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ROUTE OPTIMIZATION FOR DELIVERY OF READY MIXED CONCRETE (RMC): A LITERATURE REVIEW

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Abstract - Ready mixed concrete industry requires a lot of optimization in today's world and Route optimization is one of the prime factors today. Generally, the plant owners have five to six owned trucks and in case of higher demands, they rent two to three additional trucks. Some plant owners do not own a single RMC truck and rent all of them as may be necessary. But because of increasing demand of RMC due to infrastructure growth and plant owners having limited number of trucks, route optimization has become of prime importance and this work tries to focus upon the literature documentation of the studies carried out till date.

Index Terms - Route Optimization, Ready Mixed Concrete, .

I. INTRODUCTION

Ready mixed concrete (RMC) industry is tremendously gaining importance in construction sector. The scale and growth in terms of this industry are reaching new heights day by day. It is also one of the performance indicators that this industry has possible financial gains if adequately optimized. RMC is a major upcoming industry in many developing countries and especially in mega-cities where large scale infrastructure projects are in execution. This requires huge amounts of concrete and site-batching may not be feasible. This requires concrete to be batched at some remotely located site and then transported via truckmixers. Therefore, the productivity optimization of RMC plant is of very high importance and may directly affect the construction industry in total. Efficient delivery of RMC to construction sites is an important issue these days particularly in big cities where the demand is huge and the number of trucks with the plant owners are limited. RMC plant managers always try to control the cost of RMC delivery. This makes the delivery process a typical unconventional problem apart from the usual vehicle routing problem. The RMC plant manager has to quickly decide the dispatching sequence and prepare a schedule that can satisfy the demand of different construction sites. And therefore, route optimization of RMC today is highly desirable to have a competitive edge in the competitive market because of very high demand. The basic problems identified for the optimization of RMC production are time limitation, zero RMC inventory, uncertainty of RMC demand and limited amount of truck mixers

II. LITERATURE REVIEW

[1] Used @Risk software for the simulation of scheduling the truckmixers and revealed that queuing of truckmixers can be reduced up to 11 minutes. It was also observed that truckmixers' pattern of arrival was one of the most noteworthy factors for productivity optimization at any RMC plant.

[2] Developed an in-house computer simulation model to meet the high demand of concrete at multiple sites. It was observed that the use of this software helped to improve the service in terms of delivery and overall utilization of plant resources.

[3] Here a genetic algorithm was developed for scheduling of the RMC trucks. This algorithm generates a set of random numbers which are in normal distribution and then sets the delivery status of all the trucks in accordance to the demand stated. These set of random numbers are then adjusted in accordance to the pre-set time and quantity as given by the end-user and it is then simulated to get the best optimized result of the truckmixers delivery. In this algorithm, all the plant details are to be fed in and also the total quantity of concrete required at various sites is also fed in. The times taken at the plant like time of mixing, material loading are to be put in. Also, the time taken at the user-end like the time taken to pour the concrete, lag times are also to be given as an input to the genetic algorithm. The number of sites, the distance of each site requiring RMC is also to be given and with all this input data the genetic algorithm is then run to produce a detail simulated schedule of each of the RMC truckmixers.

[4] Worked upon the real-time tracking and monitoring of the RMC truckmixers with any of the wireless systems e.g. Global Positioning System, Dead Reckoning, Bluetooth Beacon, and Global System for Mobile Communication technologies. This integrated approach with the communication systems helped a lot for the consecutive truckmixer route planning if the presently opted route was congested. This system was highly reliable and enabled the RMC truckmixer monitoring from on-route to on-site and widened the

application of route optimization.

[5] Developed a bee colony optimization for the dispatching sequence of the RMC truckmixers and this model was found to be relatively better than the model generated with the help of genetic algorithms. This model showed lesser total waiting times as compared to the all other previous models. This model also generated more flexible and proficient results to dispatch the RMC truckmixers.

[6] Mentioned that there are many RMC manufacturers in market and material cost does not much vary. Therefore, each manufacturer competes for the customer's satisfaction. Customers are looking for the RMC plants that can deliver RMC according to their requirements fulfilling on-time delivery, etc. One major issue of RMC delivery is that RMC must be delivered to the site within certain time interval after production as it loses its plasticity after certain time. Usually, the planner solves RMC delivery problems based on experience. Since RMC dispatching sequence is quite complex, it draws interests from many researchers.

[7] Integrated scheduling of mix production and vehicle routing. The model is based on time-location diagram with five types of arches to represent operations of the plant and the trucks (truck idle time, truck work, loading or waiting for loading, unloading and returning to the plant, termination of work and returning to the base). The model was then enhanced by allowing for additional constraints: crew overtime cost and traffic-related occurrences.

[8] Stated that delivery process in RMC is one of the vital tasks. It is not always possible for the plant manager to quickly develop the dispatching schedule of RMC truckmixers when multiple while sites are calling for multiple number of deliveries. Therefore a Fast messy Genetic Algorithm(fmGA) was developed and the CYCLONE simulation technique was incorporated to find the finest dispatching sequence which would minimize the total waiting duration.

[9] Simulated the stated problem with the help of MicroCYCLONE simulation system. A sensitivity analysis and a time-cost quantity chart was then developed. The time-cost quantity and contour lines chart were then utilized for determining production cost, production time and resources for a required distance from the plant for RMC truckmixer. The feasible region chart was then used to determine the range of alternative results that can be opted to minimize production time and cost according to the required transportation distance.

[10] Developed an expert based decision support system for dispatching of RMC truckmixers and relied on human experts for the real-time decision making. Here it is stated that still the problem at large has very high number of variables that are not perceived adequately. Here a difference between the computerized systems and expert based decision making system was observed because in this systems as humans are involved, a higher cost is accepted for confirmation of a highly stabilized dispatching structure. It was observed that at 90% of the times, the expert based system was as good as the optimization models and also this system had a higher lucidity then all the previous other systems.

[11] Opted for a MS (Multi-Start) algorithm for solving Ready Mix Concrete Delivery Scheduling Problem. Integration of production and delivery is critical in the case of Ready Mix Concrete, as it expires approximately 2 hours after it is produced. This MS algorithm is based on specifically designed coding that provides the goodness- of-fit of the analysed solution.

[12] Discussed the complexity of scheduling the vehicle routing problem stating that the schedule of trips of RMC truckmixers is similar to the problem of vehicle touring over a working day. They also stated that integration of production and delivery is highly desirable as after approximately two hours of production the RMC expires in terms of validity. A Mixed-Integer Programming model was then generated. This proposed a state-of-art mixed integer programming for practice which was then found to be too difficult to solve.

[13] Simulated that the dispatching process of RMC truckmixers by comparing it with a shop problem with recirculation. This included time windows and demand postponements. Considering the cost of transportation, this model was framed as a multi-objective programming model. An investigation revealed that there were factors divided in intrinsic and imposed constrains referring to the limits that were to be fulfilled during the concrete dispatching process. Truckmixer dispatching was an intrinsic constraint while distribution process was considered as an imposed constraint that should be tried to be fulfilled up to a maximum level during dispatching. Here a recommendation of Just-in-Time practice is put forward to maintain RMC quality. It is also claimed that it is a highly reliable model.

[14] (Optimizing of ready-mixed concrete vehicle scheduling problem by hybrid heuristic algorithm) Opted for a dynamic approach for addressing the problem which was unique and was not taken into consideration previously. The dynamic approach is taken up considering the uncertainties in transportation times. This research work combines the production scheduling and vehicle dispatch problems in the same framework to form a hybrid heuristic algorithm to optimize the RMC truckmixer scheduling problem. A rapid effectiveness algorithm was generated and a MIP model was developed based on genetic algorithms focussing on the delivery problems to optimize the operations. It was observed

that this algorithm was fast and effective for the truckmixers scheduling problem. Here the authors have considered that all the input data is available with high accuracy at the time of computing the solutions which may not be always hold true. Also the problem is considered as fixed i.e. no changes in orders and time-frames, no new orders are then taken up during the day and no orders are cancelled. The authors have themselves confessed that this situation is not realistic and on a regular working day.

[15] (A Case Study of Bee Algorithm for Ready Mixed Concrete Problem) Here, authors have fixed the number of sites to three and five that a RMC plant will cater to and have provided an optimized solution for the RMC truckmixers delivery. Here a bee-colony optimization technique was used to generate the random numbers and then simulated the whole of the RMC truckmixers dispatching sequence depending on the demand stated at the site considering five RMC truck mixers. Here also the required amount of concrete, number of labourers, start time of site and many other user-defined functions were fixed with no lag allowed and also the RMC plant was simulated in accordance to the data and information provided by the user. After all the data was fed in an optimized solution space was generated and then the solution was opted out of the given solution space. It was observed that bee-colony optimizations proved to be better for the 3 and 5 sites delivery optimization problem than genetic algorithms [3].

[16] (An optimal scheduling model for ready mixed concrete supply with overtime considerations.) Here overtime considerations have been taken into consideration and the trucks that are on time are considered as zero overtime. Here a time-space network model was prepared for the operation and practical constraints were taken into account. The model was based upon mixed integer network flow problem. The mathematical program CPLEX was used for the efficient mathematical programming. It was observed that this model can be used for the planning and scheduling of the RMC truckmixers. It was also found that this model improved the productivity of RMC supply in real-time operations. This model worked effectively with minor delays of truckmixers and some delays of plant but in major incidents like any of the breakdowns of truckmixers, pumps etc. this model was not workable.

[17] A Discrete Particle Swarm Optimization (DPSO) model was formed that optimizes the routing of RMC truckmixers and showed significant cost savings for RMC plants. This approach is also proven to be more efficient as compared to the genetic algorithms in terms of fitness values and total waiting times. Here, routes are given and the time spent on the way is set as constant. But in practice there exist more than one route for any site. It has not been accounted in this research paper as it would make the model very complex to analyze and therefore the authors suggest a better approach to be opted for the route optimization. From the cited literature, it can be proved that: A mathematical model of the vehicles dispatching has to be framed which caters to the need of optimized delivery systems of the RMC trucks with minimal time lag. If technology permits then the integration of the Navigational systems for RMC truckmixers online monitoring can also be worked upon.(here satellite based accurate navigational systems are to be used, conventional GPS used in cellular phones cannot be used as it is not always accurate).

All this sets the ground that the RMC truckmixer scheduling problem still at large needs to be researched and the randomness of each of the variables needs to be discretized.

Still there is a vast scope of mathematical modelling for RMC industry using any of the following i.e. Bee algorithm (BA), Discrete Particle Swarm Optimization (DPSO), Genetic Algorithm (GA), SWARM particle optimization, Time series analysis

It has been observed that no management principles like JIT have been applied to the delivery systems of RMC trucks. Very less documentation on navigational/GPS facilities provided to RMC operators. No documentation on tracking of RMC trucks by navigation GPS system has been carried out. Rare use of simulation methods used for RMC optimization techniques. Very less documentation on supply-chain modelling. Very less modelling on Demand & Supply of RMC.

CONCLUSION

From the above literature, it can be concluded that as RMC industry is seen as an industry having potential of tremendous growth, having direct impact on the construction of large scale projects in developing cities. It is highly anticipated that the higher the optimization, higher will be the savings in monetary and timely terms. The route optimization though is a newly anticipated problem of the industry, it has a vast scope of research and a highly optimized model with a proper approach depending on realistic situations with the help of reliable state-of-art technology can be developed.

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