Optimization of number of trucks for dispatching schedule operation in ready mixed concrete plant using MATLAB App

(Single plant multi site operation)

[1]Dr. S. B. Thakare , [2]Mr. Gaikwad A. K
[1]Professor and Guide, [2]Research Scholar
[1]Principal, APCOE, Parvati, Pune, [2]Associate Prof., PCCOE, Pune

***Abstract*:** The Ready Mix Concrete (RMC) batch plant manager has to prepare an efficient schedule of dispatching RMC trucks, which will optimize number of trucks required for a dispatching sequence. There are two major types of costs associated with RMC trucks. One is the cost of owning and maintaining RMC trucks, another is the opportunity cost because of the improper dispatching schedule. From the productivity's perspective, any duration that RMC trucks wait at the construction site should be treated as a waste of time and represents the cost of the opportunity. Therefore, an efficient and balanced schedule of dispatching RMC trucks not only reduces the opportunity cost of dispatching operation but also minimizes the cost of owning and maintaining RMC trucks. The main objective of this paper is to suggest an App to reduce resources like RMC truck for dispatching schedule operation any RMC plant. This study suggests user friendly Genetic Algorithm (GA) based MATLAB App to give solution to the problem of RMC truck optimization there by reducing the number of trucks used for a dispatching.

***Key words**: GA's applications, Un-interrupted Dispatching schedule, reducing RMC trucks, Optimizing RMC trucks.*

1. INTRODUCTION

Since 20th century Ready Mixed Concrete RMC is used popularly in the construction industry. RMC is prepared generally in a concrete batch plant where ingredient materials, for concrete production, are weighed and mixed by automated devices with the request of the construction sites. RMC has several benefits compared to conventional mixed concrete. RMC usually needs to be poured within approximately 1-1.5 Hrs, after being produced by the RMC batch plant that limits the service area of the RMC batch plant. Consequently, RMC industry is concern about production and scheduling of truck dispatching. Dispatching scheduling can be done manually by experienced staff. But that may leads to use of more number of RMC trucks for dispatching. In the present study GA model App has been developed to reduce the use of RMC trucks to satisfy the dispatching demand. The GA is a global stochastic search technique based on the Darwinian Survival-of-the-fittest principle (Holland1975). A brief review of GA application to RMC trucks dispatching was found in Feng (2004). Chung et. al. (2004) has developed simulation and GA optimization to reduce waiting time of RMC trucks at construction site. Naso (2005) have applied GA model for optimal delivery of RMC on site. Sakchai Srichandum & Rujirayangong (2010) explained the advantages of Bee-colony Optimization over GA and Tabu search (TS) methods. Fritz Payr and Verena Schmid (2009) have also discussed about the delivery of RMC. Zayed and Nosair (2006) also have explained 'Cost management for batch plant using stochastic mathematical models'. We have also generated a model in MATLAB which produces optimized dispatching schedule by reducing number of RMC trucks required for satisfying the demand of RMC.

2. FACTORS AFFECTING DISPATCHING SCHEDULE OF RMC TRUCKS

Following are the important factors affecting the dispatching of RMC schedule of the trucks in India.

2.1 Start Time of Casting (STC):

It is the time at which the casting is to be started on site.

2.2 Traveling duration from plant to the job site (GO & BACK):

The traveling duration between the RMC batch plant and the job site is depending on the distance between site and plant, the speed of the RMC truck and the traffic condition. Therefore, it is not easy to predict the exact duration required to deliver RMC to different construction sites. The batch plant manager, as a thumb rule, usually assigns the RMC trucks to the job site far from the batch plant with higher priority to avoid discontinuity of casting. However, such an approach increases the chances of interrupting the working process at other job sites, which has faster casting time. Therefore, the traveling duration between the RMC plant and the job site becomes a major factor in deciding the schedule of dispatching RMC trucks. In practice, the average traveling duration between the batch plant and the construction site can be estimated from the history data or by considering average speed of the RMC truck.

2.3 The operating/casting duration (CD) of RMC at the job site:

The duration of casting RMC at the job site depends on the types of the construction activities as well as the height of delivery(Dumping or Pumping), which may affect the dispatching interval between assigning RMC trucks to the same job site. For example, the faster the casting duration, shorter is the dispatching interval between them. If the RMC trucks cannot arrive at the job site in time, it leads to the interruption of the construction activity.

2.4 Number of deliveries/trucks (i.e. Volume of RMC) needed(ND):

Number of RMC trucks, are dependent on the amount of RMC required at construction site, loading capacity of the truck, and the traffic on road. See, higher the capacity of trucks lesser the number of deliveries needed and vice-versa.

2.5 Number of trucks available at Batch Plant (C):

If the waiting time at a site increases, number of trucks required at a batch plant increase, which may leads to the extra investment of the RMC trucks at batch plant. This computer program generated in MATLAB environment, gives the optimum number of the trucks required for a batch plant.

2.6 Other Constraints:

The RMC is to be casted between 1-1.5 Hrs of its loading, so a Allowable Buffer Duration (ABD) is also to be provided for every site and every delivery, which is the balance time duration after considering all the above mentioned durations like GO, BACK and CD.

Besides all these parameters, there are some critical parameters, which cannot be considered, if dispatching schedule is to be prepared manually.

3 APPLICATIONS OF THE MATLAB APP FOR OPTIMIZING USE OF RMC TRUCKS

To prove the efficiency of the generated App, live condition of dispatching demand of a particular day is taken for CP-30, called capacity of plant (CP) and 30 indicates 30 m^3 of concrete produced per hour. As per hour i.e. 60 minutes for 30 m^3 production, it required 20 minute for 6 m^3 (Capacity of One RMC truck) to fill.

Case 1 (For 20 min. mixing Time CP-30):

Table 1 Consider a dispatching situation with following data:

Site ID	STC	GO	CD	BACK	ABD	ND
Site 1	8:00 am	30	20	25	30	3
Site 2	8:00 am	25	30	20	30	4
Site 3	8:30 am	40	25	30	15	5

Number of Trucks at Batch Plant : 12 Trucks (**C**)
Mixing Duration of Plant : 20 minute (**md**)
Max. Capacity of the Truck : 6 M^3

Where,
STC : Start casting time of the construction site (in 24 h format).
CD : Casting duration of the construction site (in min).
GO : Traveling duration from the batch plant to the construction site (in min).
BACK : Traveling duration from the construction site to the batch plant (in min).
ABD : The allowable buffer duration of construction site (in min).
ND : The number of RMC truck deliveries required for the construction site.
md : The mixing duration in min.
C : The number of trucks available at Batch Plant.

Step 1: Fill all the above data in the MATLAB App and determine the Total waiting time (TWT) for the given dispatching sequence according to the industry thumb rule using "RUN" tab provided on the App shown in Fig.1. Thumb rule for CP-30 is three trucks per demanding site one by one with balancing earlier remaining demands i.e. for 12 RMC trucks demand for 3 sites as shown in Case 1 above, it will be 1 1 1 (three trucks for first site) 2 2 2 (next three trucks for second site) and as no balance trucks of first site so 3 3 3 (three trucks for third site) now one balance truck for second site (total demand is 4 trucks) so 2 3 3. The final dispatching schedule as per thumb rule will be: 1 1 1 2 2 2 3 3 3 2 3 3.

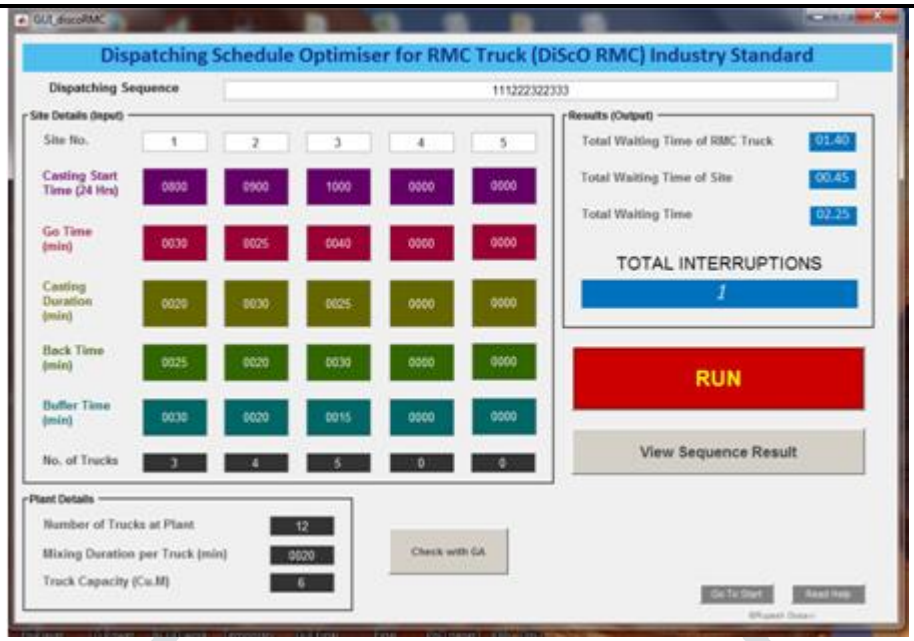

Fig.1 Result of MATLAB App for Case 1 with industry logic

Step 2: Check the 'TWT' value as 2:25 minutes. Also the time at which the last truck comes back to the plant 'TBB' value, which is 12:55 minutes (shown in Fig. 2, at TBB column and 12th row, seen when tab "View Sequence result" is hit).

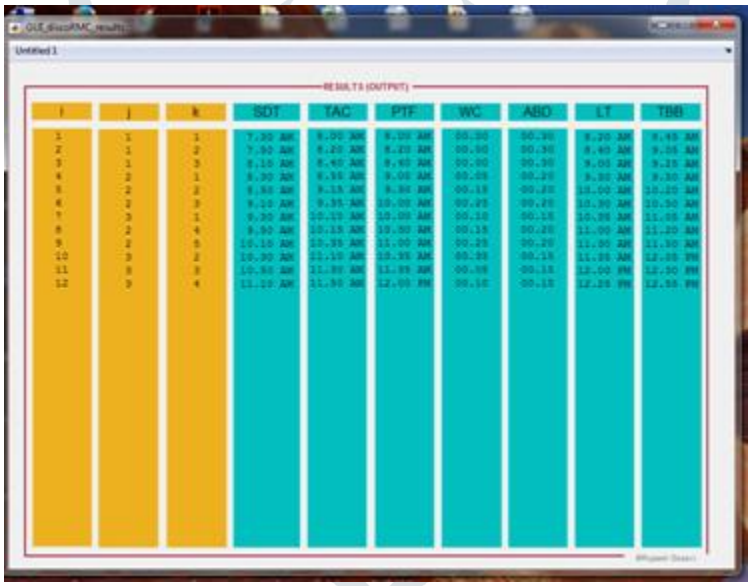

Fig. 2 View of Sequence Results for case 1 with industry thumb rule

Step 3: Go on changing the value of 'C' from '12' to '6', till there is no change in the result shown by the App. At 'C = 5', the changes are 'TWT = 2:30' and 'TBB = 1:10 pm'.

Step 4: Now for 'C = 5' and all other data same 'RUN' the MATLAB App on Genetic Algorithms (GA), the results will be 'TWT = 1:20' and 'TBB = 1:10 pm' with final dispatching sequence as '1 1 1 2 2 3 2 3 2 3 3 3', refer Fig. 3.

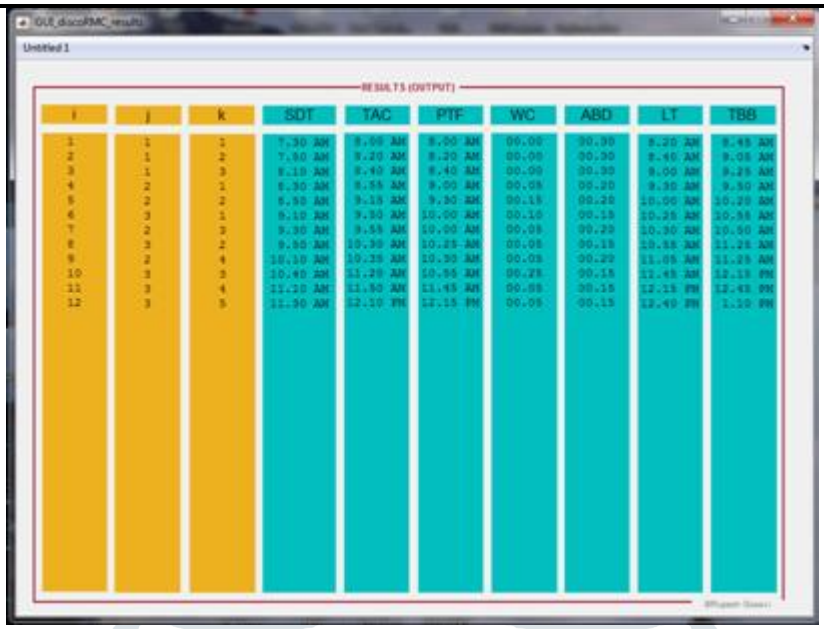

Fig. 3 View of Sequence Result by MATLAB App with GA

With respect to the Fig.3, row '4' and '6' dispatching first truck delivery to the site, the column 'TAC' values are equated to 'SCT', which are '8:55' and '10:15', instead of '9:00' and '10:00' earlier respectively.

Step 5: Now using the 'Check for New SCT' tab, make changes in the 'SCT' for new 'TAC' values and 'Calculate for New SCT' the result observed to be 'TWT = 1:10' and 'TBB = 1:05', refer Fig. 4.

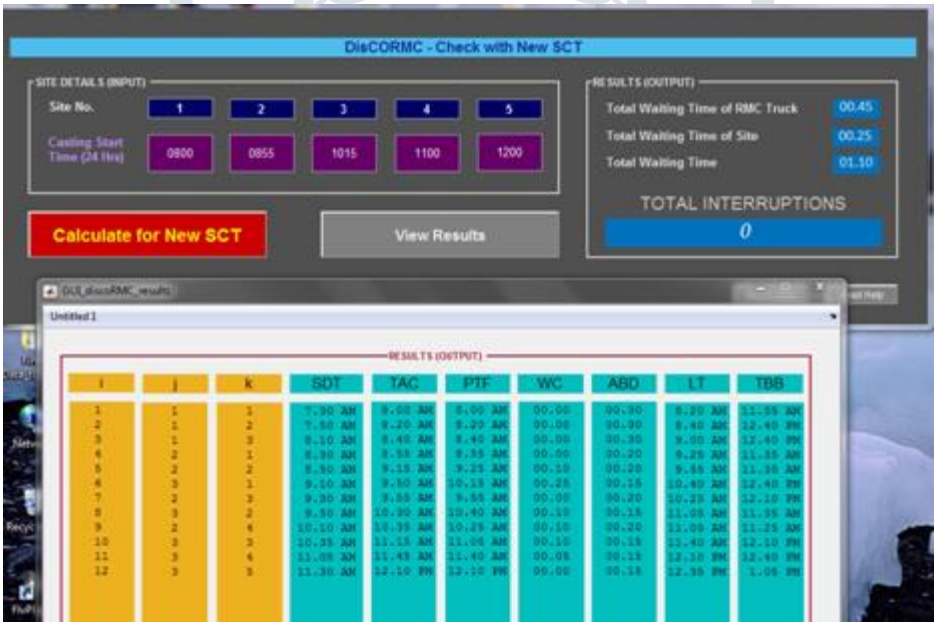

Fig. 4 Results after changes in SCT

The net saving in the 'TWT' was observed to be 1:15 minutes (51.72 %) (from 2:25 to 1:10) where as the net saving in number of RMC trucks 'C' was observed to be '2' from '7' to '5', because as per thumb rule RMC trucks required are '7'.

To check the flexibility of the MATLAB App for CP-90, with mixing duration 'md = 3minutes' and all other data for Case 1, we have created Case 2. The final results observed to save 'TWT' and 'C' as '3:52 minutes' (47 %) (from 7:54 to 04:02) and '3' respectively.

To check the efficiency of the App six more Cases were created with data from multi sites and the results were observed, which are listed in Table 2.

Table 2 Summary of Result for different site situations from Single dispatching Plant

Case No.	No. of Sites to be Delivered	No. of Total Deliveries	Type of Plant with 'md'	No. of Trucks by Thumb Rule	No. of Trucks by MATLAB App	No. RMC trucks saved	% Saving in No. of RMC Trucks
1	3	12	**CP-30**	7	5	2	**28.57**
2	2	12		7	5	2	**28.57**
3	5	18		9	6	3	**66.67**
4	2	18		7	5	2	**28.57**
1	3	12	**CP-90**	7	5	2	**28.57**
2	2	12		7	5	2	**28.57**
3	5	18		9	5	4	**44.44**
4	2	18		7	5	2	**28.57**

4. CONCLUSION

The present study demonstrates a successful application of GA based MATLAB App to produce an un-interrupted dispatching schedule by optimizing number of RMC trucks by 28 - 66 %. It also shows the efficiency and flexibility of making changes in the data parameters for reducing number of trucks required to dispatch RMC from a plant to sites and so optimization of cost of owing and cost of opportunity.

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