has five towers of seven floors, every floor has residences(2bhk). The place of every flat is 650. 0 Sq. Ft. - 900. 0 Sq. Ft. this residential complicated is beneath Neathcreation and the completing paintings (plastering) goes on. As the web website online is presently beneath Neath creation, so to find out the defects of plastering a tick list changed into organized. Once the tick list for defects changed into organized the plastering ofeightyresidences out of one hundred had been randomly checked. In those 10 residences had plastering defects. following desk indicates no of defects determined in 10 residences.

4.2. Details Of Site: -

Name of Site: - Rahul Eastview Construction project.

Positioned at well-connected locality Hadapsar, RahulEastview is associate degree esthetically designed project of Pune. the costs ofthis meticulously planned Rahul Eastview project be the vary of Rs. 27. 0 lac

- 44. 0 Lac. This project has its expanse over a locality of 5 Acre. a complete of 288 are gift within the project

Location: - Sr. No. 56/2 to 56/8, Near Swami Vivekanand Industrial Estate, Handewadi Rd, behind JSPM College, Satav Nagar, Hadapsar, Pune, Maharashtra, 411028, is the postal address of Rahul Eastview in Pune.

Project Specification: -

- Designer Entrance Lobby
- Gypsum Finished Walls
- Vitrified Tiles in entire flat
- Designer Toilet
- Granite Kitchen Counter with Stainless Steel Sink
- Good Quality Sliding Windows with mosquito mesh
- Generator Backup for common area

4.3. Site visit photos: -

Fig 6: Site Entry & Exit photo

Fig 7: Site Passage photo

Fig 8: Site building photo

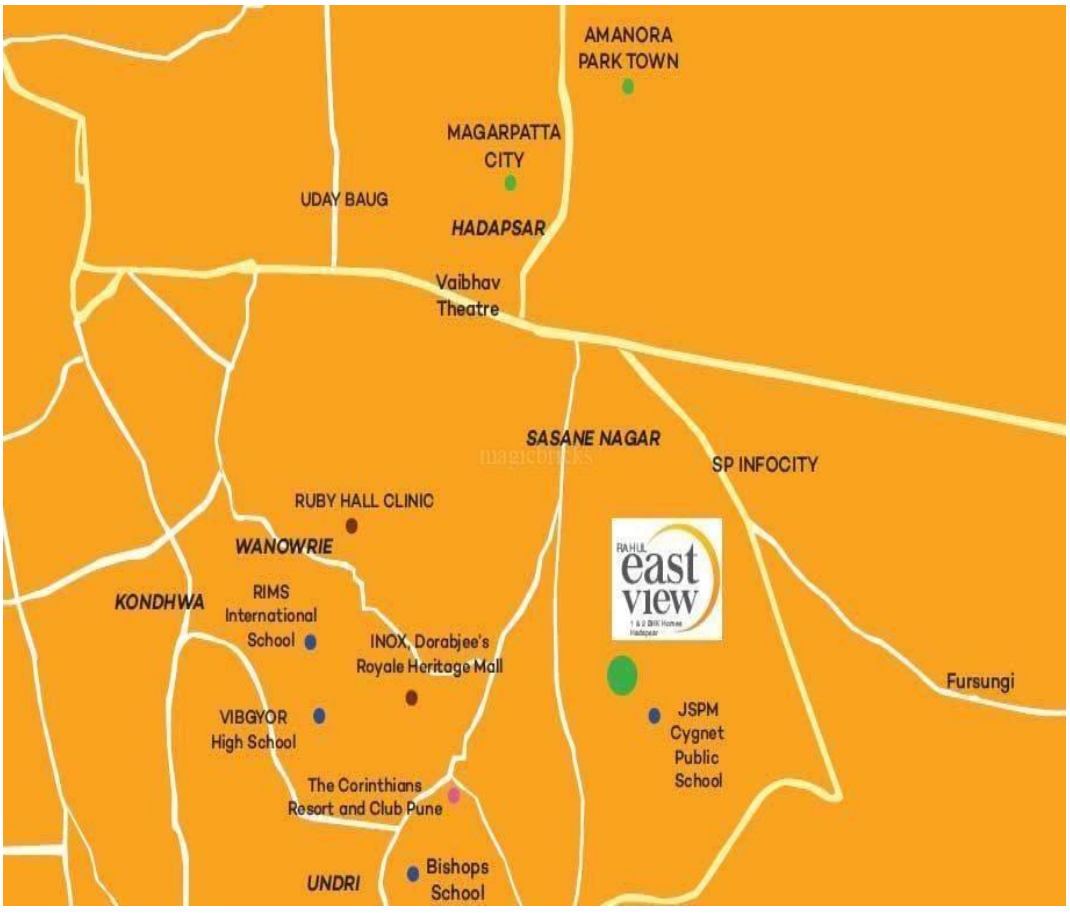

Fig 9: Site Location on map photo

Table I: Assessment sheet

Sr no.	Defects	Living Room	Kitchen	Master Bed Room	Bed room
1	Crack of wall	5	2	1	2
2	Vertical Edge of door & window	6	5	4	3
3	Uneven Surface of plaster	5	4	4	1
4	Horizontal Edge	2	2	2	1
5	Air Gap between plastering & ceiling	2	1	1	1
6	Damaged Plaster Surface	3	4	2	1

5. DATA COLLECTION & ANALYSIS

5.1. General: -

Rahul East View in Hadapsar, Pune is a ready to move in housing association. It offers apartments in different budget ranges. A perfect blend of comfort and style, these units have been specifically designed to meet your needs and convenience. 1BHK and 2BHK apartments are available in this project. This housing association is now ready to be called home as families have started moving in.

5.2. Introduction: -

- Rahul East View Hadapsar offers 7 towers each with 7 floors and 251units.
- Rahul East View covers an area of 2.16 hectares and is one of the mostspacious housing companies in the Pune region.
- With all the basic amenities available, the Rahul East View fits your budgetand lifestyle

5.3.. Data Collection: -

Site management faces another challenge when it comes to customer service. Few other companies have the customer standing right in front of them whilethe product in question is being assembled. Such is the case in construction, however, where many homeowners regularly visit the site to oversee — and sometimes micromanage — the construction process. For this reason, it can bebeneficial for contractors to pay close attention to customer service and, if necessary, to think creatively about ways to avoid costly conflicts with One approach to consider is "Six Sigma" for construction. Management: a disciplined, data-driven methodology for improving all business processes, but especially useful for improving customer service

5.4. Site visit photos: -

Fig 10: Crack of wall

Fig 11: Vertical Edge of door & window

Fig 12: Uneven Surface of plaster

Fig 13: Horizontal Edge

Fig 14: Air Gap between plastering & ceiling

5.5. Data collection sheet with observation: -

1. Before Applying SIX SIGMA: -

Table 2: before applying Six Sigma method

Sr. No.	Building	Defects	Opportunities
1.	Building before handover to customer	2013	5777

Therefore,

DPMO = (2013 x 1000000)/(5777x10)DPMO = 46627.46

Based on Sigma conversion table,Sigma level = 3.30

Yield = 93.3%

(Percentage of items executed properly by contractors is 93.3%).

2. After applying SIX SIGMA: -

Table 3: Data collected on site before handover to customerTherefore,

Sr.no	Flat no.	Defects	Opportunities
1	101	12	100
2	105	6	100
3	202	3	100
4	206	3	100
5	305	5	100
6	401	4	100
7	406	8	100
8	506	7	100
9	602	4	100
10	605	6	100
Total		65	1000

DPMO = (65x1000000)/(1000x10)DPMO = 6500

Based on Sigma conversion table,Sigma level = 3.66

Yield = 99.30%

(Percentage of items executed properly by contractors is 99.30%)

3. SIX SIGMA TABLE:

Table 4: Sigma levels

YIELD	DPMO	SIGMA LEVEL
30.9	690000	1
69.2	308000	2
93.3	66800	3
99.4	6210	4
99.98	320	5
99.9997	3.4	6

6. RESULT & DISCUSSION

6.1. Introduction: -

After calculating the sigma degree, the DMAIC method changed into carried out to enhance the first-class of plastering paintings for development of first- class procedure for higher clientpleasure. The DMAIC carried out as follows: Define- Define is the level wherein trouble is recognized & troubles inflictingreduced client pleasure. Plastering is the maximum critical a part of the completing process in a constructing mission. But the defects in plastering canspoilall the creativity of constructing. These defects in plastering want to be repaired as soon as theyare determined. In this look at a tick list is ready to discover the defects of plaster withinside the decided-on case looks at of beneath Neath creation case look at of residential constructingof one hundredresidences. The defects determined in plastering are cracks on wall, choppy floor of plaster, vertical edges of window, door & column, horizonal edges of window, door &column, air hole among wall & ceiling, broken plaster floor. The vertical & horizontal edges of beam, column, window & door and the choppy floor of plaster and air hole are precipitatedin basic terms because of bad workmanship. The cracks on plastered floor are purpose due to bad creation practices - mistaken instruction of history floor, harm floor of plaster atsome stagein operating on web website online - Lack of supervision, Improperblend of materials, becauseof speedy drying, Damages to completed plaster floor at some stage in different sports is precipitated due to horrific supervisionfrom contractor.

Result: - Sigma stage pleasant of manufacturing degree casing Units isanticipated to boom from 3.30 to 3.66

6.2. Discussion: -Measure: -

Measure is the level wherein records is accumulated from procedure. Measureadditionally allows to pick out the maximum significant elements, indicates wherein to cognizance efforts and higher use of restrained sources to triumph over the determined defects. As consistent withthe case look at findings 70% of plastering defects are precipitated due to the fact of bad workmanship. 5% defects precipitated due to bad creation practices - mistaken blend of fabric, mistaken instruction of history floor, speedy drying because of moisture loss. 25% defects precipitated due to horrific supervision.

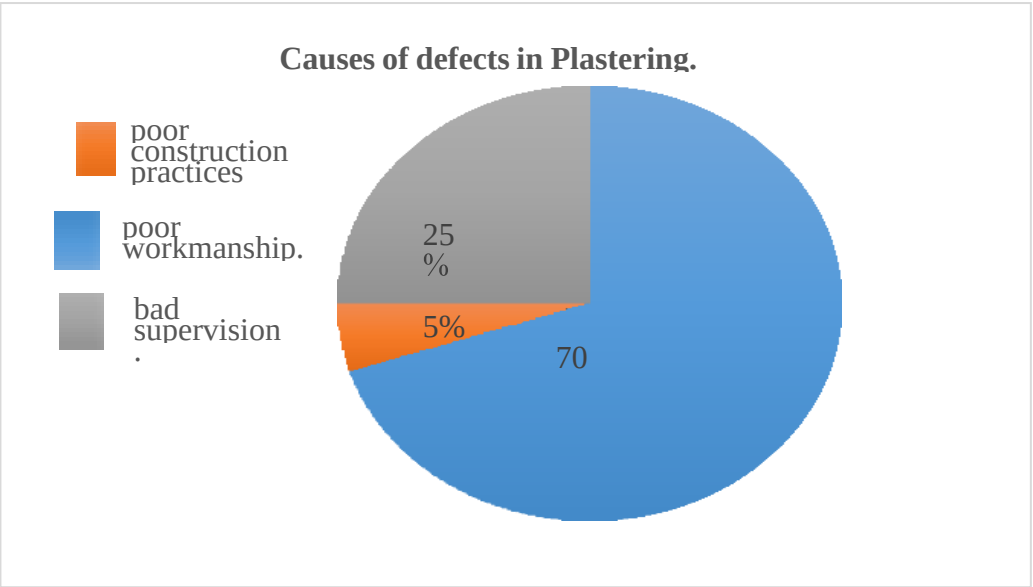

Fig 15: Pia chart

Analyze:-

Analyze is level wherein the foundation reasons of the troubles or defects are evaluated. For analyzing the purpose and impact diagram is used. The purpose and impact diagram take a look at why something befell or may occur through organizing capacity reasons into smaller categories One of the significant purposes of bad workmanship is Unskilled workman. The Factors whichmightbe accountable for professional labor scarcity in creation enterprise now a daysis due to loss of vocational education & schooling, loss of motivation & incentives, professional labor migrate remote places, extrade in talent requirement, bad operating surroundings. Another purpose for bad workmanship is locate of wrong equipment & equipment's. one of the purposes for broken equipment & equipment is the mistaken managing of them. The motives of bad creation practices are mistaken blend of fabric, mistaken instruction of history& speedy drying. Another motive for defects is horrific supervision and getting greater paintings carried out in much less time.

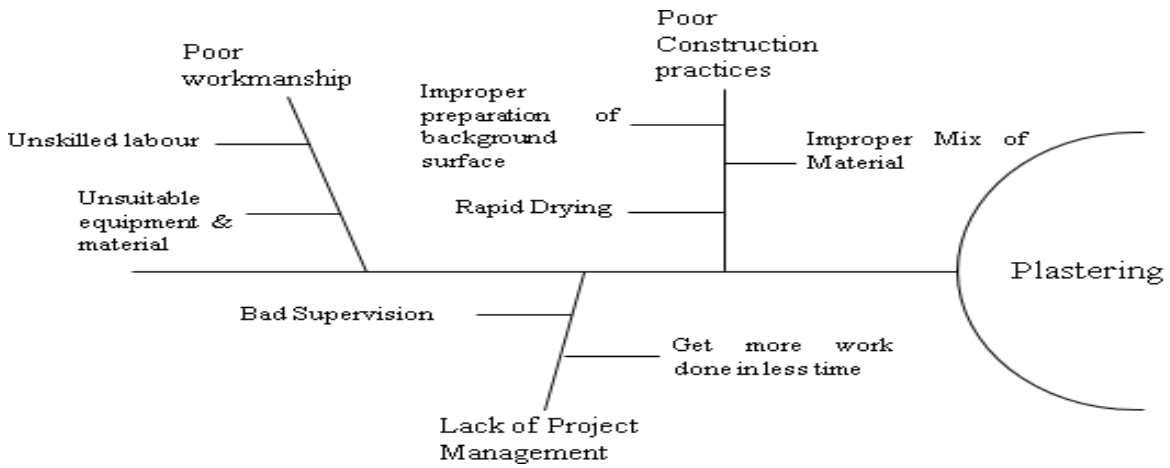

Fig 16: Analyze process (Note: -McCracken, 2000, Professional Safety, 45, p. 31)

Improve: –

Improve is the step wherein the methods are recognized to dispose of the disorder through growing the answer for defects. The trouble of unskilled lab our or loss of professional labor is there due to the fact loss of schooling and vocational education, lack of motivation and incentive, extrade in talent necessities or new technology, due to unfair wages the workmen are migratingremote places. As maximum of people are seasonal, migrants' people from bad agricultural states, so they don't have the right knowledge approximatelythe activity of creation. So, it's miles important to offer the workman with righteducation of creation sports earlier than beginning that activity. Also, a few vocational education packages need to be arranged for them to get greater knowledge approximately creation sports. The vocational schooling and education gadget have critical position in assisting with the matching of the abilities wanted through enterprise with the abilities supplied through the labor. As consistentwith on survey the 10 % of professional workman migrateremote places to gulf nations in maximum cases for buying better wages. Also,due to put off in payment through contractor, the workman feels unhappy andmigrate to every other web website online. So, through giving them bills on time we are able to prevent them through migrating. Also appreciating them through giving incentives and through presenting them right web website online safety & surroundings we are able to prevent their migration.

Another trouble of bad workmanship of use of wrong equipment and fabric may be stepped forward through well the use of and preserving them in right location in order that they may now no longer get broken. The device desires to be wiped clean after use of them. So, for supervising those sports we are able to employ a supervisor aside from contractor will test theones things. The trouble of bad creation practices which include mistaken blend of materials, mistaken instruction of history floor and speedy drying can be stepped forwardthrough following the right manufacturer of plastering unique through Indian general codes. By the useof the combination Ture of 1: 4 or 1:6 we are able tosave you defects.

Proper instruction of history floor is important for the adhesion of bond amonghistory and theplaster, so desires to be wiped clean well, need to have requiredroughness. If the floor is smooth, then it needs to made hard through cord brushing. Also, to received hard floor, a mortar1 cement: 1 to three coarse sandsthrough quantity organized to a moist consistency can be forcibly dashed or tothe floor (spatter sprint treatment) through appropriate way directly to a hard floor like concrete. Rapid Drying may be avoided through, watering the bottom coat as aminimum sooner or later earlier than plastering,

through preserving the clean floor moist & cool for as a minimum 15 days, the floor needs to be kept semi moist as consistent with the exact requirement. Also, through enforcing right mission control practices and preserving tuneof sports time to time we are able to mitigate the defects of plastering.

Control: –

Control is the step wherein we put together a manage plan. Control plan will assist us to test atthe numerous preventive measures which will assist us to achieve the desired end result. Control plan is a description of the procedures,assessments or assigned sports with admire to specifications, marking and overall performance. To manage all the sports, it's miles importantto offer the right tick list to comply with the method and the contractor and supervisor need tosupervise their paintings well. Also, through following the right mission control guidelines weare able to manage the delays of mission completion. Also, through presenting following measures as first-class manage plan, we are able to lessen and manage the defects.

Table 5: Quality Control Plan

Sr.no	Quality Control Plan	
1.	By Issuing a written, web website online specific first- class manage document	We can percentage this with everyone involved withinside the mission – from architect to suppliers, to set expectations, outline responsibilities and align goals right from the start
2.	By forming afirst-classmanage committee.	This will include key individuals of our web website online team of workers and subcontractors to give everyone a sense of possession and to make sure that team iscovering all elements of our paintings.
3.	By protecting pre activitymeetings.	As experts lose almost two full operating days everyweek fixing avoidable troubles and searching for related records. Holding meeting only allows everyone to review specs together but they are also a exceptional discussion board for clarifying troubles and stopping misunderstanding
4.	Be conducting constructabilitycritiques	Led through the designer and contractor, those critiques will assist assume and alleviate subject.
5.	By acting regular inspections	According to a few estimates, creation rework can account for among 2% and 20% of a typical projectscontract amount. We can keep away from that steeply-priced final results through assessing the first-class of the workmanship andfiguring out errors earlier than they lead to most important troubles and rework.
6.	By checking the first-class of fabric while accepting	When receiving materials, we can whole a first- class manage inspection to ensure only approvedproducts are regular and objects have now no longer been broken while
7.	By preserving statistics of approvals and verifications	Project managers need to get formal owner verifications and secure approvals of workmanship.This can be carried out through both through hiring third party celebration inspectors.

7. CONCLUSION

- In this the look at, it's miles visible how different factors have high effect at thefirst-class of the development. These elements must be recognized asearly as feasible in orderthat first-class may be stepped forward. Detailed method has been carried out primarily basedtotally on Six Sigma concepts which offer us systematic method to pick out and improvise thecutting- edge procedure. Six Sigma additionally gives scale to degree whether or not the first- class has been stepped forward or now no longer. 7% choppyfloor, 27 % mistaken vertical edges of column, window and door, 32% mistaken horizontal edges of window, door, four% air hole in plastered floor, and 15 image plastered floor at some stage in sporting out different sports are determined. Further the sigma degree is calculated the use of DPMO, the calculatedsigma degree changed into three.27.

- After making use of DMAIC its miles determined that those 70%defects are precipitated due to bad workmanship,5 %purpose of bad creation practices and 25% purpose of loss of mission control practices. So, those difficulty which are main to plastering defects are attempted to decrease through making use of DMAIC a good way to at once boom the sigma degree of first-class.

- After comparing the defects through making use of DMAIC is determined that the shortage of professional labor or unskilled labor, use of wrong equipment's and equipment is main to the bad workmanship, mistaken instruction of history floor, mistaken blend of fabric and speedy drying those troubles are main too bad creation practices and additionally differenttroubles which include loss of supervision through contractor and loss of mission control practices main to the defects which are deteriorating the first-class of completing paintings (plastering) of residential mission. Deteriorating of first-class of completing paintings will result in bad clientpleasure. But through the use of six sigma method that's theset of control approach and device for higher development of first-class procedure can assist infiguring out and minimizing defects in advance which will enhancethe client pleasure which will additionally enhance the productiveness of creation enterprise.

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