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Effective Scheduling and Control of 4M by Applying OR Techniques and Advance Technology at RMC Plant: A Review

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Abstract: This is 21st century is era of technology and development. Infrastructures and Mega projects are common for developing countries. India will become 3rd largest construction market by year 2025. As per one research concrete is second most consumed material after water in world. For making concrete need to manage different materials like cement, sand, aggregate, water and other ingredients at one place. For mega projects it is necessary to manage these ingredients in mass quantity, equipment, manpower and location of production. From small to large projects to meet concrete demand it is essential to manage the Ready Mix Concrete supplies. After the revolution of RMC Plant a mass concreting become very popular and it boosting up speedy construction of facility. But major problem is when RMC Plant have to deal with multiple target, different grades, different locations and multiple projects at a time it very difficult to manage on time with the quality, quantity and resources. Sometimes it cause delay to milestones and this delay leads to cost overrun and time overrun. If multiple projects which depended on one RMC Plant and delay occur then subsequently delay follows to other projects. There are many possibility of upcoming technologies like advance GPS, GIS and IT applications can utilize in effective management of RMC Plant. This research work is mainly contains of experimental work based on past literature, application of mathematical model, operation research techniques and utilization of new advance technology with management fundamentals.

Keywords: Construction, Management, Operation Research, RMC

I. INTRODUCTION

A. General

Construction sector is one of largest sector in developing country like India. Many different class of people depends on this sector somehow. Construction of Small house to Buildings, Bridges, Roads and Other Infrastructure facilities are now become common in India. In these mega projects a huge amount of labours, materials, machineries, money and time is requires to convert plan dreams into reality. As per National accounts estimates of main aggregates India is 4th largest construction Gross Value Added in 2018. [12] More than 50 million people depends on construction. In past two decades there are great revolution takes place within construction technology.[12] The biggest growth drivers for India's RMC and batching Plants is Indian Government's large scale infrastructure and housing projects. These projects include Bharat mala Pariyojna, Sagarmala Project and Pradhanmantri Awas Yojna. As per report of Present status and Future growth prospect of Ultratech a total concrete consumption will be 808 Million Cubic Meter in 2022. [13] Out of that Concrete used on sites without dedicated Plants where RMC could be used of will be 241.80 Million Cubic Meter. Expected no. of RMC Plant will be 3200 in India in 2022. [13] So there are huge potential of rapid growth of RMC Plant. Till now we understand the economic importance of RMC Plant but there are other importance of RMC Plant such as Speedy construction, Time saving, Material Saving, Utilization of space and Mass production are very beneficial. Many activities like P.C.C. of Footing, Casting of Footing, Column, Beam and Slab are mainly depends on concrete.

For producing good quality of concrete a good combined efforts are requires to reach milestones. For producing concrete on remote location or in urban areas it is essential to arrange all materials at one place at a right time. But as know principal of material management is to deliver right quality material in right quantity on right time and right place is necessary to save cost and time of project work. In large construction project a huge delay noticed in RMC supply because of no proper management of RMC Plant Resources and Scheduling of activities.

On RMC Plant there were demand from multiple site on daily basis and if delay occurs then it affects to all other subsequent demand and projects. To meet all demand we should build system that manage all the RMC related activities and save valuable cost and time of project. So it is very essential to manage the RMC Plants to complete project within time and cost. By applying fundamental of project management, operation research techniques, GPS-GIS and IT application we can help engineers and stakeholders in saving time and cost with improved quality.

B. RMC Plant

Ready Mix Concrete Plant means a concrete is mixed on central batch mix Plant and delivers to site by means of transit mixture truck instead of mixing at job site. RMC Plant is place where all required materials for making concrete is stored in mass quantity and mixed up at batching machinery. Then after loaded in transit mixer truck and delivered to site. In RMC Plant system different recipe of perfect proportion are installed in operating Plant. As per demand of client or contractor a different recipe is used to prepare concrete and then deliver to site.

C. 4M of construction

- 1) *Men:* Men power are very essential in construction sector for completing activities and project. On RMC Plant sufficient no. of non-technical and technical persons are required for proper functionality. On site it is very essential that enough no. of persons available for completing complex activities where machine can't work.
- 2) *Machine:* Machines plays very important role in construction because it helps in finish complex and hard task in time at less cost. In RMC Plant batching machine, Loaders, Transit mixers and automated operating system are major machine.
- 3) *Material:* Raw material are required to produce any commodity. In RMC Plant a major ingredients of concrete required in sufficient quantity to produce quality concrete.
- 4) *Money:* Money is play vital role for smooth function of any system. Availability of finance on right time and cash flow requires to achieve project mission.

D. Project Management

According to K. K. Chitkara (3rd Edition 2014) management is the art and science of managing all aspects of project to achieve the project mission objectives, within specified time, budgeted cost and predefined quality specification; working efficiently and effectively in changing project environment with due regard to workers safety and health. [05]

E. Operation Research

Operation Research means to make overall arrangement of limited resources of human, financial and material in the economic system by using analytical, experimental and numerical method, aiming to provide optimal plans for decision makers to achieve the most effective management.

F. Objective of Study

The objectives of study are listed below:

- 1) To save loss of delays in Construction work due to RMC save overall cost and time of site and RMC Plant too.
- 2) To improve productivity of Plant by supplying and purchasing material on right time.
- 3) To managing all RMC related demand from various site and improve Quality of work.
- 4) To manage all 4M of RMC and save overall cost and time of site and RMC Plant too.
- 5) To implement use of Primavera on RMC Plant and use of GPS and GIS tracking for right path and Transit mixture movement.

G. Need of Study

RMC Plants plays very important role in completion of multiple projects at a time with acceptable quality standards but during my experience I have noticed many problems that rises up due to improper management and that affects the other projects related to RMC. I have observed that there is no proper management of material on RMC Plant affects the achieve milestone of project on time. There is no satisfactory linkage between project progress and RMC Plant schedule. It effects on purchasing and delivery process of materials, demand and supply and quality of material. There are lack of information transmission between sites and it leads to last minute planning and huge load on RMC Plant and its indirectly Impact on efficiency and productivity of Labour, Drivers, technical staff, Non-technical staff and Plants.

Purchasing material on wrong time cause financial loss for price increments of materials. No tracking system for transit mixture cause unnecessary delay in delivery of concrete that affects the quality of concrete. These all cause problems of delay and huge financial loss of projects so it is very essentials to manage all 4M of RMC Plants. Due to no proper implementation of project management principles, tools and techniques in this area so it is necessary to do research and development related to this work.

H. RMC Plant Management

As earlier discuss in introduction that 4M of construction are very essential to manage. To manage these four resources are difficult when they are not pre-planned. On RMC Plant a no. of orders and demands fluctuating according to site and nature of work. To meet these fluctuations a necessary to apply management at various level effectively. During the literature a lack of research work is carried out on management part of RMC Plant. On RMC Plant from purchasing material to producing concrete and supplying to site a huge sub activities are involved. These all activity can't be give satisfactory result without help of management fundamentals. When any order is receive from any site first process is loading of material is requires in inline bins. After loading, an automated Plant takes sufficient materials for mixing as per recipe. Than after mixing in central mixer and loading in transit mixture carried. Transit mixture travels to construction site and wait for unloading. The following Fig.1 shows a different RMC Plant Management related aspects.

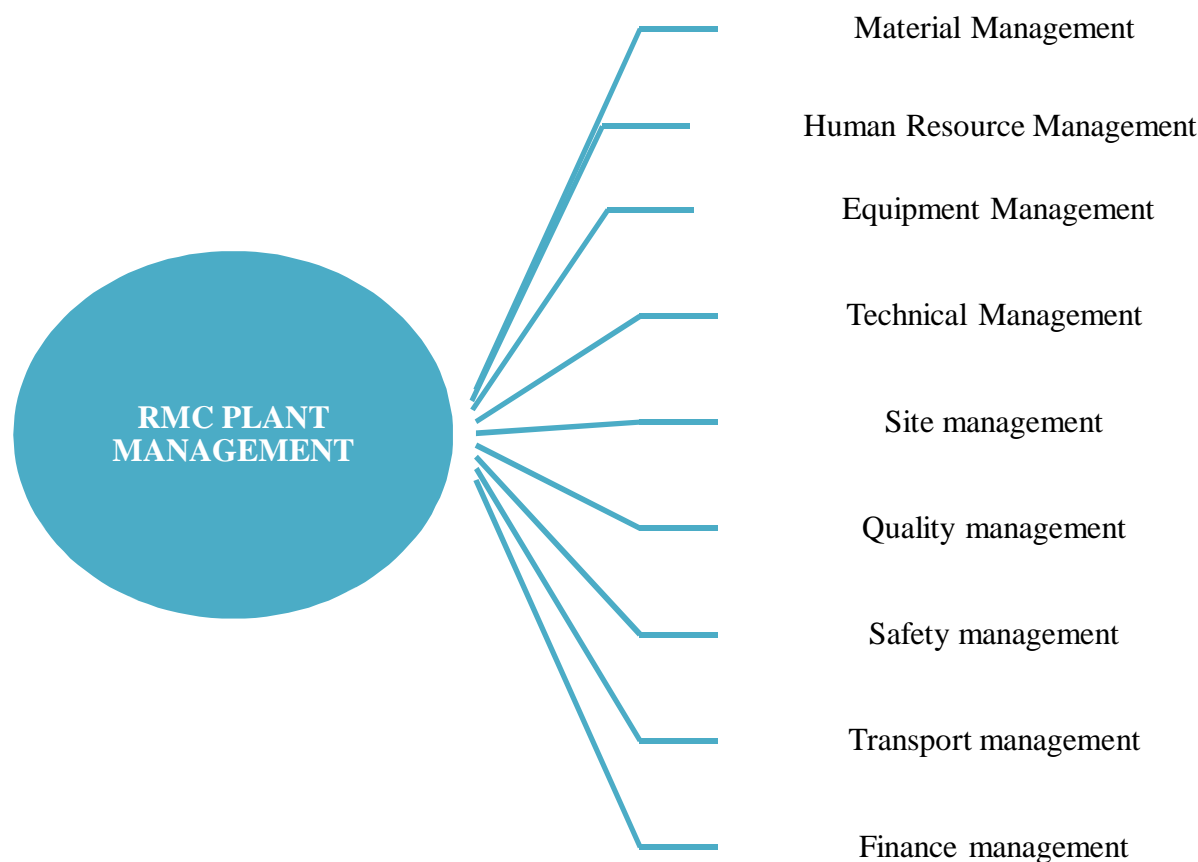


Fig. 1 RMC Plant Management

Maximum time consumption are travelling time and unloading time. Unloading of transit mixer is mainly depend on method of pouring. Unloading with help of pump and boom placer takes less time compared to manual. Sufficient site crew requires to meet the situation of delay while placing. After unloading a washing of transit mixer drum is very essential because if concrete slurry once settled in transit mixer it will decrease the capacity of transit mixer. Return of transit mixer again for loading and cycle goes on. An operation of RMC at different level explained in following Fig. 2.

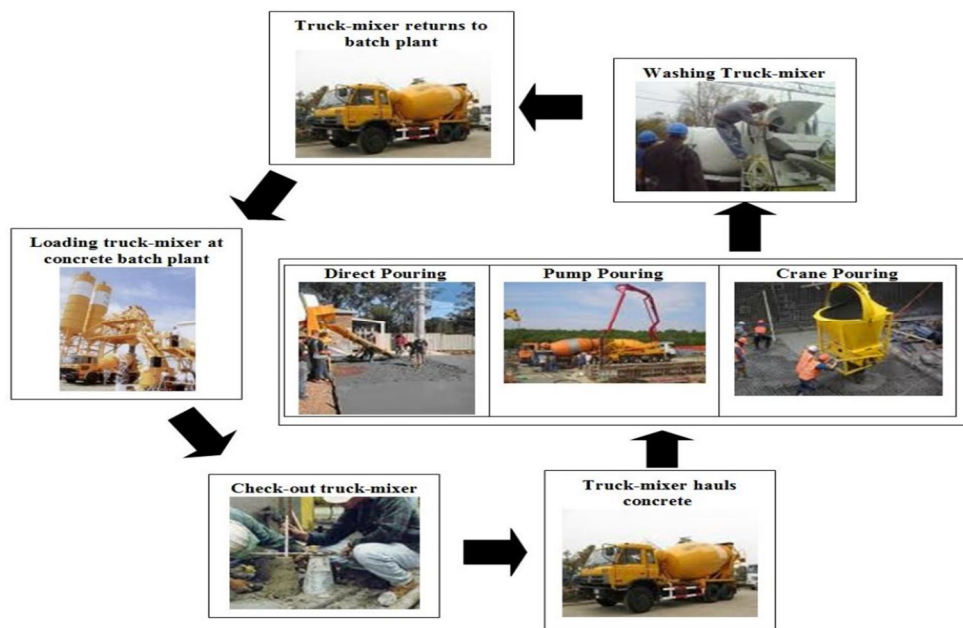


Fig. 2 Process involves in Production and Delivery of RMC

II. LITERATURE REVIEW

This contains existing literature on the RMC Plant management. Literature published in various national, international and other online and local journals; national, international and other conferences; various reports; dissertations; books; various standards published by various authorities; etc. have been studied and their small important contents have been stated here. Then, major findings have been stated describing the most important findings of this literature review stating different aspects of RMC Plant in terms of material management, delivery, management, GPS techniques and Operation research techniques.

Tarek Zayed et al. (2006) studied that major cause of delay which affects the RMC Plant system and Classified Uncontrolled delay and Controlled delay. The uncontrolled delay because of factors that are out of concrete batching Plant management. The controlled delay are that type of delay which due to factors that can be controlled by proper concrete batching Plant management. He describe major elements responsible for uncontrolled delay are like low demand, concrete pouring method, available space for truck mixer beside the pump and weather conditions. A delay which can be minimize by taking effective steps is known as controlled delay. Major factors which cause controlled delay are insufficient no. of truck, pouring crew skill, delay due to mechanical problems, material delivery problems and coordination delay. During research he founded that maximum probability of delay is due to management related delay, no work delay and mechanical delay are responsible for decreasing productivity of RMC. These all factor increase expenses of transportation and extra expenses due to insufficient work. Fig. 3. Shown below is about various delay factors with occurrence probability. [20]

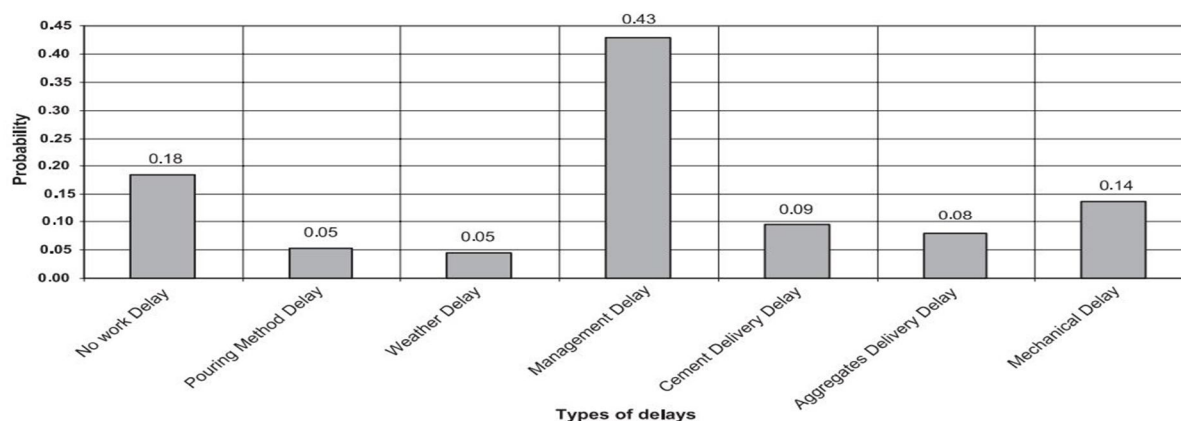


Fig. 3 Probability of Various Concrete Batching Plant Delay

Ming Lu et al. (2006) consider RMC material is time sensitive in nature so developed of RMC Transport Monitoring System that can monitor and track the position of transit mixture in real time. RMC monitoring from on-route to on-site, which could significantly broaden the application value of the system in construction management. [6]

Mehdi Ravanshadian et al. (2014) investigated that minimization of inventory cost and control of inventory can lead to the optimal production of concrete. An inventory control models are very important factors which specifies the health level of supply chain and also effects the financial health of the balance sheet. He investigated that fuzzy logic and neural network modeling of inventory control of batching Plant can be very helpful. Proposed model for minimum volume & number of material reservoir is explained below. He concluded that Inventory control models can be used in concrete manufacturing workshops, civil projects and also ready-mixed concrete centres. Fuzzy logic and neural network are the tools which can be used as methods of Artificial Intelligence for implementation of an inventory control system for the material of a batching Plant. Some fuzzy rules for gravel model are explained in work. [8]

Faaique Mohammed O et al. (2016) mentioned in his work that major factors which are influencing RMC Plant productivity are improper use of admixtures, receiving raw material without testing, delay in transportation of material, frequent breakdown of machine and non-availability of spare parts. In his study he has founded many negative impacts of these all problems and suggested remedial measures that will minimize risk involves in operation chain of RMC activity and it will help in increase the production and supply cost of RMC Plant. In his investigation he founded many factors which cause reduction in productivity of RMC Plants regarding material, man, machine and method. By figure fishbone diagram for cause for reduced productivity of RMC explained. A major factor that responsible for reducing productivity of RMC Plant Shown below in Fig. 4. [3]

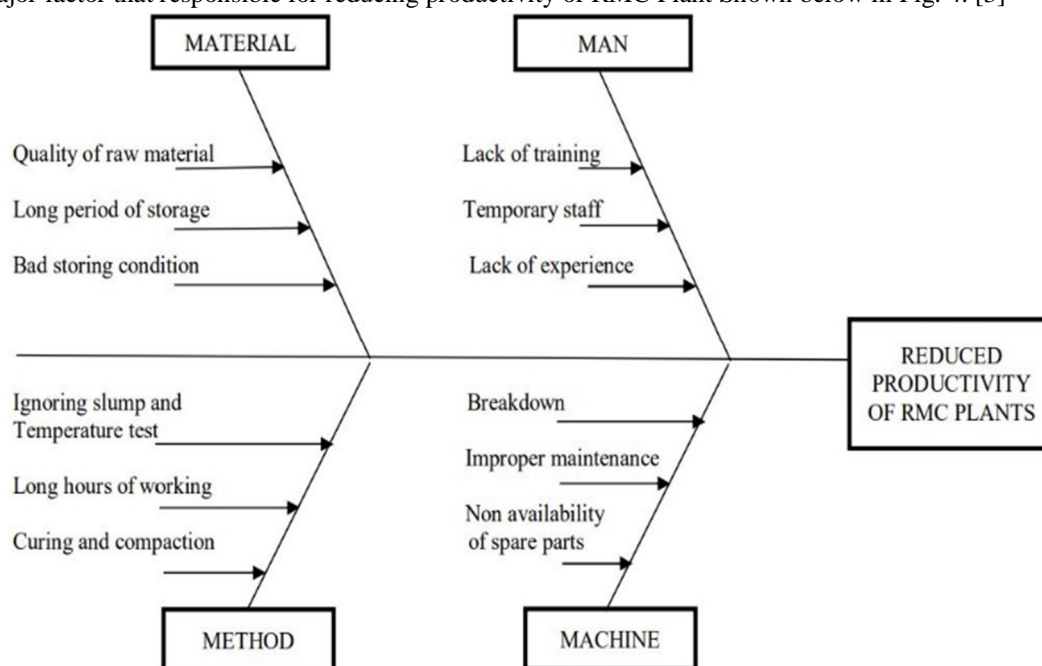


Fig. 4 Fishbone Diagram for major Cause Responsible for Reduced Productivity of RMC

Shushant Pradhan et al. (2016) noticed that while handling multiple projects major challenges rises like: Project Duration – the project duration tends to lag while managing things at multiple sites. Interdependency of resources- since a single a company will be handling all the projects. The interdependency with activities and resources should be well understood. Scheduling of activities- to avoid any obstruction in delay of activity the scheduling should be in order throughout the project cycle. Project cost overrun- unfortunately sometime despite of utter care and precaution the cost moves up. Handling constraints in each site respectively- every site will have its own constraint. These constraints should be dealt properly in time of planning and execution. The cost of individual work break down can be known along with the duration. The milestones for project such as slab and beam concreting which is one of the biggest activities can be forecasted earlier. Thus decisions can be made wisely for proper management. For finishing works there is always more amount of additional labor needed, thus scheduling them properly gives us an option to maintain proper procurement of resources. In multiple projects resource leveling is very important to maintain proper resource distribution. Scheduling simultaneous projects is also an important criterion for managing multiple projects. [18]

Gulcag Albayrak et al. (2016) explained way of using linear programming and genetic algorithm for solving transportation related problem for minimizing the shipping cost while satisfying supply and demand constraints. RMC Plant produces concrete, supply it and fulfil demand of various sites. He described model and solutions which can works with real world environment. Linear programming and genetic algorithm both techniques satisfy balance between supply and demand of RMC. Linear programming gives better result compare to genetic algorithm for delivering RMC. [4]

Mohd Amir Khan et al. (2017) investigated quantify risk involved in supply of RMC in Indian construction scenario. He mentioned serval source of risk that affects production system. They identified major Sources of risks which are impacts and can be affects in the concrete production system for ready mix concrete: Ready-Mix Concrete Plants have limited capacity, Demand Fluctuation, Placement Size, Delivery Cycle and Location and Accuracy in Order Quantity. [9]

Sumit Kakade et al. (2018) gave concerns about the factors such as operations management, equipment conditions, operator's skills, management delay affect the productivity and that affect the projects. The most important causes of delay identified were a frequent change of staffs, poor site management, improper management of the engineers, delay in supply of material and lack of manpower. Management related delay are such as lethargic attitude of management team must be avoided. This is one of main reasons for delay. Supply of material at site at right time should be taken care by site engineer. He suggested that indent planning must be done in advance to avoid material supply delay since the material is also one of the major delay reasons. Mechanical delay such as frequent breakdown of transit mixture, batching machinery and pumping accessories are second major delay factor after management delay as shown below in Fig. 5. [16]

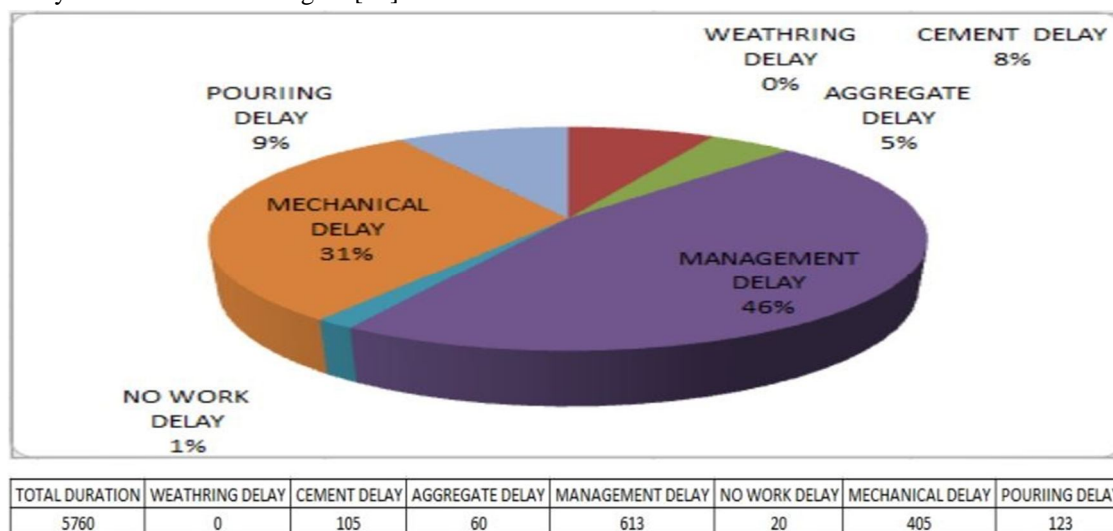


Fig. 5 Major Cause of Delay

Saurabh M. Palande et al. (2018) Author focused on the factors that are affecting the Functionality of RMC Plant. They mentioned in their remedial measures that location of Plant must be near to construction zone of city. For effective and economical management of RMC Plant it is essential to planning, organizing and controlling flow of material. He made main concern on various resources utilization must have consistent deliveries to RMC. Use of economic order quantity of inventory that minimizes the total cost of inventory management can be beneficial. Major respondent for analysis and questionnaires are as shown in Table. I. [14]

Table I
Respondent Distribution

Company Work Field	% of Respondents
RMC Engineer	80
Site Engineers	10
Equipment Owner	5
Other	5

Sohail Afzal et al. (2018) identified major Cause that affects the schedule of RMC activities. He concluded that factors which affects the delivery of RMC are distance between Plant and site, fleet size, weather condition, route and skill of crew. The major factors that affects the Dispatching of RMC is shown in Table. II. [13]

Table II
Factors And Sub-Factors Affect Schedule

Factors that affects the Dispatching of RMC	Variables that influence each Factors
1. Travel Duration	1. Distance between Plant and site. 2. Speed & Traffic condition.
2. Duration of Unloading	1. Type of casting operations. 2. Number of unloading equipment and Number of crew at Job site 3. Pumping Speed
3. Number of Trucks	1. Amount of RMC ordered 2. Truck capacity & Road bearing limitation.

A. K. Gaikwad et al. (2019) investigated factors that affects the dispatching of RMC schedule of trucks in India and gave optimization of dispatching schedule. A main decision making parameters are shown below in Fig. 6.

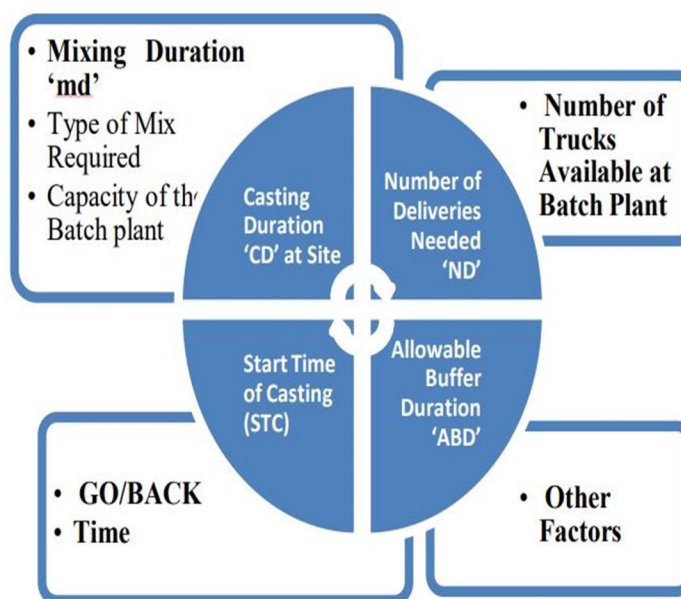


Fig. 6 Decision making parameter

They founded during their research work many challenges like: supply in crowded areas, setting up of pumps supply line, deciding the quantity of the last TM (Transit Mixer), planning in advance is need of time as delay at one site, for any reason, will change the schedule of the entire line. They demonstrated a successful application of genetic algorithm mode for dispatching schedule of RMC trucks. [2]

Shobhana Jadhav et al. (2019) studied about use of geographical information system for selection of best transportation route of supply of concrete with transit mixture. She studied about the different site and traffic conditions and demands. After the analysis of road network she gives shortest route from Plant to site using QGIS. Methodology for selection of best route for delivery of transit mixture is shown below in Fig. 7. [15]

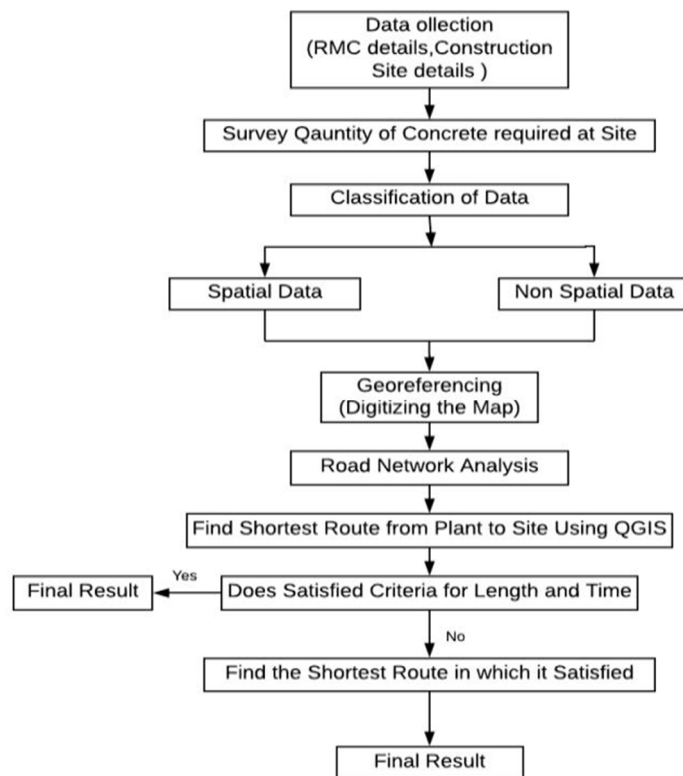


Fig. 7 Methodology for Best route analysis for RMC by GIS

Suthar Nisarg et al. (2020) explained different method of operation research can useful in construction for internal control, managing of fund, and resolving disputes of scheduling production over different time periods for construction materials by using the transportation model. Generally NWCM, LCM, VAM and MODI method are useful for optimization of RMC cost. [17]

A. Changing trends in RMC Management

Before year 1990 a RMC Plant was not so popular in India. 1st RMC Plant was established for construction of Bhakra nagal dam during year 1960s. It takes three decades to reach private selling of RMC. In beginning of last decade of 20th century an efforts made by different private industry. In year 1993 a 1st RMC Plant was established in Pune. Fig.8 Shown below shows the Changing trends in RMC Plant management. [13]

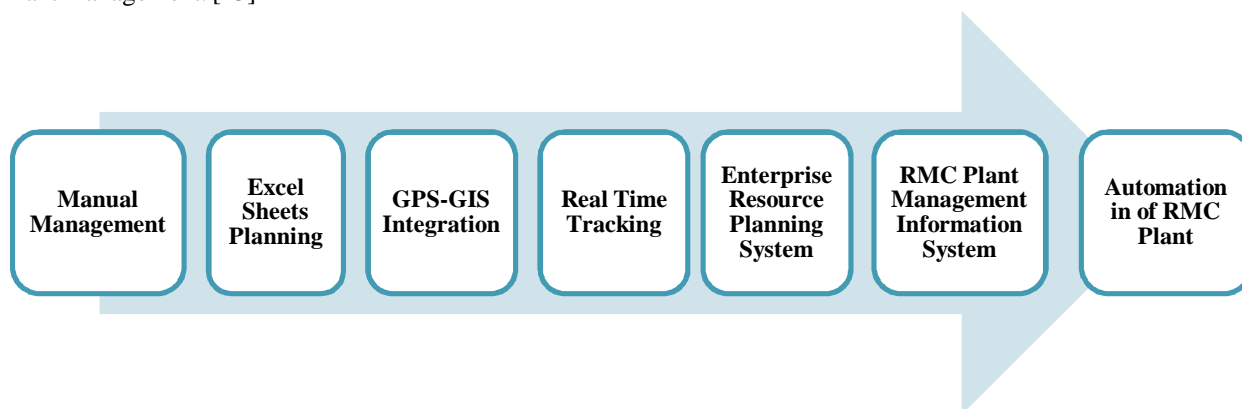


Fig. 8 Changing trends in terms of Technology and Management

A communication gap between site and RMC Plants are more when it comes to planning and scheduling. Many sites have fix RMC supplier. In many cases a material is supplied by owner side and Plant in of contractor's scope. In some cases company own Plant and supply material to multiple site.

But for this above cases one thing is missing is management and application of operation research for cost and time optimization. It is seen that more than 70% construction sector still not using any project management software.[1] No application of fundamentals of project management anywhere. During my experience as RMC engineer I have faced many management related issue which can be solved by application of project management theories and operation research techniques. No proper scheduling, insufficient transit mixer, insufficient site crew, late in material delivery and no control over resources leads to huge financial loss to site and Plant too. So it necessary to do research work and applying project management fundamentals in RMC Plant management.

B. Limitation of RMC

These below mentioned limitations affects the productivity of RMC and it affects the subsequent projects. As earlier discussed a RMC Plant have many management part and any management need to planning, scheduling, controlling, directing and monitoring. It seems looks like that RMC Plant productivity and RMC related activity does not affects the project progress but it affects project schedule. Time is money in construction.

- 1) Production capacity
- 2) Concrete pouring method
- 3) Limited resources
- 4) Mechanical breakdown
- 5) Cement, Fly ash and Aggregate delivery
- 6) Availability of insufficient space
- 7) Limited no. of Pumping crew
- 8) Chocking up of pipeline
- 9) Insufficient no. of labour on site
- 10) Different grade of concrete production at a time
- 11) Transportations problems
- 12) Distance from Plant

III. CONCLUSION

Following major conclusion and outcomes are from the literature review:

- A. Implementation of Construction management strategies like Planning, Scheduling, and Controlling can be very beneficial in functionality of RMC Plant.
- B. Improper management of Site staff, Engineers and carelessness of RMC engineers cause major delay in operation of RMC activities.
- C. Implementation of technologies like GIS and GPS with real time tracking can be very helpful to manage transit mixture movement, best feasible routes for transportation and avoid unnecessary delay due to congestion and space problem.
- D. Ready-Mix Concrete Plants have limited capacity, Demand Fluctuation, Placement Size, Delivery Cycle and Location, Accuracy in Order Quantity and Efficiency of site staff affects the productivity of Plant.
- E. Uncontrolled coordination between various sites, Lack of scheduling, Uncertainties and lack of communications leads to end time planning that affect subsequent project and delay.
- F. Lake of knowledge of management software and Utilization are major drawback in India. Using software like Primavera for multiple projects helps in better control over purchasing of material, Scheduling, Resource optimization and management of resources.
- G. Utilization of Operation research techniques like PERT, Transportation problem and Queuing Theory can be beneficial in Resources, time and cost optimizations.

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