Analysis Quality Improvement of Structural Work in Ciputra World Surabaya Project 3

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Abstract—Quality is very important in the success of construction projects. Tatamulia Nusantara Indah Contractor, has a standard of work quality based on the SMM (Quality Management System) for all projects undertaken. One of the projects is Ciputra World Surabaya 3, this project is a large project consisting of a Mall, Office Tower, SOHO and Vertu Apartments. This research will be carried out to improve the quality of structural work. The method used is the Six Sigma DMAIC approach (Define, Measure, Analyze, Improve, Control). Data collected from the Employment Nonconformity Report (LKP) in 2019. Starting from identifying the job with the highest number of LKPs, then calculating work disability using the sigma level. Defects that are at the sigma level will be analyzed and corrective actions sought. Furthermore, different field tests will be carried out to determine the comparison of work with the quality produced. The results obtained in this study using the Six Sigma DMAIC approach are successful in improving the quality of structure work compared to the previous conditions, because applying the recommendations of the best work actions before work will produce good quality as well.

Keywords—Quality of Structure Work, Six Sigma DMAIC, Structure Work Disability.

I. INTRODUCTION

AT THIS time the building projects are required to meet the safety, comfort and durability requirements as well as the efficient use of energy and environmental management. To anticipate the free market in the construction industry, construction services in Indonesia need to improve the quality of their products as a business strategy to remain existent and competitive. Because by improving the quality of products or services, hoping that customer satisfaction will be achieved[1].

Quality is a major requirement in a construction project. Quality is now no longer interpreted as a traditional sense where as a fulfillment of a requirement, but a product or result that can satisfy consumers. Quality improvement is one way to achieve customer satisfaction. Stages in maintaining a quality so that it stays at a predetermined standard, becomes an important emphasis in the sustainability of a construction project. The stages of quality planning, the stage of implementation required quality assurance, the stage of evaluation required an oversight and the stage of maintaining and developing quality. Quality control is an important work in a construction project management [2].

The quality of buildings can be seen from the aspects of construction strength, material durability, method of implementation. The strength of construction is determined by the accuracy of structure selection and material selection, as well as the correct implementation. In other words the quality of the building is determined from the time of planning, implementation and maintenance stages. The work of building structures with material systems and durability is information needed by planners in carrying out their duties. Likewise, the contractor must know the material specifications and the correct implementation of the system [3].

In general, every construction company or contractor has a good plan in assessing, managing management systems that improve the quality of work and improve it. One of them is Tatamulia's contractor who has a management system for the quality of every project she works on, so that the planned quality runs according to its initial requirements. QMS (Quality Management System) is a quality assessment standard used by Tatamulia by using a numerical score in the assessment of her work. The problem is that in this project the quality has decreased with the increase in LKP by 54.89% from the start of the project in July 2017 to November 2019, especially the structural work which resulted in porous concrete. As a result, there was an increase in costs to make improvements to the work.

Quality degradation can be seen from the defect control limits of structural work carried out by using Control Chart. The work that has been designated as Critical to Quality in the structure work in 2019 will be used to determine the upper and lower control limits. If later the structure work defects are in a position with the specified limit, it is concluded that this project has decreased quality. Data on the Report Employment Nonconformities in 2019 can be seen in Table 1 and Figure 1.

In this thesis an evaluation will be conducted to improve the quality of work by minimizing quality variations, the Six Sigma approach aims to make continuous improvements. According to [4] the Six Sigma philosophy is a philosophy of continuous quality improvement, where the variability of the process is trying to be minimized so that only 3.4 failures occur in one million times. The results of this experiment will be re-assessed with the existing Quality Management System at Tatamulia and will see differences in the results of the quality of work before and after.

Table 1.
Data on the Report Employment Nonconformities in 2019

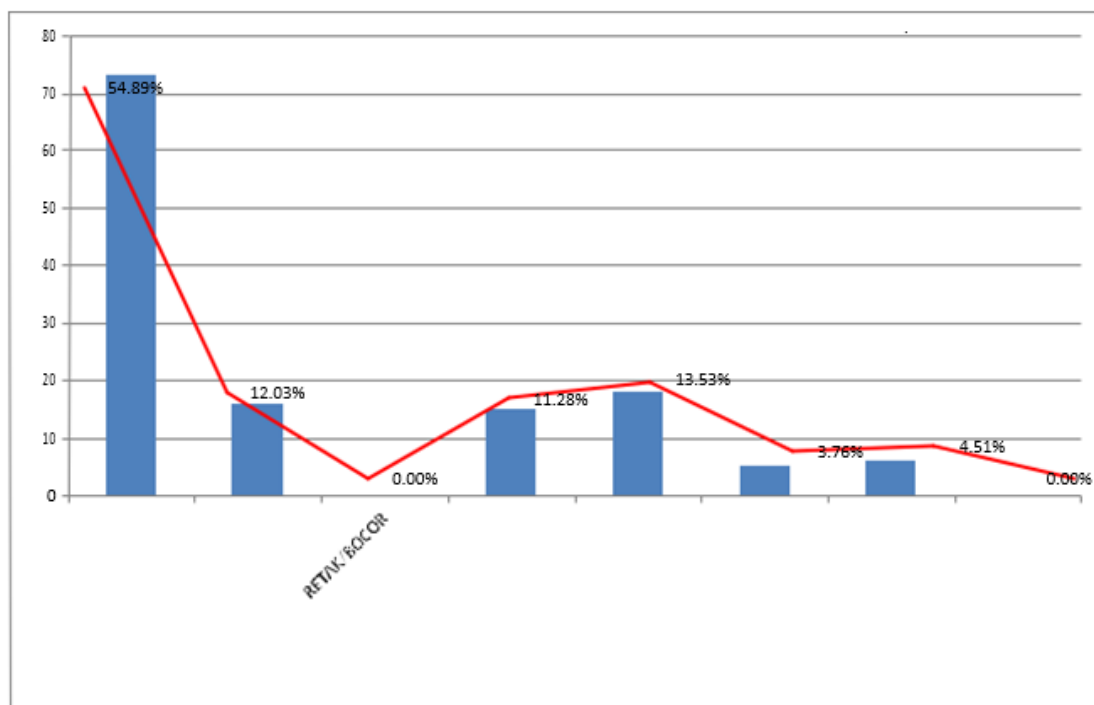| LKP until JULI 2019		LKP	Prosentase
1	HONEY COMBING	73	54.89%
2	CONCRETE DEFORMATION	16	12.03%
3	CRACK / LEAK CONCRETE	0	0.00%
4	MATERIALS NOT ACCORD TO SPECIFICATIONS 15		11.28%
5	JOBS DO NOT ACCORDING TO IMAGES	18	13.53%
6	STEEL WORK	5	3.76%
7	BROKEN MOLD	6	4.51%
8	DELAY OF JOB .	0	0.00%
	Total	133	100.00%

Figure 1. Graph of Reports on Job Non-Conformities 2019.

II. METHOD

This research will use the Six Sigma approach to simplify the problem solving process and analyze the results of data processing through good management so that it can be of higher quality. The Six Sigma DMAIC approach method (define, measure, analyze, improve, control) will be used to process the Work Incompatibility Report (LKP) from the field and will be explained as follows.

A. Identification of Work Defects (Define)

At this stage structural work defects will be identified using the Pareto Diagram. Work defects will be classified based on their respective work and the percentage will be calculated with the highest number of defects to the smallest number of defects.

B. Measurement of the Amountf of Work Disability (Measure)

After identification of structural work defects, a sigma level will be measured for work disabilities using the DPMO (Defect Per Million Opportunity) calculation. First is to classify the structure of work defects that have been determined by calculating the presentation of pareto defect diagram, then measuring the capability of the work to know the number of work defects that appear in a million times the process.

$$DPMO = (D / (U \times O)) \times 1,000,000 \qquad (1)$$

Keterangan :
DPMO = Defects Per Million Opportunities
D = Defect
U = Unit
O = Opportunities

C. Analysis of Factors Causing Work Disability (Analyze)

Based on the calculation of the Six Sigma level, the lowest sigma level will be known and the most dominant defect type will be identified. At this stage, the factors that cause job disability are analyzed using a causal diagram and conduct questionnaire interviews with project leaders such as the Project Coordinator, Project Manager, Site Manager, QA / QC, Supervisior and Foreman.

D. Search for Corrective Actions (Improve)

Focus Group Discussion (FGD) will be used in this study to conduct group interviews and approve corrective actions on work structure defects. the results of this discussion will be a variable that will later be carried out questionnaires and
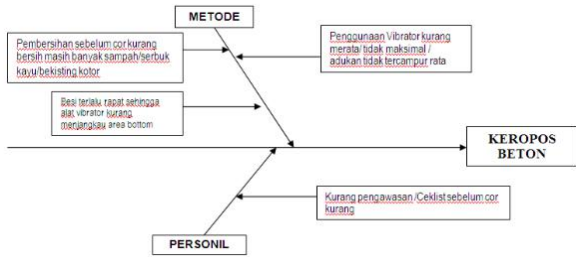
Figure 2. Concrete Cause Caused Concrete.
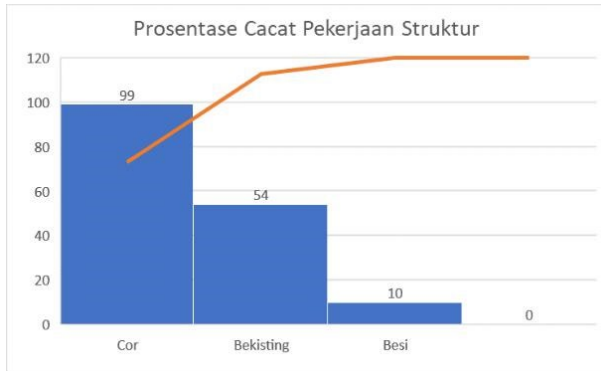

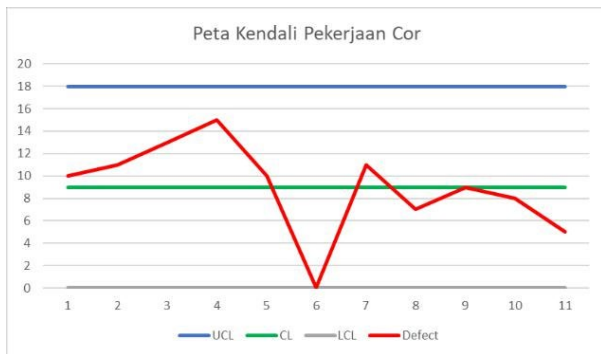Figure 3. Pareto Diagram of Work Defect Structure.

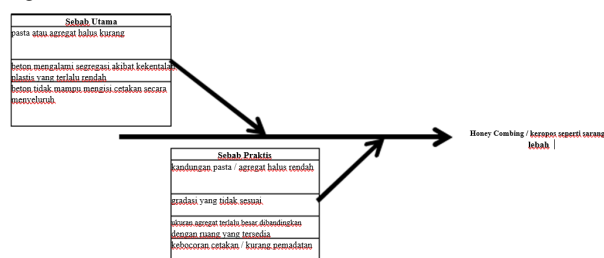Figure 4. Control limit C cast / concrete work.
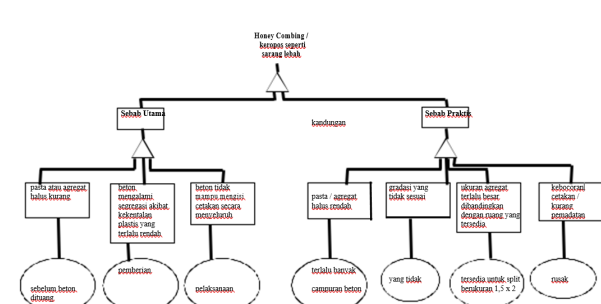

Figure 5. Honey Combing Fish Bone Diagram.

Figure 6. Fault Tree Analysis Honey Combing.

re-interviews of the project leader to approve the improvement of a job. Recommended work improvement measures with high weights will be the first choice for dealing with problems of defects in the most dominant structural work.

E. Controlling the Results of the Best Actions by Testing in the Field (Control)

The final stage of this method is the control process which in this process will be tested in different fields with different test statistics. The aim is to control employment in different fields. Where the field work is done with the best action recommendations and the field work is done without the best action recommendations. If there are differences in the statistical tests and the numbers are higher, then it is declared successful and can solve solutions to improve the quality of structural work.

III. RESULT AND DISCUSSION

A. Determination of Critical to Quality (CTQ) Structural Work

This stage is an identification of structures that have more work defects and will be made Critical to Quality (CTQ). The object of the study consisted of 3 structural works namely formwork, pembesian and casting / concrete work in Figure 3.

In the picture above it can be seen that the cast job has the highest number of defects, then this work becomes Critical to Quality will be further analyzed related to the defects that are caused as well as the factors causing defects in the job.

B. Measurement of the Amount of Work Disability

Measurement of structural work defect control limits is carried out using the C-Chart control map. This control map will measure the work that has been defined as CTQ, that is, the cast work and the data is obtained from LKP in January 2019 until November 2019 in Figure 4.

Based on the above results the stability measurement of concrete works is still within the tolerance limits of the control map, so it can be assessed that concrete works are experiencing stable conditions. Next will be done the grouping of concrete work defects, where in this study the object is 7 samples of concrete work defects every month, the types of concrete work defects are Honey Combing, Scaling, Blow Holes, Cold Joint, Surface or very bad and uneven casting results. , Color variations and plastic cracks.

Measurement of sigma and DPMO values for each concrete work disability sub-type is to determine the concrete work disability at level 4 sigma and then further analyzed.

C. Disability Analysis Concrete Work

At this stage, the cause and effect analysis will cause problems in concrete work which will be the main focus of the work to improve the quality of the work in Figure 5 – 6.

The cause of porous concrete is analyzed with fish bone diagram and Faul Tree Anaylsis (FTA), because the main porous concrete, namely paste or fine aggregate is lacking, the concrete experiences segregation due to very low plastic thickness, the concrete is not able to fill the mold thoroughly. The practical cause is low paste or fine aggregate content, inappropriate gradation, too large aggregate size compared to available space and mold leakage is also one of the causes of porous concrete.

D. Recommendations for the best action against concrete job disabilities with Focus Group Discussion (FGD)

After the FGDs, there were several recommendations for the best actions for each job, one of which was concrete work

Table 2.
Value of Six Sigma and DPMO concrete work

No	Jenis Cacat Pekerjaan	Jumlah Cacat	Jumlah Luas	Total Prosentase Cacat	DPMO	Nilai Sigma
1	Honey Combing	31	1720,32	31,31	18019,9	3,504
2	Scaling	14	1720,32	14,14	8138,02	3,997
3	Blow holes	14	385,63	14,14	36304,23	3,205
4	Cold joint	16	861	16,16	18583,04	3,516
5	Bad Surface Results	14	1720,32	14,14	8138,02	3,997
6	Color Variations	2	385,63	2,02	5186,32	4,034
7	Plastic Cracks	8	1720,32	8,08	4650,3	4,199
	Total	99		Total 100		

Table 3.
Assessment of Recommended Best Actions for Porous Concrete Defects

No Action Recommendations	R1	R2	R3	R4	R5	R6	R7	Mean
1 Increasing the fine aggregate content	4	4	3	4	4	5	4	4
2 Using a minimum 450 kg/m3 powder	3	4	3	3	4	3	4	3.428571429
3 Adding Water entraining	3	3	3	2	3	2	2	2.571428571
4 Continous Gradation	3	4	3	4	4	4	4	3.714285714
5 Aggregate size is made smaller	4	3	4	4	5	5	4	4.142857143
6 Checking the integrity of the main mold	4	4	4	4	4	4	4	3.857142857
7 Quite compacting with a vibrator	5	4	5	4	4	5	4	4.42857142

Table 4.
Recommended Value of Best Action for Porous Concrete Defects

Factor Causing Defects	Mean	Recommendations of Respondent	Mean	Bobot
Concrete is not able to fill	3.734693878	Rekomendasi 1	4	14.93877551
The mold thoroughly		Rekomendasi 2	3.428571429	12.80466472
		Rekomendasi 3	2.571428571	9.603498542
		Rekomendasi 4	3.714285714	13.87172012
		Rekomendasi 5	4.142857143	15.47230321
		Rekomendasi 6	3.857142857	14.40524781
		Rekomendasi 7	4.428571429	16.5393586

Tabel 5.
Independent Sample Test

Quality Value	Levene's Test		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailded)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	3.947	0.094	3.25	6	0.017	11.25	3.4611	2.781	19.719
Equal variances not assumed	-	-	3.25	3.88	0.033	11.25	3.4611	1.5223	20.9777

with porous concrete work defects. The main factors causing porous concrete are not able to fill the mold thoroughly, some of the actions that will be taken are increasing the fine aggregate content, using a minimum of 450 kg / m3 powder, adding water entraining, continuous gradation, aggregate size is made smaller, checking the integrity of the main mold especially the connection part and quite compacting with a vibrator.

Next will be an assessment of recommendations for the best actions and taken with the highest value can be seen in Table 3 – 4.

The best recommended action for porous concrete is recommendation 7 with the highest value, namely the use of a maximum vibrator and in accordance with formwork size. This recommendation was agreed upon and chosen because at the time of the cast work, supervision was lacking and had to be required to use internal and external vibrators.

E. Applying the Best Action Recommendationss with a Statiscal Difference Test

1) Independent Sample Test

In the independent sample t test, this test aims to compare two samples that are not paired with each other, namely the unit sample that is done with the recommendation of the best action and the unit sample that is done without the recommendation of the best action.

At this stage decision making based on the comparison of the value of t arithmetic with t bael in the independent sample t test which results are t arithmetic of 3.25> 2.477 t table, concluded that H0 is rejected and Ha is accepted. There is a difference in the average test results of the work with the best action recommendations and jobs without the best action recommendations. In other words the job with the best action recommendations will produce a better quality of work as well.

IV. CONCLUSION

Based on the results of research conducted by researchers in analyzing structural work defects and their causes by using Six Sigma DMAIC :

1. Structural work that has the highest number of defects is concrete work. The job defect with the lowest Sigma value for concrete work is 3.205 Blow Holes / dotted concrete. Job defects with the highest Sigma value for concrete work are 3,505 Honey Combing / porous concrete. In this study more focused on porous concrete because it has a very large area of 1720.32 m^3.

2. The main factor causing porous concrete defects is the concrete is not able to fill the mold thoroughly.

3. The best recommended action for porous concrete is enough compaction with a vibrator according to the size of the formwork, increasing fine aggregate and making aggregate smaller with available field conditions.

4. After recommending the best actions and calculating the statistical difference test, the Six Sigma method in this study is considered successful in improving the quality of structural work and reducing structural work that is incompatible with the quality of planning.

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