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Influence of Six Sigma for Quality control in construction industry: A review

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Abstract—This paper investigates the level of implementation of Six Sigma in the construction industry along with the current state of affairs and the challenges, and opportunities for a successful implementation. The research is purely exploratory in nature. A number of questionnaire surveys and interviews are conducted to refine and quantify the impact of Quality control in construction industry. This analysis helps in acknowledging the current trends for QC being going on in the market. It gives an idea about the mindset of professional associated with construction industry

Keywords: Quality Control, Six Sigma, Construction Industry, Questionnaire

I. INTRODUCTION

Construction industry is very important for any country from economic point of view. Its makeup and nature are quite complex which call for an expert management by considering not only budgets and schedules but also quality and environmental impacts (Howell and Ballard, 1998). Thus it is imperative to facilitate the industry in order to get the best out of its performance. Montgomery and Woodall (2008) stated that improving project performance has become an important business strategy for many organizations including manufacturers, distributors, transportation companies, financial service providers, health care foundations and public agencies. Project performance can surely dominate the competitors and increase the customer satisfaction resulting into overall project success (Jurburg et al., 2015).

Majority of the construction projects suffer from inadequacies in implementation, resulting in huge time and cost overruns, affecting their viability, and acting as a drag on the economy. For these projects, the consequences of decision on essentially how well the project is to be managed, with commitment to communication and coordination, will generally far outweigh the consequence of how well the specific technical role is performed (Wideman, 1990). Originally a manufacturing industry concern, quality is now recognized as a key issue in construction sector whose clients increasingly demand quality certifications (Chung, 2007). Construction quality relies on accurate, clear statements of quality control requirements arrived at by translating user needs into specification, and project quality plans and programs (Stukhart, 1989). Previous studies have addressed improving the quality of construction processes and strategies for the reduction of construction waste (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; Love et al. 2009). For example, Serpell and Alarcun (1998) created a framework for improving the construction processes through a set of structured activities and tools to help improve quality

LITERATURE REVIEW

Six Sigma is a ‘cultural and belief’ system and a ‘management philosophy’ that guides organizations in repositioning towards world-class business performance by increasing customer satisfaction and enhancing bottom lines based on factual decision making (Pheng and Hui, 2004). As per Kwak and Anbari (2006) Six Sigma has two key methods: DMAIC (Define, Measure, Analyze, Improve, and Control) and DFSS (Design for Six Sigma). DMAIC is for existing processes which require significant improvement due to falling below expected quality specification (Forbes and Ahmed, 2010) whereas DFSS as a systematic methodology is used for designing new products and processes at Six Sigma quality levels (Mader, 2002).

Six Sigma has been transformed over the last twenty years. It is now a flexible and adaptive business strategy, applicable to many aspects of business and organizations. Its roots can be traced back to 1809 with introduction of normal curve by Gauss and later in 1920s when Walter Shewhart showed that three sigma from the mean is a point where process requires correction. But, credit for coining the term “Six Sigma” goes to Motorola who used it to quantify the manufacturing defects, resulting in major savings. They formally developed Six Sigma in 1987 and targeted an aggressive goal of 3.4 parts per million (ppm) defects (Folaron, 2003; Pheng and Hui, 2004). In 1994, AlliedSignal introduced Six Sigma as a business initiative to “produce high-level results, improve work processes, expand all employees’ skills and change the culture” (ASQ, 2002, p. 14). This was followed by the well-publicized implementation of Six Sigma at General Electric beginning in 1995 (Slater, 2003).

II. METHODOLOGY

This study aims to assess and measure the competitiveness of the construction industry from different quality and success perspectives. Semi-structured interviews along with a multi-stepped comprehensive questionnaire survey are the main sources of information gathering. In the survey, the participants were asked to rate the importance and weightage of factors. This Questionnaire survey was done by means of google form to acknowledge current scenario regarding Quality Control in the construction industry. The questions based on ongoing projects, its types, trends and reasons for drawback in QC are inserted in the form. The aim of this exercise was to know the perspective of Six Sigma and observe its influence on construction industry performance

III. DATA COLLECTION AND ANALYSIS

The questionnaire sets out with the introduction where the respondents were asked to provide information about their organizations and its type. Then they were asked about the age of their organizations, employees training, etc. They were asked various questions regarding basics of the ongoing procedure, Six Sigma, potential barriers to its implementation, and organizational deficiencies and effectiveness of Six Sigma in dealing those

The targeted respondents were experienced construction professionals of construction industry. An approach to hundreds of individuals was done all over Gujarat, India by means of electronic media. Out of them 60 professionals responded to this initiative. The majority respondents were from Ahmedabad, Rajkot and Surat.

Out of 60 respondents, 69% are working on residential construction, 17% are working on commercial construction, 9% are working on industrial shed construction and 5% are constructing public works.

This survey is done to check out the scenario of Quality control done on construction sites, out of 60 responses 97% respondents were doing QC on their sites while there were 3% i.e. 2 of respondents who weren't doing QC on their sites.

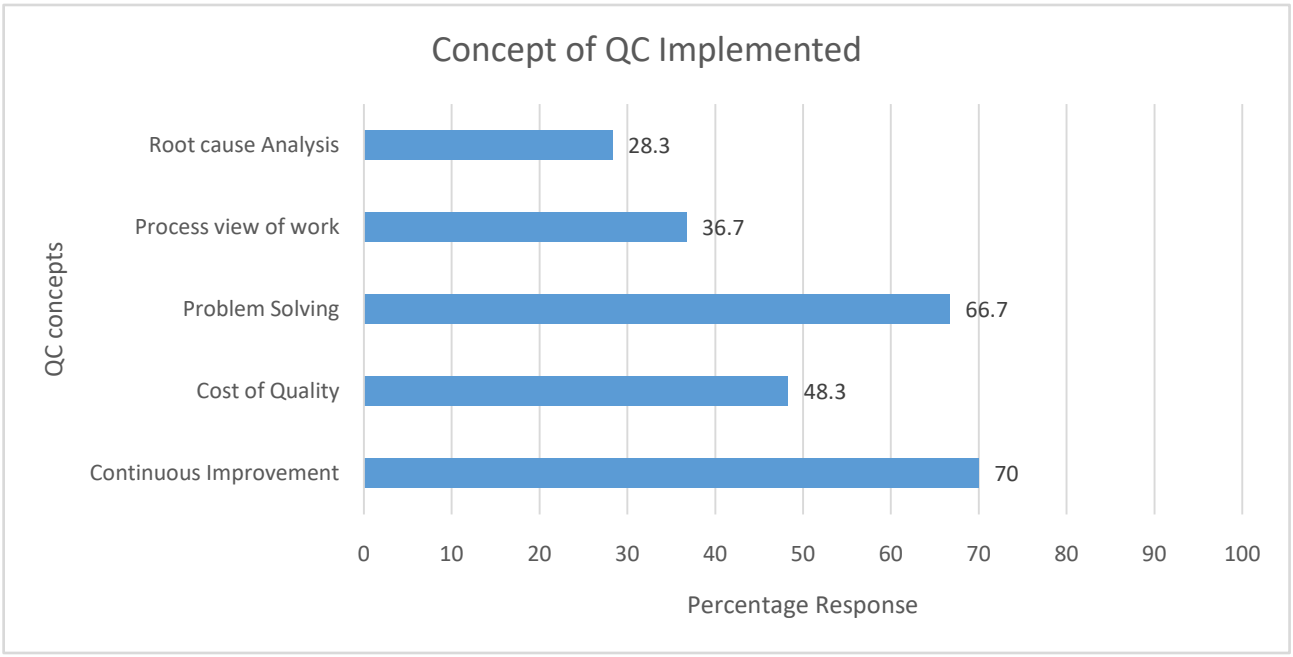


Figure 1: Concepts of Quality Control

Another question was asked regarding the concept of QC being implemented on the construction site. The most used concept of QC is Continuous Improvement with 70%. The least used concept is Root cause analysis with only 28.3 % ratings. Other concepts were rated as of Process view of work is used up to 36.7 % and Cost of quality is used up to 48.3 % extent. The problem solving is a general concept implemented in the companies with a response of 66.7%. It is shown in figure 1.

From this analysis it can be seen that the mind set of most of individuals are of eliminating the defects which are occurred in present and not seeking to know the root cause of defects which will help in preventing the upcoming defects.

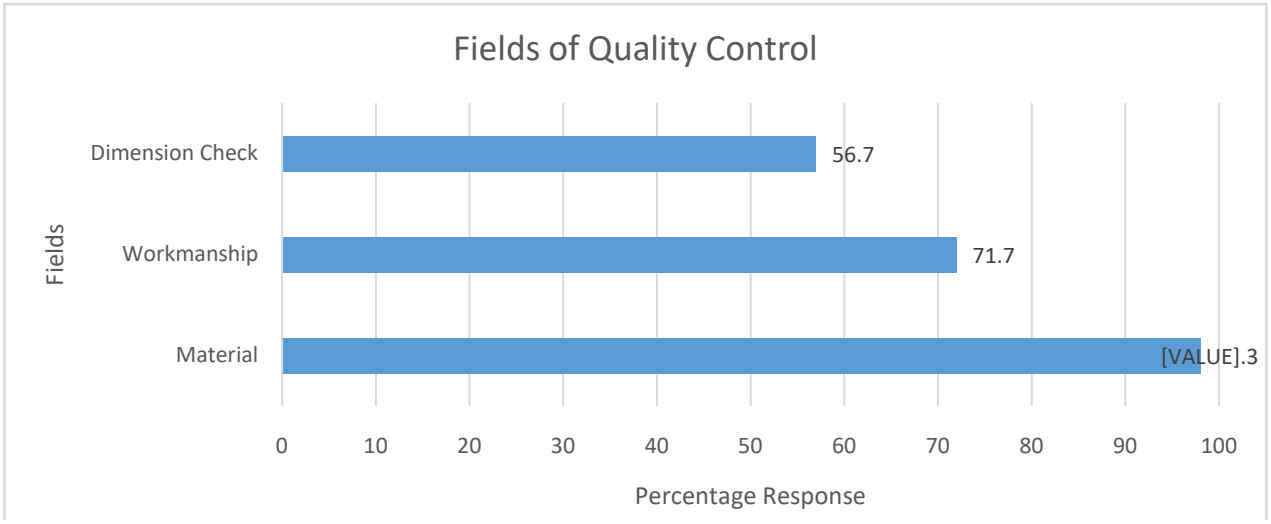


Figure 2: Fields of QC

This question broadens our mind about the different fields where QC is conducted. From figure 2 it can be observed that 98.3 % of the Quality control is done on the materials i.e. concrete, steel, etc. Then comes workmanship with 71.7% responses and 56.7% of respondents do dimension check as a part of Quality Control.

From the above data it can be said that the field with major impact is material for which slump test, cube test, tensile test for steel is conducted. The others fields include only observation and measurement hence not necessarily all do the dimension check.

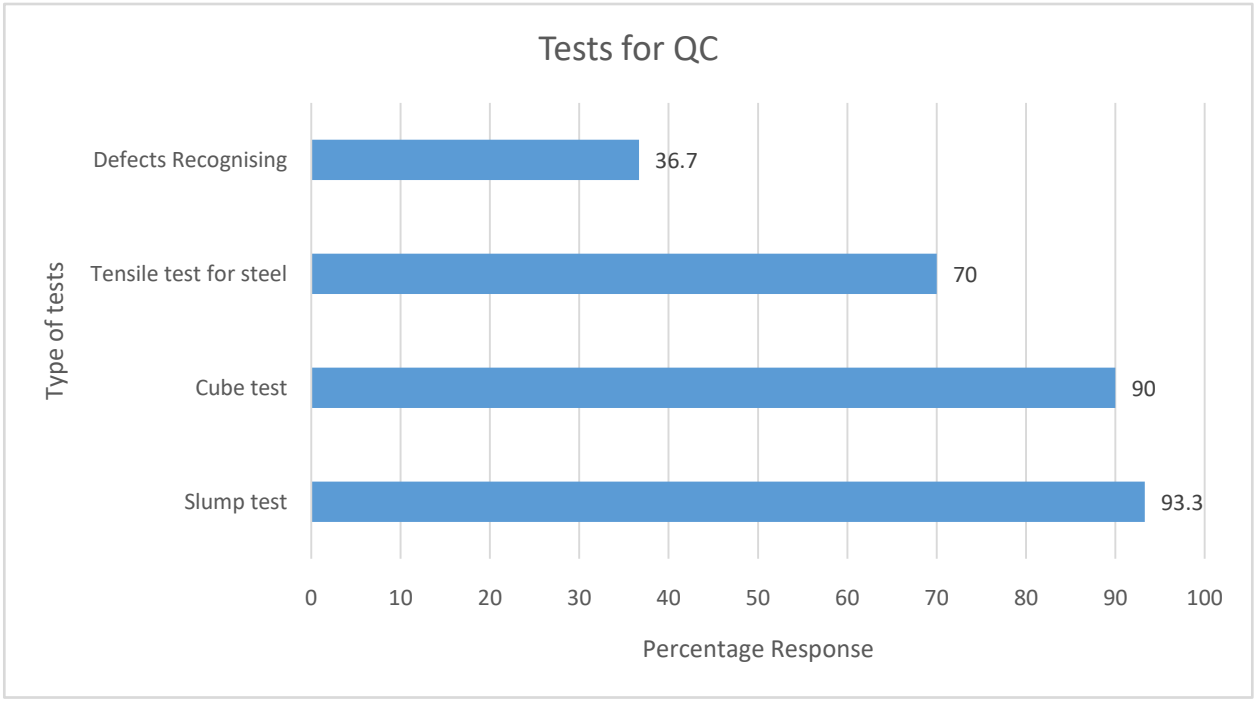


Figure 3: Tests for QC

There are several tests conducted on a construction site. Hence the next question was asked regarding tests conducted on site for QC. From the survey it was observed and analyzed from figure 3 that Slump test and cube test are done by almost every firm as it shows 93.3 % and 90% respectively. The other test conducted was tensile test for steel which is done by 70% of the responders. The other thing done for QC is defect recognizing which is done by 36.7% of firms.

From this question it is cleared that slump test and cube test are considered vital for construction industry in Gujarat, India.

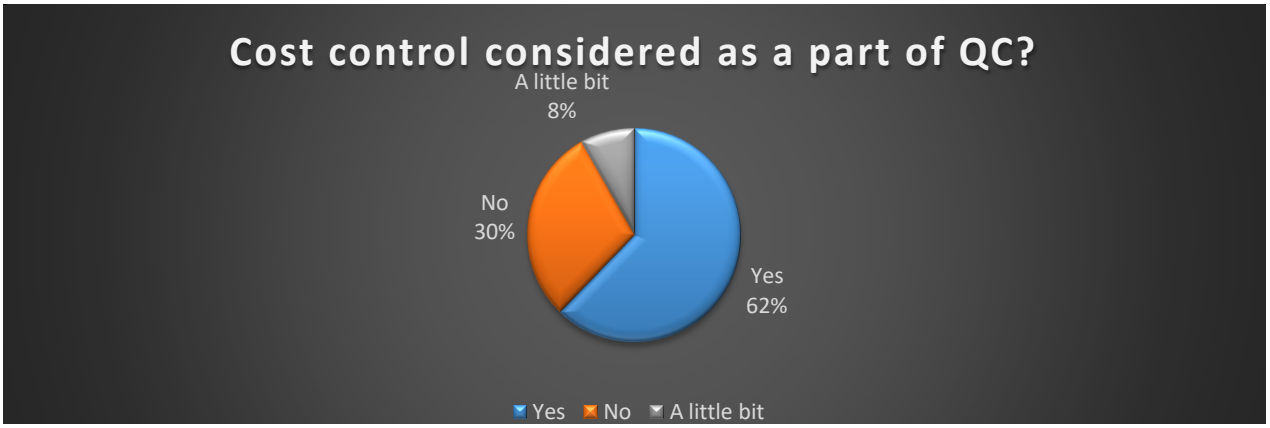


Figure 4: Cost Control as Quality Control

The other question asked was, whether the professionals considered cost control as a part of QC or not. As a result, from figure 4 it was observed that more than half i.e. 62% agrees cost control as a part of QC and 30% responders disagrees with the fact while 8% population has neutral reaction on this.

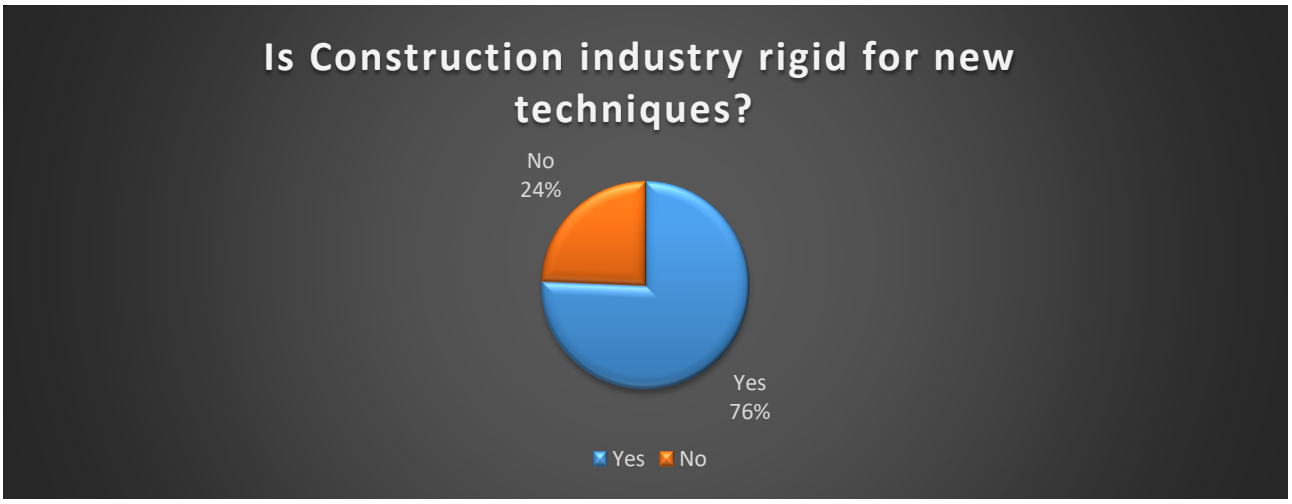


Figure 5: Adoption of new technologies

A question was asked to know the mentality of site professionals. They were asked about their views for adopting new technologies in construction industry. 76% of the responders were in favor that the industry is rigid for new techniques and 24% of them disagrees with the fact. It is portrayed in figure 5

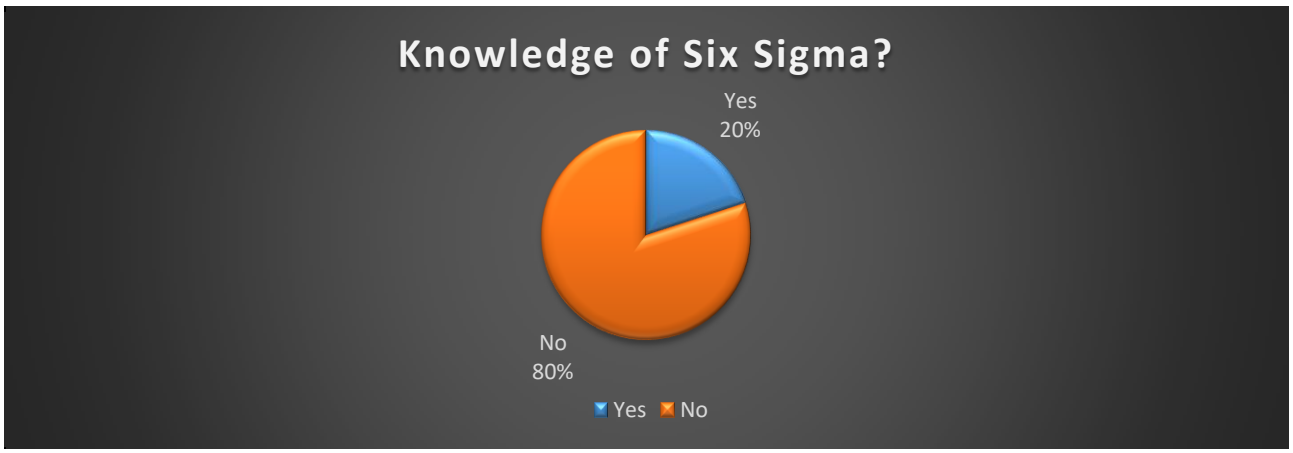


Figure 6: Knowledge of Six Sigma

As the research is going on Six Sigma, they were asked if they had knowledge of Six Sigma technique. Figure 6 clearly says that only 20% of responders were aware about Six Sigma technique while 80% were unaware about the technique as they never heard of it. Further they were asked about the reason for not applying Six Sigma for which 75% of the responders lacked the knowledge of Six Sigma while 43.3% of them believed that they were comfortable with traditional methods. There was a mass of 30% who had insecurities for adopting new techniques such as SS which is portrayed in figure 7

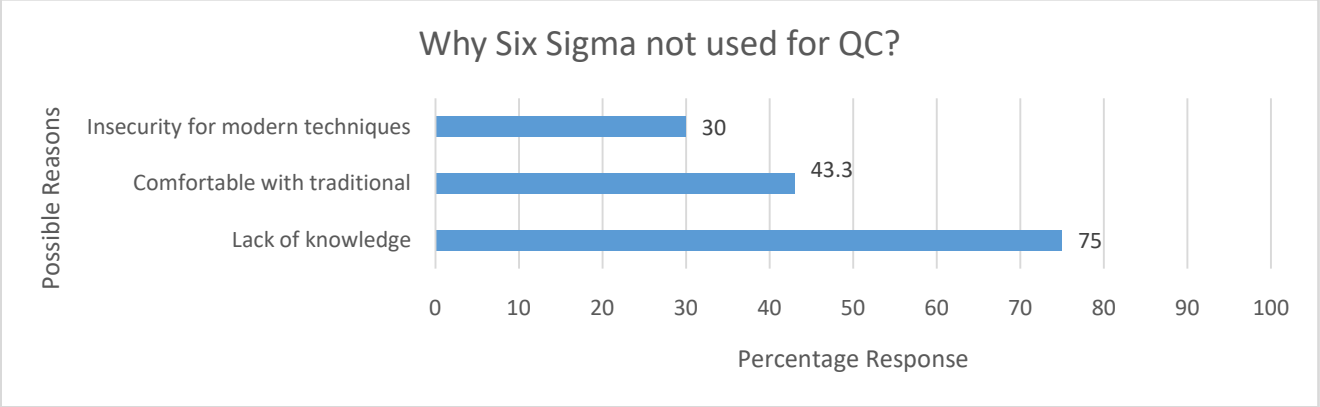


Figure 7: Reason for not using Six Sigma

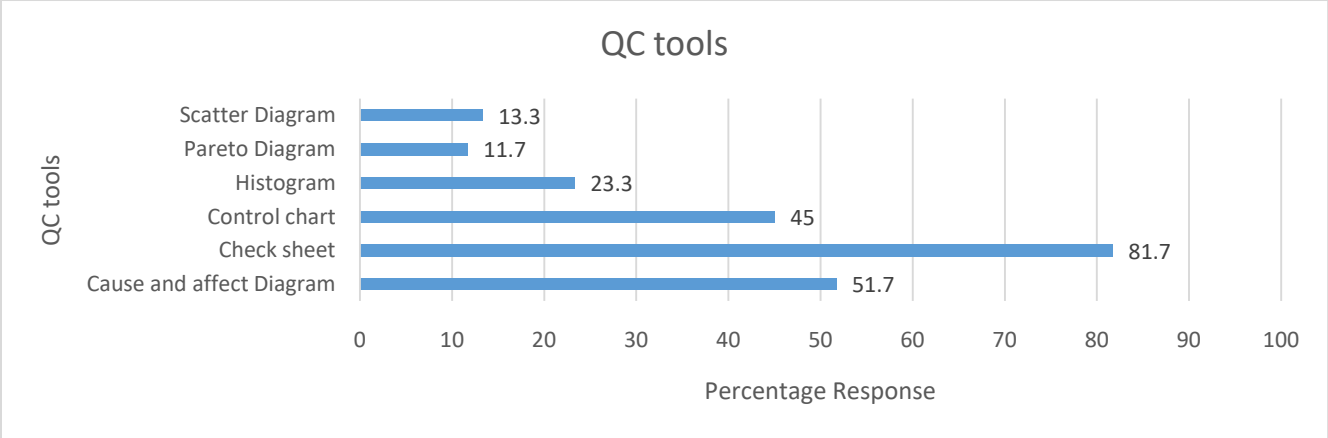


Figure 8: QC tools

Quality Control comprises of many Quality control tools and hence question regarding the tools used by the firm were asked. On a construction site multiple tools are used hence at the end of the survey it was analyzed that

Pareto diagram is the tool least used as it shows the result with only 11.7% Scatter diagram, histogram and control chart tools has average usage with 13.3 %, 23.3% and 45% respectively. Compared to the average usage, the Cause and effect diagram is used more at 51.7 % Check sheet tool is more used at 81.7 % which is done on almost every construction site which is shown in figure 8.

Figure 91: Slump test for every batch

It was seen in above analysis that three QC tests were conducted on most of the sites hence questions related to these tests were asked. For doing QC whether slump test was done for every arrival of batch or eventually. In response to that it is observed that majority of professionals i.e. 52% of them conduct it eventually while 48% of them conducted it for every batch from figure 9.

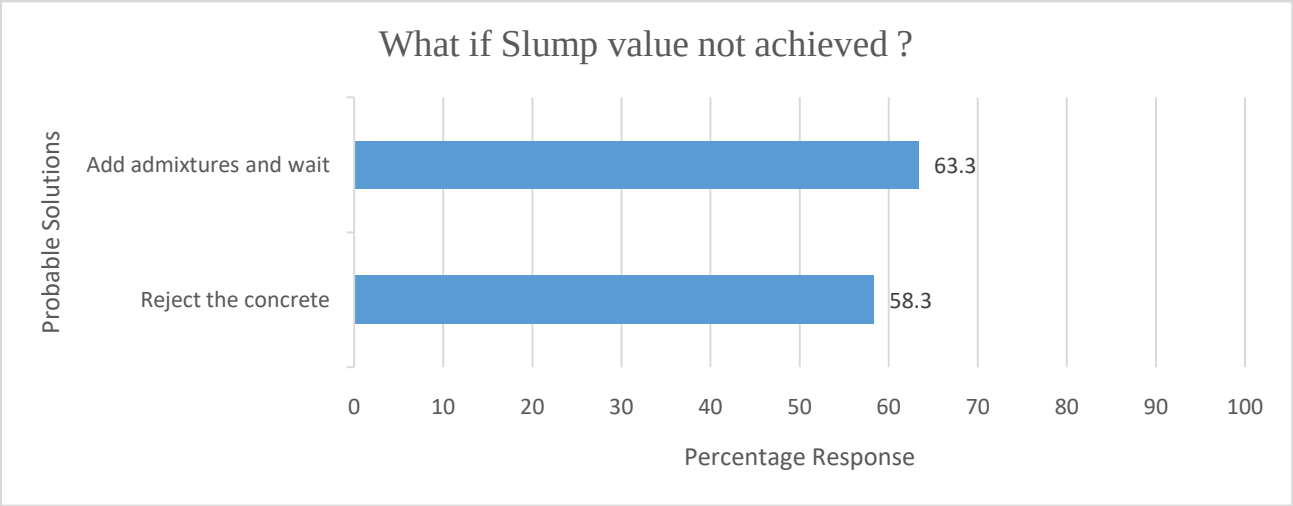


Figure 20: Probable solutions when Slump value not achieved

Another question asked was about what actions are taken if the desired slump value is not achieved. As its response, 63.3% chances are to admixtures and again wait for the result and 58.3% chances are of rejection of concrete.

There are several factors affecting for not achieving desired slump value. For this question the responses are shown in figure 10

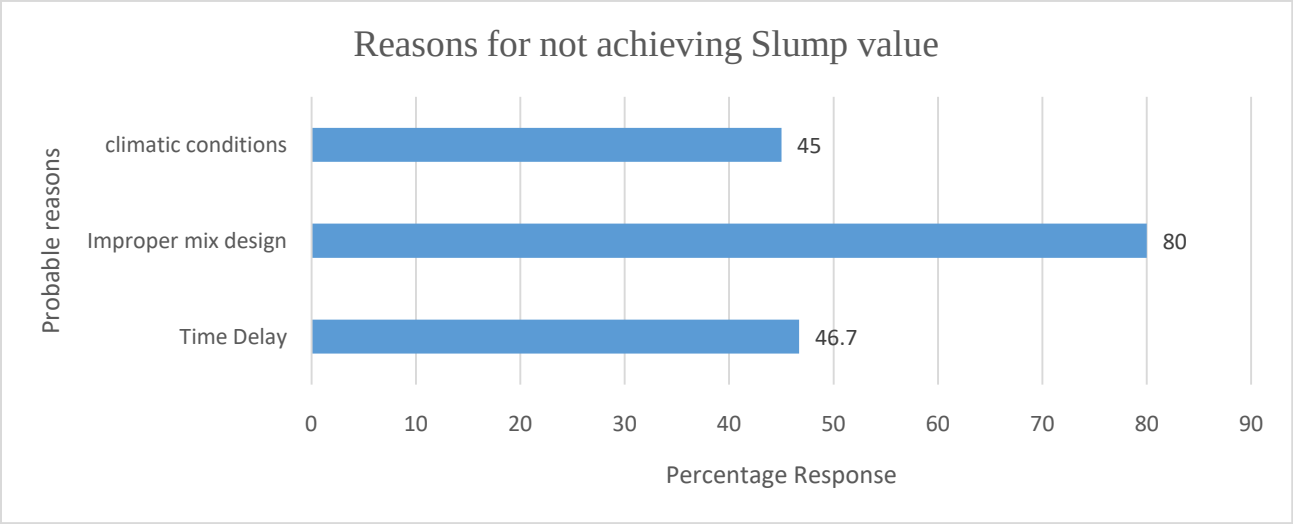


Figure 31: Reasons for not achieving desired slump

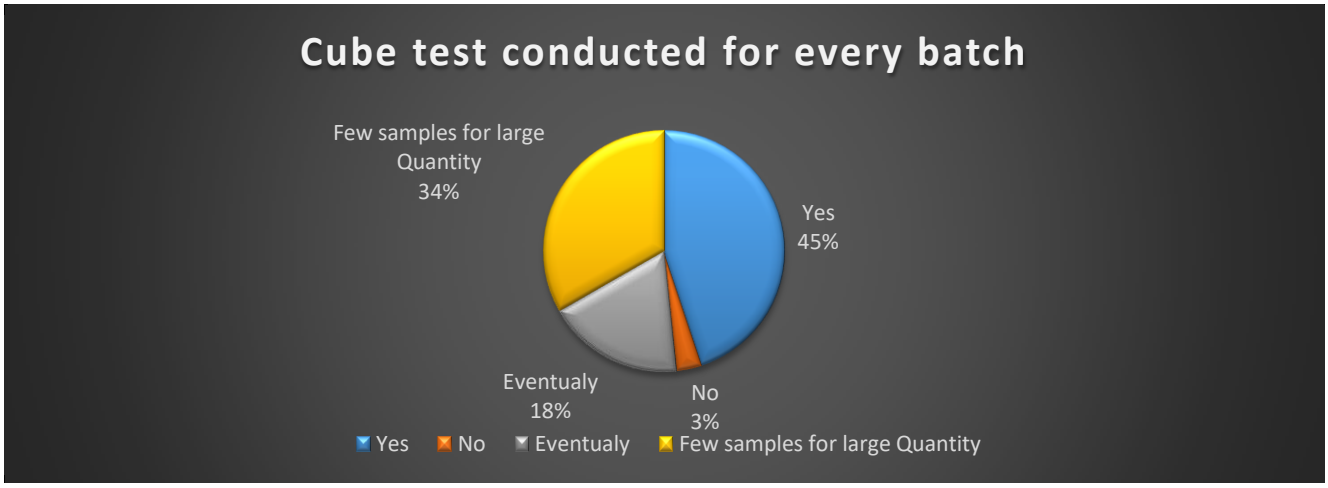
The main and basic reason is improper mix design as the result shows the output where 80% is due to this reason.

Time delay and climatic condition becomes hindrance as it affects 46.7 % and 45% on not receiving slump value.

When question was asked regarding cube test, it was analyzed that 78%

Yes, it is generally taken and the analysis shows the same result with 78% and 22% shows that it is rarely not taken.

This observation is represented in figure 11.



Cube test can be said as the most important test for Quality Control. Hence question regarding its conduction was asked. As a result, 45% people gave positive response, 34% shows that it is taken also for few samples when quantity is large and 18% shows that it is conducted at times and rarely it is not conducted that is only 3%. It can be observed in figure 12.

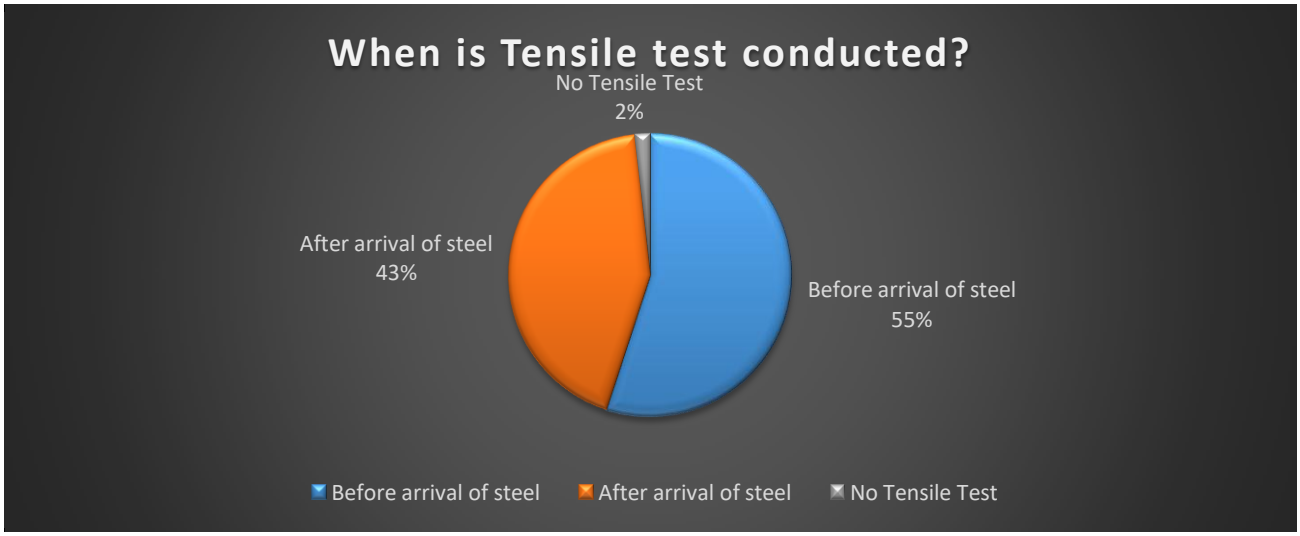


Figure 13: Tensile test conduction

When question related to tensile test for steel RF was asked majority of the firm i.e. 83.3% did conduct tensile test while 16.7% of the responders didn't believe in conducting this test. And then to acknowledge current scenario as shown in figure 13 majority of tensile test is conducted before arrival of steel while 43% of tensile tests are conducted by sending samples to the lab after arrival of steel and there is too a population with 3% that doesn't conduct tensile test.

IV. CONCLUSION

The construction industry of Gujarat, India is still functioning in a traditional way; marred with low level of awareness and narrow minded approaches, this research concludes to a huge improvement opportunity. The limited level of awareness possessed by the respondents constrains the possible outreach of this work in industrially developed contexts. However, the work may become an impetus for further research in managing quality in construction industry. The findings can be used to improve the quality provision of construction projects near future.

This work may trigger an important debate over the research and implementation of Six Sigma in construction industry of our country (i.e. India) that may greatly benefit by improving the quality of their projects and rectify their diminishing reputation for project success. This paper identified the deficiencies existing in construction industry through extensive data gathering, analyzed the perception of construction professionals regarding Six Sigma, investigated the Six Sigma implementation barriers and observed its influence on project success. When it comes to the knowledge of Six Sigma, almost half of the construction professionals have no idea about this technique which is one of the main implementation barriers

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