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RESEARCH ARTICLE

LEVERAGING LEAN SIX SIGMA TECHNIQUES FOR ACCELERATED ON-SITE CASTING: FACTORS AND STRATEGIES

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Abstract

In the construction industry, issues such as excessive waste, rising costs, and strained relationships are prevalent. A pressing matter of plunged casting time during mass concreting activities has engulfed numerous construction contracting firms around the world. The increased time of concrete utilization not only risks the commencement of the heat of hydration but also initiates the setting time of concrete. The use of admixtures has often been a boon to curb this situation but human errors are almost impossible to escape from as inappropriate dosage of the admixtures can result in changing the properties of the concrete, affects the quality and pumping ability, which ultimately reducing the speed of casting and elapsed schedules. Other factors on site, though minor, vastly affect the pumping efficiency and causes considerable delays in the casting which not only affects the schedules but also causes time overrun and affects the productivity at site. The focus of this study is to address the issues encountered at the site that directly affect the speed of on-site casting and corrective actions.

Introduction:-

With the never ending urban sprawl of metropolitan cities that act as the economic nerves of the countries, the demand for construction of new infrastructure to boast the city life has been directly proportional to time. Hence, such cities have been witnessing a constant demand for new infrastructure projects and local authorities have been giving green signals to various milestone projects in cities that cater to the design population of the next few decades.

Despite the high demand for construction projects, contracting firms have several problems, especially in terms of the difficulty of construction within the constraints of urban settings. Cities have their own problems of a swelling population, which translates into traffic congestion and a lack of space, coupled with strict adherence to city ordinances. Although concreting at night relieves these traffic concerns, it disturbs sleeping residents who complain and can cause work stoppage orders. Firms working within city perimeters must deliver projects under extreme pressure regarding city regulations. Therefore, there is an urgent need to determine the factors that affect the casting speed and develop strategies to solve these challenges within the regulations of urban areas. The need to increase the resources engaged and a thorough research was conducted at an independent level to devise a plan to increase the velocity of construction activities and finish them within the allowed time.

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Literature Review:-

An experimental study indicated that reducing the casting rate of self-consolidating concrete (SCC) can decrease the initial formwork pressure, while variations in concrete temperature have a limited effect on the maximum lateral pressure but significantly affect the rate of pressure drop with time, and the use of Type 30 cement or a set-accelerating admixture can reduce the initial pressure and accelerate the rate of pressure drop (Kamal 2006). The delay factors in prefabricated construction projects are analyzed using the decision- making trial and evaluation laboratory model and the analytic network process method. The DEMATEL model was applied to measure the degree to which one delay factor affected other factors. The quantified extents from the DEMATEL model are then translated into a prioritization matrix using the ANP method, which calculates the priorities of criteria and their relations, enabling a systematic analysis of the delay factors and their consequences in terms of deviation from project schedules (Y Ji et al. 2018) . Labor productivity factors in the construction of Pre-stressed Concrete Bridges in Egypt, discussing design challenges, equipment availability, construction execution delays, and other factors such as climate conditions, financial aspects, health and safety problems, labor issues, leadership and supervision, material availability, organizational factors, and project-specific challenges. Finally, recommendations based on an in-depth analysis of the factors that would improve the productivity of crews and effectively reduces project delays effectively (Mortensvik 2024) . A 30% drop in the pump ability of concrete can be experienced because of the inner walls of the concrete pipeline which can experience up to 20% more usage of admixtures (I M Basha et al. 2005) . Based on the Toyota lean production system, the seven basic types of waste are defects, waiting, transportation of goods , motion, inventory, overproduction and unnecessary processing steps.(H. W. Lee et al. 2017). In 2002, Bechtel corporation saved approximately $ 200 million by investing in its six sigma program to prevent defects in everything from design to construction (Y W Kim and S H Han 2012). The Critical Total Quality (CTQ) is the main performance of the DMAIC (Y W Kim 2012).

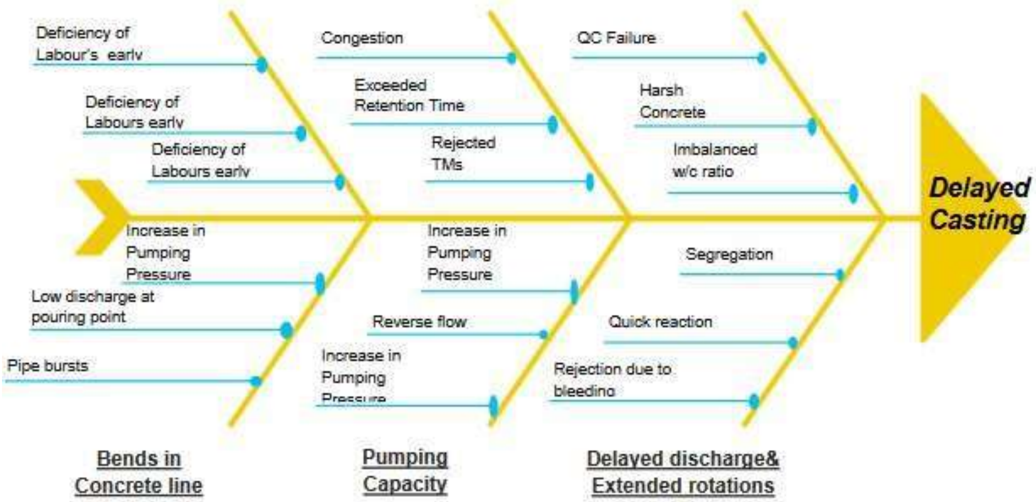


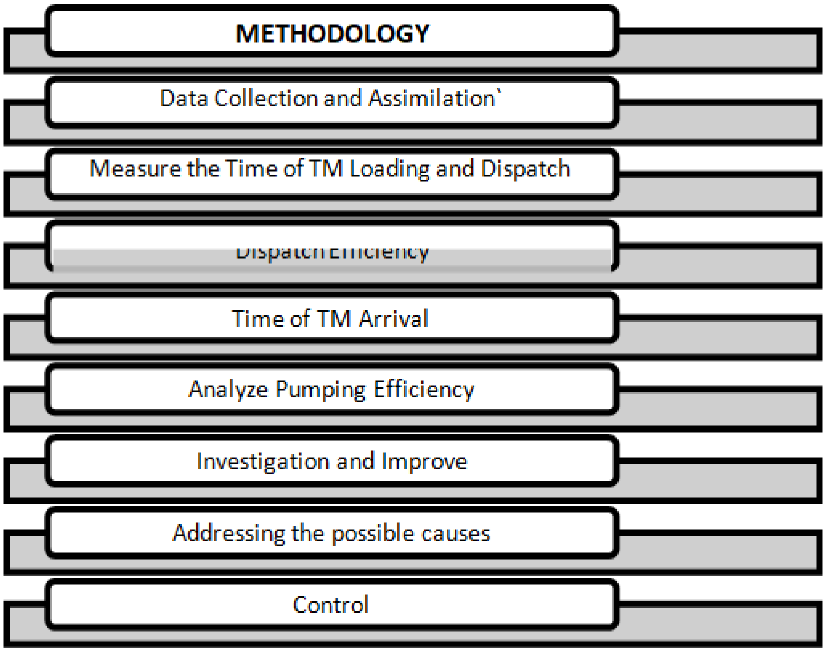
Figure 1:- Fishbone Diagram.

Root Cause Analysis

A Comprehensive data on the movement of 1000 transit mixers ferrying to the construction site from their respective plants were collected and the factors that which directly impact the speed of casting were carefully devised. The factors that impacted the casting speed were as follow.

1. Pre-casting Activities
2. the traffic study throughout the day
3. The temperature at which the casting is being done and the grade of concrete
4. number of instances the bends were a introduced in the line
5. Pumping capacity of the pump
6. Labor Psychology
7. Delayed Discharge time and extended counts of the Ready mix plant

Methodology:-



Turn Around Time
The most important factor is the Turn Around Time (TAT) of the transit mixer, briefly the TAT of the supply of concrete begins at the time the Transit Mixer is started with the loading of concrete after the batches are completed. The complete time taken by one transit mixer from the time it is loaded until the TM reaches the site, unload and returns to the site is regarded as the turnaround time of the transit mixer.

Pumping Efficiency Ratio and Calculations
To achieve a fast pumping rate, the variance between the dispatch efficiency of the plant and pumping efficiency at the site. It is practically

It is impossible to maintain a dispatch efficiency ratio that is nearly equal to the pumping efficiency, especially if the transit mixers ferry during operation. For reasons, the dispatch efficiency at the plant can never match the pumping efficiency at the site. The efficiency ratio depends on the number of resources deployed at the site to pump concrete. Although the Pumping Ratio (Rp) can never be determined as a constant value, it can be determined accurately with the deployment of the exact quantity of resources needed with the metrics to gauge the shortfall of resources.

Dispatch Efficiency (Ed) + Resources Deployed (Dr) Pumping Efficiency (Ep)

For example,
It was assumed that the dispatch efficiency of the given concrete plant was 50 Cu.M/Hr. Nine transit mixers with 6Cu.M capacity deployed. Hence, the quantity in transit was 54 Cu.m. The site was provided with two concrete pumps of 1407 capacity, each with a practical output of 20 Cu.M/Hr.

$$\frac{50}{40} + \frac{2}{1} = 3.25$$

To ensure that casting is ongoing, the Pumping Ratio should be maintained at 3.25 throughout the casting process. In simple terms, this means that both pumps function fully and there are two additional transit mixers on standby to cater to the continuous demand of the pumps.

Assuming that there is just one transit mixer waiting, there would be a deficiency in the entire operation and the ratio would fall to 2.25, which means that one pump is idle and thus the pumping efficiency of the entire operation reduces thus causing a delay in the completion of casting.

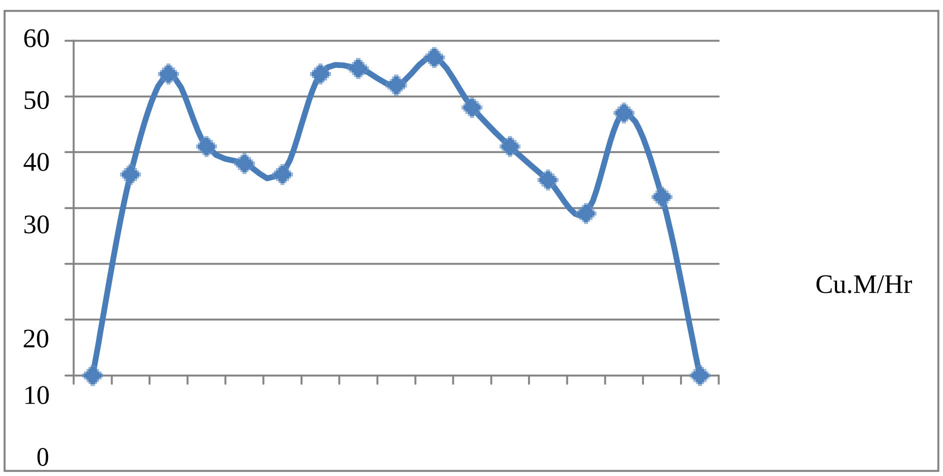
Pre Casting Activities

Starting the deployed resources and maintaining them in the ready to cast condition is mandatory to ensure that casting will start smoothly. The internal face of the concrete pipes has dried cement flakes adhering to it, which tends to absorb the water content in the green concrete, thus misbalancing the w/c ratio of the concrete, resulting in harsh concrete by the time it reaches the pouring point as it causes friction, resulting in choke ups. To address these issues , it is often advised to use pumping lubes or cement slurry as it ensures proper lubrication and facilitates the smooth passage of concrete from the pipe. Although such issues will not be encountered if the length of the concrete line is comparatively less, while casting at elevation, considering such measures is highly advisable.

Figure 2:- Concrete Pumping Lube.

Traffic Study Throughout the Day

While planning the logistics for the site, selecting a route that is less fluxed with traffic will help in rapid transit, thus ensuring that no resources on site remain idle. Considering that the traffic movements are optimum, the concreting activity should be resumed during dawn. The entire casting phase of concrete is divided into milestones and efforts must be made to achieve the first milestone before the normal rush hours of the city.



Graph 1:- Concrete Supply Throughout the Day.

Temperature at Which the Casting is Being Done and the Grade of Concrete

The temperature of the environment can have notable effects on the pumping of concrete, affecting both the material properties of the concrete itself and the operation of the pumping equipment. The imfluence of temperature on concrete pumping is as follows:

Concrete Rheology:
Temperature affects the rheological properties of concrete, including its viscosity, flow ability, and frictional resistance. In hot environments, higher temperatures can decrease the viscosity of concrete, making it more fluid and easier to pump. Conversely, cold temperatures increase concrete viscosity, resulting in a thicker, more sluggish material that may be more challenging to pump. Therefore, temperature extremes can alter the pumping characteristics of concrete, thereby affecting the required pressure, pumping rate, and overall efficiency.

Setting Time:
Temperature influences the setting time of concrete, which is the time required for the material to transition from a plastic to a solid state. Higher temperatures accelerate the hydration process, leading to faster setting times. While this can be advantageous for early strength development, it also means that concrete may begin to set more rapidly once pumped, requiring quicker placement and finishing to avoid issues such as blockages or equipment cleanup.

Pump Performance:
Environmental temperature can affect the performance of concrete pumping equipment, particularly under extreme conditions. In hot environments, elevated temperatures can cause the pump components to expand, thereby affecting the seal integrity, lubrication, and overall equipment reliability. Conversely, cold temperatures can stiffen hoses, valves, and seals, increasing the risk of material blockages, line congestion, and equipment malfunctions. Proper equipment maintenance and temperature control measures are essential to mitigate these effects and ensure a consistent pumping performance.

Concrete Cooling:
Control of concrete temperature in hot climates or hot weather concreting is important to delay the early setting of concrete and to maintain workability at the time of pumping. Cooling the concrete with chilled mixing water, addition of ice, or shading will help regulate the temperature and thereby extend the pumping time before setting.

Material Handling:
Extreme temperatures affect the handling and placement of concrete materials both before and during pumping operations. During hot weather, there may be rapid evaporation of mixing water that can lead to slump loss, segregation, and loss of pumpability, if not properly controlled.

Figure 3:- Workability Lost due to Temperature.

Figure 4:- Temperature of Concrete Maintained below 25 Degree Celsius.

Bends in the Concrete Pipe

Frictional Resistance:

Bends in the concrete pipe create frictional resistance as concrete flows through curved sections. This resistance increases the pumping pressure required to overcome friction and maintain a consistent flow rate. Consequently, the pumping efficiency may decrease, requiring higher pumping pressures and energy consumption to deliver concrete to the desired location.

Pressure Loss:

The presence of bends in the concrete pipe leads to pressure losses owning to fluid dynamic effects such as turbulence and eddies. These pressure losses can result in a reduction in pumping capacity and flow rate, particularly in systems with multiple bends or sharp curves. Pumping systems must be designed to account for these pressure losses to ensure adequate concrete delivery rates and prevent potential blockages or pump overload.

Concrete Segregation:

Bends in concrete pipes can exacerbate segregation issues, particularly in high- slump or self-consolidating concrete mixtures. The centrifugal forces generated as the concrete flows through the bend can cause coarse aggregates to separate from the mortar matrix, leading to the segregation and uneven distribution of materials. This can compromise the quality and homogeneity of pumped concrete, affecting its structural integrity and performance.

Wear and Abrasion:

Bends in concrete pipes are prone to wear and abrasion owning to the high-velocity and abrasive nature of pumped concrete. The constant friction and impact of concrete particles on the inner surface of the pipe can cause erosion and deterioration over time, which leads to to reduced pipe integrity and increased maintenance requirements. Abrasion-resistant materials or protective liners may be employed to mitigate wear in bend areas and prolong the pipe service life of the pipes.

Pumping Pressure Requirements:

With bends, the concrete pipe has increased pumping pressure requirements, especially at the bend points, where frictional losses are the highest. Pumping equipment must be able to generate sufficient pressure to handle such losses and maintain appropriate flow rates. The extra pressure may limit the pumping distance or larger, more powerful pumps may have to be implemented to maintain proper concrete delivery.

In short, bends in concrete pipes bring in an effect on the ability of pumping concrete with regard to pumping efficiency, material integrity, maintenance and increased pressure on the pump. Hence the pour plan should be designed such that the alignment of the line involves as few bends as possible .

Figure 5:- Improper Bends Provided to Concrete Pipes.

Pumping Capacity of the Pump

Pump Condition and Maintenance:

Proper maintenance and regular inspection of the pump, including its components such as the pumping cylinders, valves, and seals, are crucial for ensuring an optimal pumping capacity.

Pump Type and Size:

Different types of concrete pumps (e.g., boom pumps and line pumps) have varying pumping capacities. The size and power of the pump also affect its ability to pump concrete over different distances and heights. Concrete Temperature: Concrete temperature affects its viscosity and setting time, which in turn influence the pump ability. Hot weather can accelerate the setting, whereas cold weather can retard it, both affecting pumping capacity.

Aggregate Gradation:

The size, shape, and grading of aggregates influence the flow ability of concrete. Properly graded aggregates can reduce friction and improve the pump ability.

Water Content:

The water-cement ratio affects the workability and pump ability of concrete. Excess water can lead to segregation and loss of pump ability.

Admixtures:

Chemical admixtures such as plasticizers, super plasticizers, and air-entraining agents can enhance the workability and pump ability of concrete by modifying its rheological properties.

Delayed Discharge Time and Extended Counts of Revolution of the Rmc Plant

Loss of Workability:

Concrete is a time-sensitive material and delays in discharge can lead to loss of workability. As concrete sits in the truck mixer or transit mixer for an extended period, it may start to stiffen or set, making it more difficult to pump.

Increased Viscosity:

Extended waiting times can increase the viscosity of the concrete mixture. This higher viscosity makes it harder for concrete to flow smoothly through the pump, leading to potential blockages and reduced pump ability.

Setting Time:

Delayed discharge can accelerate the initial setting time of concrete owing to the hydration reactions occurring in the mixer. A concrete mixture that sets too quickly may become unworkable and challenging to effectively pump.

Loss of Air Content:
Extended waiting times can also lead to a loss of air content in the concrete. Air- entrained concrete is more pump able as it has improved flow ability and reduced friction within the pump lines. The loss of air content can increase the pumping resistance and decrease the pump ability.

Increased Pumping Pressure:
As concrete becomes stiffer and less workable owing to delays, higher pumping pressures may be required to push the mixture through pump lines. This increased pressure can strain pump equipment and increase the risk of blockages or equipment failure.

Operator Challenges:
Pump operators may face difficulties in managing the flow of concrete and controlling the pump owing to changes in its properties of the mixture caused by the delayed discharge. They may need to adjust the pumping parameters or take corrective actions to maintain pump ability.

Labor Pyschology
The ramifications of keeping labor idle due to concrete unavailability extend beyond morale and productivity issues. It can create a ripple effect throughout the entire project, affecting not only the immediate tasks at hand but also the long-term dynamics within the workforce. First, the dissatisfaction and sense of unproductively among laborers can lead to disintegration of workforce cohesion. Workers who feel undervalued and unengaged may become disheartened and de- motivated, resulting in decreased teamwork and collaboration. This breakdown in communication and cooperation can further exacerbate delays and inefficiencies in the construction process, ultimately affecting project timelines and budgets.

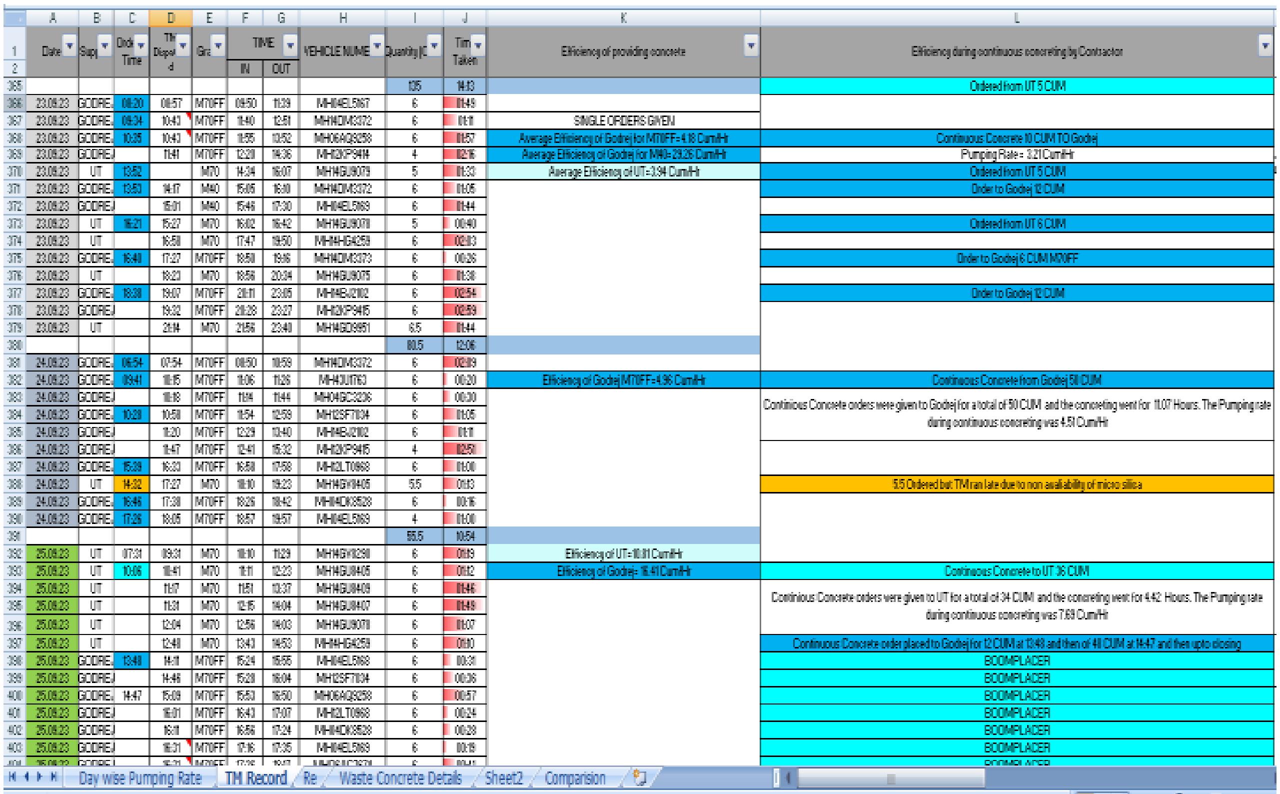
Additionally, the negative perception of engineers on-site can have lasting consequences for project management and stakeholder relationships. Laborers may begin to question the competence and decision-making abilities of the engineering team, eroding their trust and confidence in their leadership. This can lead to strained relations between different parties involved in the project, including contractors, subcontractors, and project owners, potentially jeopardizing the overall success of the project. Furthermore, the reluctance of laborers to showcase productivity even when concrete becomes available, later underscores deeper issues of motivation and engagement. This behavior reflects a lack of trust in the reliability of the construction schedule and the commitment of project managers to promptly address resource shortages. It also highlights the need for effective communication and transparency in managing expectations and addressing onsite challenges. In conclusion, the impact of keeping labor idle due to concrete unavailability extends far beyond the immediate concerns of morale and productivity.

This can disrupt workforce dynamics, strain stakeholder relationships, and undermine the overall success of the project. Addressing these issues requires proactive measures to ensure the availability of timely resources.

Allocation, effective communication, and a supportive work environment conducive to collaboration and productivity.

DMAIC
Establishing a robust DAMIC strategy, a six sigma tool, is paramount in overseeing the transit mixer's journey from departure at the plant to unloading site. This comprehensive approach ensures the seamless execution of the entire operation, minimizing delays and maximizing efficiency.

The core of this strategy is the utilization of an illustrative dashboard, which serves as a centralized hub for the real-time tracking and management of transit mixer activities.

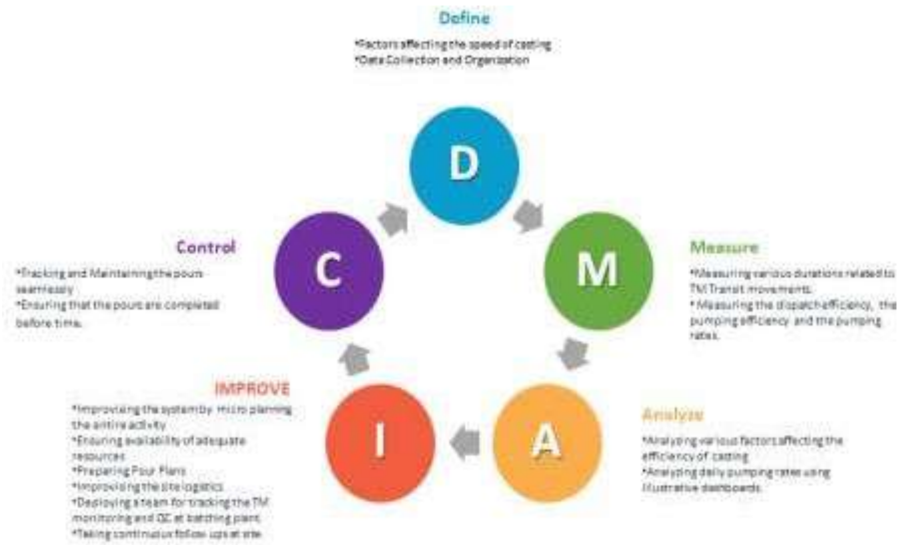


	Date	Supp	Ordr Time	TM Dispatched	Gra	TIME IN	TIME OUT	VEHICLE NUMB	Quantity (C	Tim Taken	Efficiency of providing concrete	Efficiency during continuous concreting by Contractor
365									135	14:13		Ordered from UT 5 CUM
366	23.09.23	GODREJ	08:20	08:57	M70FF	09:50	11:39	MH04EL5067	6	01:49		
367	23.09.23	GODREJ	08:34	10:40	M70FF	11:40	12:51	MH14DM3372	6	01:11	SINGLE ORDERS GIVEN	
368	23.09.23	GODREJ	10:35	10:40	M70FF	11:55	13:52	MH06AQ9258	6	01:57	Average Efficiency of Godrej for M70FF=4.18 Cum/Hr	Continuous Concrete 10 CUM TO Godrej
369	23.09.23	GODREJ		11:41	M70FF	12:20	14:36	MH12KP9414	4	02:16	Average Efficiency of Godrej for M40=29.26 Cum/Hr	Pumping Rate = 3.21 Cum/Hr
370	23.09.23	UT	13:52		M70	14:34	16:07	MH14GU9079	5	01:33	Average Efficiency of UT=3.94 Cum/Hr	Ordered from UT 5 CUM
371	23.09.23	GODREJ	13:53	14:17	M40	15:05	16:10	MH14DM3372	6	01:05		Order to Godrej 12 CUM
372	23.09.23	GODREJ		15:01	M40	15:46	17:30	MH04EL5069	6	01:44		
373	23.09.23	UT	16:21	15:27	M70	16:02	16:42	MH14GU9078	5	00:40		Ordered from UT 6 CUM
374	23.09.23	UT		16:58	M70	17:47	19:50	MH14HG4259	6	02:03		
375	23.09.23	GODREJ	16:40	17:27	M70FF	18:50	19:16	MH14DM3373	6	00:26		Order to Godrej 6 CUM M70FF
376	23.09.23	UT		18:23	M70	18:56	20:34	MH14GU9075	6	01:38		
377	23.09.23	GODREJ	18:38	19:07	M70FF	20:11	23:05	MH14BJ2102	6	02:54		Order to Godrej 12 CUM
378	23.09.23	GODREJ		19:32	M70FF	20:28	23:27	MH12KP9415	6	02:59		
379	23.09.23	UT		21:14	M70	21:56	23:40	MH14GD9951	6.5	01:44		
380									80.5	12:06		
381	24.09.23	GODREJ	06:54	07:54	M70FF	08:50	10:59	MH14DM3372	6	02:09		
382	24.09.23	GODREJ	09:41	10:15	M70FF	11:06	11:26	MH43UT763	6	00:20	Efficiency of Godrej M70FF=4.96 Cum/Hr	Continuous Concrete from Godrej 50 CUM
383	24.09.23	GODREJ		10:18	M70FF	11:14	11:44	MH04GC3236	6	00:30		Continious Concrete orders were given to Godrej for a total of 50 CUM and the concreting went for 11.07 Hours. The Pumping rate during continuous concreting was 4.51 Cum/Hr
384	24.09.23	GODREJ	10:28	10:58	M70FF	11:54	12:59	MH12SF7034	6	01:05		
385	24.09.23	GODREJ		11:20	M70FF	12:29	13:40	MH14BJ2102	6	01:11		
386	24.09.23	GODREJ		11:47	M70FF	12:41	15:32	MH12KP9415	4	02:51		
387	24.09.23	GODREJ	15:39	16:33	M70FF	16:58	17:58	MH12LT0868	6	01:00		
388	24.09.23	UT	14:32	17:27	M70	18:10	19:23	MH14GY9405	5.5	01:13		5.5 Ordered but TM ran late due to non availability of micro silica
389	24.09.23	GODREJ	16:46	17:38	M70FF	18:26	18:42	MH14DK3528	6	00:16		
390	24.09.23	GODREJ	17:26	18:05	M70FF	18:57	19:57	MH04EL5069	4	01:00		
391									55.5	10:54		
392	25.09.23	UT	07:31	09:31	M70	10:10	11:29	MH14GY9290	6	01:19	Efficiency of UT=10.81 Cum/Hr	
393	25.09.23	UT	10:06	10:41	M70	11:11	12:23	MH14GU8405	6	01:12	Efficiency of Godrej= 16.41 Cum/Hr	Continuous Concrete to UT 36 CUM
394	25.09.23	UT		11:17	M70	11:51	13:37	MH14GU8409	6	01:46		Continious Concrete orders were given to UT for a total of 34 CUM and the concreting went for 4.42 Hours. The Pumping rate during continuous concreting was 7.69 Cum/Hr
395	25.09.23	UT		11:31	M70	12:15	14:04	MH14GU8407	6	01:49		
396	25.09.23	UT		12:04	M70	12:56	14:03	MH14GU9078	6	01:07		
397	25.09.23	UT		12:48	M70	13:43	14:53	MH14HG4259	6	01:10		Continuous Concrete order placed to Godrej for 12 CUM at 13:48 and then of 48 CUM at 14:47 and then upto closing
398	25.09.23	GODREJ	13:48	14:11	M70FF	15:24	15:55	MH04EL5068	6	00:31		BOOMPLACER
399	25.09.23	GODREJ		14:46	M70FF	15:28	16:04	MH12SF7034	6	00:36		BOOMPLACER
400	25.09.23	GODREJ	14:47	15:09	M70FF	15:53	16:50	MH06AQ9258	6	00:57		BOOMPLACER
401	25.09.23	GODREJ		16:01	M70FF	16:43	17:07	MH12LT0868	6	00:24		BOOMPLACER
402	25.09.23	GODREJ		16:11	M70FF	16:56	17:24	MH14DK3528	6	00:28		BOOMPLACER
403	25.09.23	GODREJ		16:31	M70FF	17:16	17:35	MH04EL5069	6	00:19		BOOMPLACER

Figure 6:- Dashboard for Monitoring and Tracking of Concrete.

Through this dashboard, stakeholders can monitor the progress of the transit mixer at every stage of the journey, from its initial dispatch to its arrival and unloading at the designated site. Key metrics, such as transit times, route deviations, and unloading durations, were continuously captured and displayed on the dashboard, providing valuable insights into the performance of the transit mixer fleet. This real-time visibility enables proactive decision-making, allowing operators to promptly address any issues or bottlenecks that may arise during transit. Moreover, the dashboard facilitates the calculation of the pumping efficiency, which is a critical parameter for assessing the overall effectiveness of the operation. By correlating the data on transit times and unloading rates, stakeholders can accurately measured the efficiency of the pumping process and identified areas for improvement and optimization. Overall, the implementation of this monitoring and control strategy not only enhances operational efficiency but also ensures the timely and reliable delivery of concrete to the construction site. Through continuous monitoring and analysis, stakeholders can drive productivity gains and uphold the highest standards of performance in transit mixer operations. The dashboard provides a user-friendly tool for assessing daily pumping rates. This simplifies the performance evaluation of all stakeholders participating in the casting process.

Critical TO Quality (CTQ) is the main indicator of DMAIC. In this study, CTQ is the pumping rate at which the rate of casting depends.



Tool 1:- DMAIC for improving efficiency.

Takt Time
The time the precisely matches production with demand is known as takt time.
The time the precisely matchesproduction with demand is known as takt time.

$$\textit{Takt Time} = \frac{\textit{Workable Production Time}}{\textit{Units Required}}$$

$$= \frac{960}{111}$$

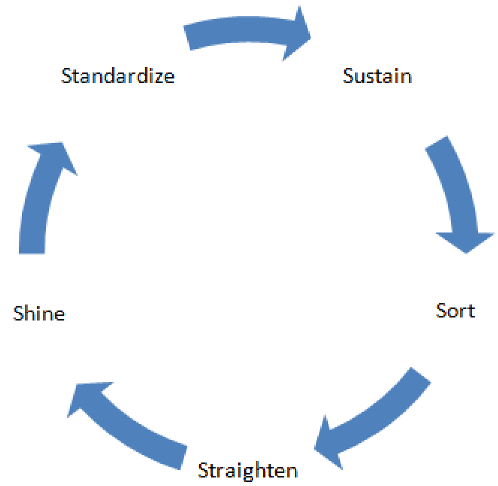
$$= 8.5 \textit{ Min / Transit Mixer}$$

Meticulous breakdown of data into manageable work packages, with a continuous focus on improvement and ongoing monitoring during work in progress, drives the motivation for Value In Progress. (Lundkvist et al. 2014).

Through monitoring and control, the time taken by the transit mixers to unload was always maintained below the takt time implying that the pumps were never idle.

Kaizen Via. Plan-Do-Check-Act
The continuous improvement in ensuring that not only the speed of casting improved continuously, improving the speed of casting to such an extent that the practical rate of casting at site increased more than four fold after application of Lean Six Sigma Techniques. The pumping rate, but this was swiftly overshadowed by a remarkable surge, with the pumping rate skyrocketing more than four times, measured in cubic meters per hour. Simultaneously, there was a significant acceleration in casting speed, accompanied by a considerable decrease in the occurrence of accidents, underscoring the profound positive impact of LSS integration on both

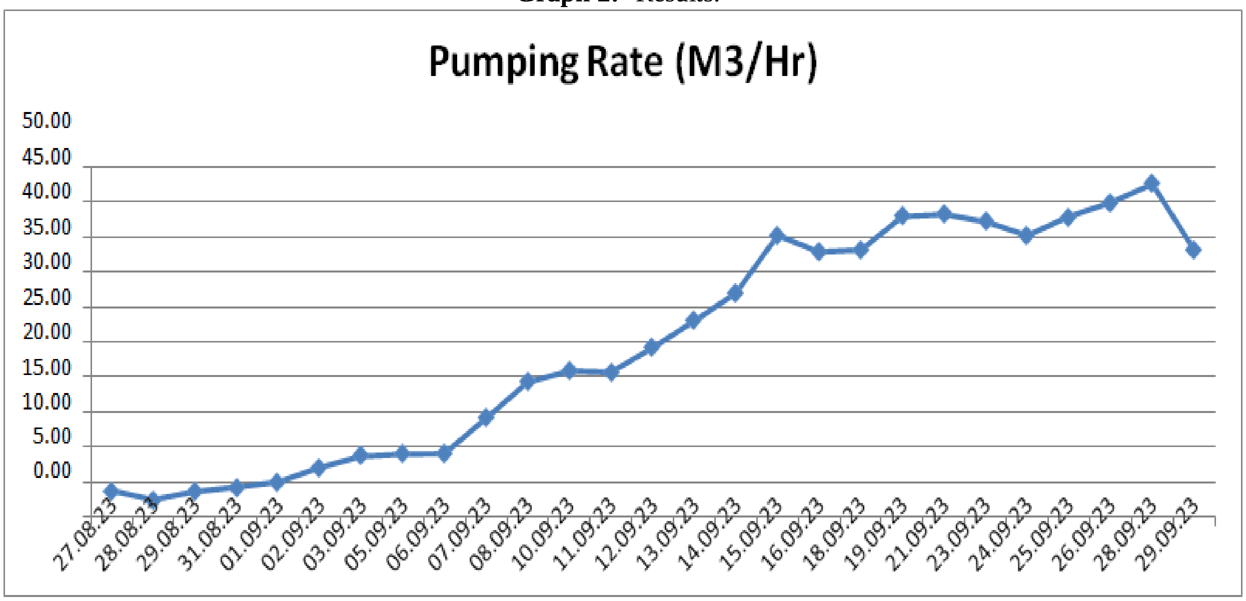
Lean Six Sigma For Arresting Labour Accidents
The integration of lean principles with worker safety behavior, achieved through the implementation of the 5S technique, effectively addresses the underlying causes of accidents. By inspiring and training workers to prioritize workplace safety, accidents can be significantly reduced, ultimately fostering an environment free of incidents (H W Lee et al. 2017).



Results:-

In the aftermath of implementing LSS techniques, a notable evolution in operational performance occured within one month. Initially, there was a temporary decline in productivity and safety.

Graph 2:- Results.



Conclusion:-

Addressing these issues substantially increased the pumping efficiency. The derivation of the formula for the pumping efficiency ratio helped address the issue of idle resources. Cement Slurry or Pumping Lube aids the efficient pumping ability of concrete avoiding choke up issues that waste resources. Through traffic study of the site location shall be done in advance and pours shall be initiated centering the traffic flow. The alignment and passage of the concrete pipe line should be effectively planned to ensure that fewer bends are introduced in the concrete line. Concrete pumps must be routinely maintained and cleaned. The temperature of the concrete plays a vital role in the pumping ability of the concrete at the site. Extended counts of revolution per batch shall be avoided at the batching plant. Labour Psychology plays a vital role in their productivity and they shall not be kept idle. Since the time to unload was much less than the takt time, and casting was performed at a much faster rate. The implementation of 5s techniques substantially reduced the accidents and thus increased labor productivity.

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