

Genetic Algorithm based Optimized Un-Interrupted Dispatching Schedule for Ready Mix Concrete truck with User friendly Interface on Single window (Single Plant Multi-sites)



Gaikwad A. K., S. B. Thakare

Abstract: Delivering Ready Mixed Concrete (RMC) to construction sites is an important task for the RMC Batch Plant (BP) manager. The RMC BP manager has to prepare an efficient schedule of dispatching RMC trucks, which will optimize the operations at the construction sites and also at the batch plant. The existing dispatching schedule mainly depends on the experience of the dispatching manager and preferences from sites. The RMC plant manager dispatches more and more RMC trucks to the longer construction site which may results in the lineup of RMC trucks at one site and keeping other sites waiting for the arrivals of RMC trucks, this may leads to 'interruption'. In this model attempt is made to reduce the interruptions by giving scope to the BP manager to make changes in the SCT (Scheduled Casting Time) on single window called user friendly interface. A Genetic Algorithm User Interface (GAUI) model is developed in MATLAB environment to reduce waiting time of dispatching trucks. Result shows that GAUI model gives an un-interrupted dispatching schedule with reduced waiting time over the industry thumb rules results.

Key words: GA's applications, Un-interrupted Dispatching, User interfaced optimization of RMC truck dispatching, Optimization of Dispatching schedule.

I. INTRODUCTION:

Looking to the infrastructural development and growth in the construction sector, the demand for the concrete, especially RMC has increased tremendously. The current production of the RMC has increase 25% to 30% in last few years [Cover Storey, Indian Review Journal 2013]. RMC being one of the most popular building materials in 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 over concrete prepared by conventional methods at site. RMC usually needs to be poured within 1-1.5 Hrs, after being produced by the RMC plant that limits the service area of the RMC plant.

Consequently, RMC industry is concern about production and scheduling of truck dispatching. Dispatching/Scheduling can be done manually by experienced BP manager. But that may leads to the possibility of interruptions at construction site. This paper present a model which has been developed to reduce the interruption as well as waiting time of construction sites and RMC trucks.

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. The main objective of this study is to suggest user-friendly model in MATLAB environment namely GAUI, to decide un-interrupted optimized dispatching schedule for RMC trucks.

1. Factors affecting the dispatching schedule of RMC trucks:

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

2.1 Start Casting Time (SCT):

Generally in India the casting is started in the morning from 7am to 11am. But in some extreme conditions it can be up to 4pm.

1.2 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.

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* Correspondence Author

Mr. Gaikwad A. K.* Research Scholar, Department, DYPIT, Pimpri, Civil Engineering, Associate Professor, PCCOE, Pune

Dr. S. B. Thakare Professor, Department, Civil Engineering DYPIT, Pimpri, Principal, APCOE, Pune

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It can also be estimated with the help of Google maps or GPS devices.

1.3 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 truck cannot arrive at the job site in time, it leads to the interruption of the construction activity.

1.4 Number of deliveries/trucks 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.

1.5 Number of trucks available at 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 batch plant. This computer program generated in MATLAB environment, gives the optimum number of the trucks required for a batch plant.

1.6 Capacity of the Plant (CP):

Capacity of the plant is the amount of concrete in m³ that plant produce per hour. It means CP30 plant produces 30 m³ of concrete per hours requires 20 minutes to fill one RMC truck. The time for CP90 is 3 minutes. This restricts the sequence of the orders to be taken for dispatching.

2.7 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.

II. APPLICATION OF THE GAUI MODEL FOR PREPARING AN UN-INTERRUPTED DISPATCHING SCHEDULE OF RMC TRUCKS:

EXAMPLE1 (For CP90, md =03 minute):

Table 1 Site situation with following decision making 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	20	4
Site 3	8:30 am	40	25	30	15	5

Number of Trucks at Batch Plant : 5 Trucks (C)
 Mixing Duration of Plant : 3 minute (md)
 Max. Capacity of the Truck : 6.0 M³

Step 1: Fill all the above data in the “GUI_disco RMC” MATLAB APP called herein as GAUI model, as shown in

the Fig.1 and determine the Total Waiting Time (TWT) by pressing the “RUN”.

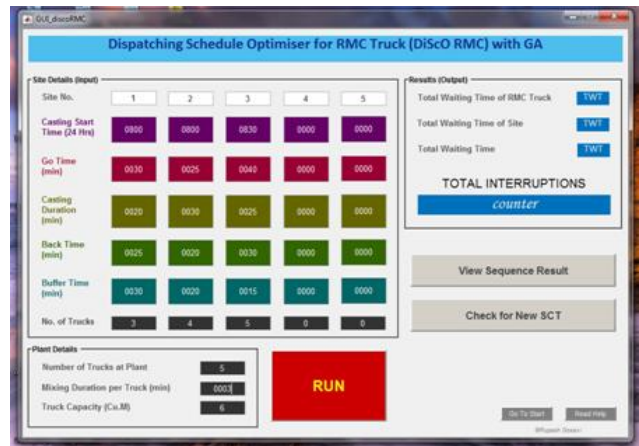


Fig.1 GAUI model screen

Where,

$$FDT \min[08:00 - 00:30, 08:00 - 00:25, 08:30 - 00:40] = 07:30$$

i 1 2 3 4 5 6 7 8 9 10 11 12

$$IDT = 07:30 \quad 07:33 \quad 07:36 \quad 07:39 \quad 07:42 \quad 07:45 \quad 07:48 \quad 07:51 \quad 07:54 \quad 07:57 \quad 08:00 \quad 08:03$$

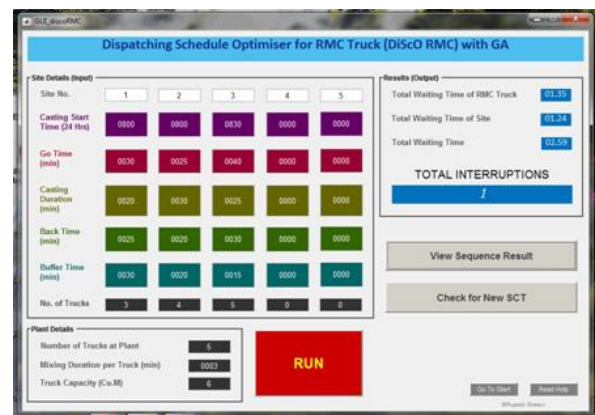


Fig.2 Results for Example 1

$$FDT = \min (SCT-GO)_i, i = 1 \text{ to } m \quad \dots(1)$$

$$IDT_i = FDT + (i-1)* md, i = 1 \text{ to } N \quad \dots(2)$$

$$n = \sum_{i=1}^m k_i$$

Where,

- FDT is the departing time of the first dispatched truck,
- IDT is the ideal departing time of the dispatched truck,
- i is the dispatched order of the truck,
- m is the number of construction sites that request RMC deliveries,
- k is the required RMC deliveries of the construction site,

The result will be displayed as shown in the Fig.2. Check for “Total Interruptions’ window and “Total Waiting Time shown”. If the value shown at, “Total Interruptions”, is not zero.

IF $i \leq n$, Number of Trucks at Batch Plant,

$$SDT(i) = IDT(i) \quad \dots(3)$$

else
SDT(i) = mmm + md,

$$(mmm = \text{Minimum of TBB}) \dots\dots\dots(4)$$

$$TAC(i) = SDT(i) + GO(Ix(i)) \dots\dots\dots(5)$$

IF t(i) == 1
PTF(i) = SCT(Ix(i)) \dots\dots\dots(6)

Else
PTF(i) = LT(Ix(i)-1)

$$WC(i) = -TAC(i) + PTF(i) \dots\dots\dots(7)$$

If WC(i) > 0
LT(i) = PTF(i) + CD(Ix(i)) \dots\dots\dots(8)

Else
LT(i) = PTF(i) + CD(Ix(i)) + WC(i) \dots\dots\dots(9)

$$TBB(i) = LT(i) + BACK(Ix(i)) \dots\dots\dots(10)$$

$$TWT = \text{Sum of WC}(i) \dots\dots\dots(11)$$

Step 2: Click on “View Sequence Results”, it will open the dispatching schedule for all the deliveries as shown in Fig.3. Compare ‘TAC’ and ‘PTF’ of every first delivery ‘k’ of respective site ‘j’.

j	k	SDT	TAC	PTF	WC	ABD	LT	TBB
1	1	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
1	2	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
1	3	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
1	4	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
1	5	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	1	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	2	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	3	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	4	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	5	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	1	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	2	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	3	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	4	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	5	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	1	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	2	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	3	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	4	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	5	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
5	1	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
5	2	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
5	3	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
5	4	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
5	5	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM

Fig.3 Sequence Results for Example 1



Fig.4 Check for New SCT

If they are not same make SCT of that site ‘j’ equals to ‘PTF’ and enter this ‘SCT’ in a window which will be opened by clicking “Check for New SCT” as shown in Fig.4. Click “Calculate for New SCT”, which will display revised results on the same window, as shown in Fig.5.



Fig.5 Results for New SCT

Check whether the “Total Interruption” is zero and “Total Waiting Time” is also reduced or not.

Thus, on a single window the GAUI helps the dispatching manager to give efficient, flexible and optimized solution for dispatching RMC trucks for single plant multi sites operation. To prove the efficiency of the GAUI model, on less capacity plant **CP30** with ‘md’ =20 min, the same example is run on the GAUI model. The outputs are as shown in the Fig.6 to Fig.9.



Fig.6 Data Entry for Example 2

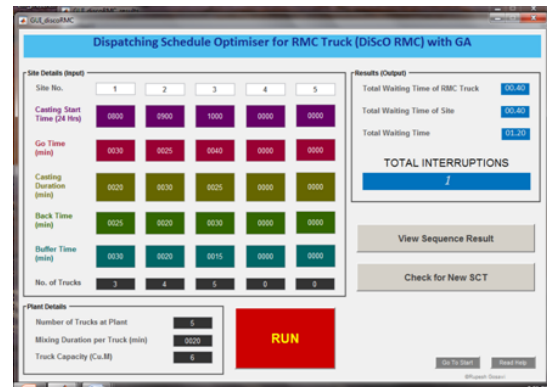


Fig.7 Results for Example 2

j	k	SDT	TAC	PTF	WC	ABD	LT	TBB
1	1	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
1	2	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
1	3	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
1	4	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
1	5	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	1	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	2	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	3	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	4	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
2	5	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	1	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	2	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	3	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	4	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
3	5	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	1	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	2	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	3	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	4	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM
4	5	1:30 AM	8:00 AM	8:00 AM	00:00	8:30 AM	8:30 AM	8:30 AM

Fig.8 Sequence Results for Example 2



Fig.9 Results for New SCT

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These results can also be compared with the Dispatching Sequence (Thumb rule) of the industry. E.g. For CP30 plant generally 3 trucks are send to the site1 ordered first and then next 3 truck are send to the site2 ordering second. If the deliveries of the site1 are over, then the next sites order is followed in a pair of 3 trucks. i.e. for the shown case2 of CP30, if the deliveries are 3, 4 and 5 for site 1, 2 and 3 respectively thn the dispatching sequence followed in the industry is : 1 1 1 ; 2 2 2 ; 3 3 3 ; 2 3 3.

The facility is also given in the GAUI model to compare the results with industry.

Click on “Go to Start” a window will open as shown in Fig.10, click “Yes” a window will open as shown in Fig.11, make changes in the model as per the Table 1 with md=20 minutes.

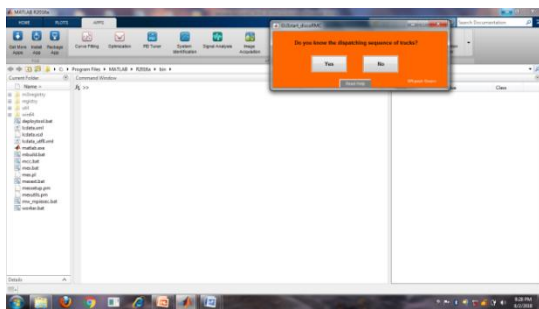


Fig.10 GAUI model screen

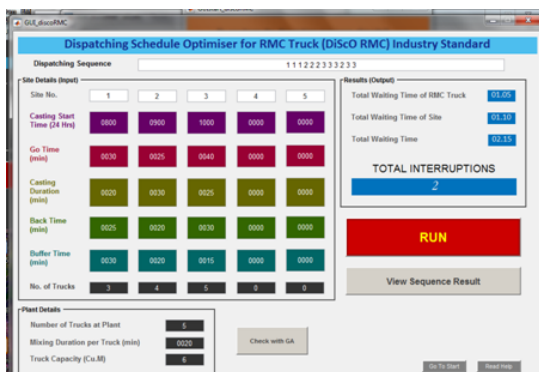


Fig.11 Results for Example 2 with given Dispatching Sequence

Add the dispatching sequence as : 1 1 1 2 2 2 3 3 3 2 3 3, with a space in between. Click on “RUN”, it will show the results to compare with GAUI model as shown in Fig.11.

The comparisons are made for CP30 and CP90 with eight different cases with increase or decrease in the number of sites as well as trucks to be delivered to show the efficiency of the GAUI model. The **Table 2** shows the percentage saving in the TWT (Total Waiting Time) and reductions in the “Interruptions”.

2. GA optimization for Fitness Value (FV):

As shown in Fig.2, the number of interruptions displayed as ”Total Interruption” is 1. Since the interruptions are to be avoided and waiting time is to be reduced, the Penalty Value (P) is calculated by Eq. (12).

$$P = (\text{Number of interruption}) \times 60 \times 24 \dots\dots(12)$$

Then fitness value (FV) of a dispatched schedule is determined as $FV = P + TWC$, where TWC is the total waiting time of RMC trucks that wait at the construction sites. In example 1, the fitness value of the dispatched schedule is equal to 1635 ($= 1 \times 60 \times 24 + 195$). [195minutes = 3:15 Hrs. Fig.2]

$$FV = (\text{Number of interruption}) \times 60 \times 24 + 195 \dots\dots(13)$$

The GAUI model works for minimum 51 iterations (Default setting) and calculates the FV for each iteration. The minimum FV of all iterations is displayed at last, being the fittest value for the iteration as per the Darwin’s Principle. Fig.12 is a graphical representation of all the iterations (Generations) and respective FV.

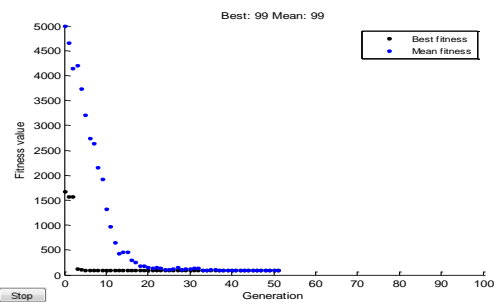


Fig.12 Graphical Representation of FV for Example 1

Usually the best FV equals to mean FV of the earlier iteration from 20th iteration, still the GA works for default set 50 to 53 iterations in GA. The mean and best FV from 20th to last iterations are same and gives the same Total Waiting Time, for any of the dispatching sequence for that respective best FV.

III. RESULT

Results of eight different cases were worked out on the GAUI model, to show the efficiency of the model and compare the results for two different plants called CP30 and CP90.

Odd Case numbers in the Table2 are showing the percentage saving in TWT for CP30, where as the even Case number (bold letters) is showing for CP90.

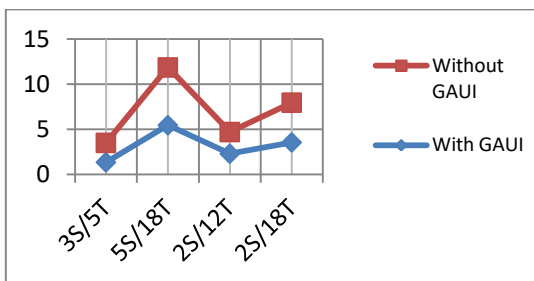
Table 2 Comparison of the Results for saving in TWT

Case No.	No. of Sites	Mixing Duration (Min.)	No. of Trucks Dispatched	TWT by Thumb Rule / Interruptions (Hrs : min / No.)	TWT by GA / Interruptions (Hrs : min / No.)	Total Saving in TWT (Hrs : min)	% Saving in TWT
1	3	3	12	3:32 / 1	2:03 / 0	1:29	60.84
2	3	20	12	2:15 / 1	1:35 / 0	0:45	33.33
3	5	3	18	7:34 / 1	6:04 / 1	1:30	19.82
4	5	20	18	6:40 / 1	5:45 / 0	0:55	13.75
5	2	3	12	3:09 / 3	2:56 / 0	0:13	6.87
6	2	20	12	2:40 / 2	2:30 / 0	0:10	6.25
7	2	3	18	4:44 / 2	3:38 / 0	1:06	23.24
8	2	20	18	4:40 / 4	3:55 / 1	0:45	16.07

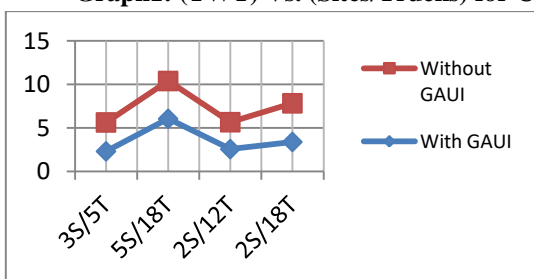
Thus the Prepared GA model proves to **save, 5.1 TWT from 6 % to 60 %** [10 min to 1:30 min] with interruption always reduced to ZERO, indicating the Un-interrupted optimized dispatching schedule.

flexibility to make changes in decision making parameters. Thus the presented GAUI model generates efficient, flexible and un-interrupted dispatching schedule. It helps plant manager to decide quickly the dispatching schedules by providing him a scope to make changes / rescheduling in the Start Casting Time (STC) of sites.

More saving in TWT for higher Capacity Plant, than lower Capacity Plant, proves the need and versatility of GAUI model for modern higher capacity plants also.



Graph1: (TWT) Vs. (Sites/Trucks) for CP30



Graph2: (TWT) Vs. (Sites/Trucks) for CP90

5.2 TWT in CP30 (md =20 min) is 6.25 % to 33 %,

5.3 TWT in CP90 (md =03 min) is 6.87 % to 60 %,

IV. CONCLUSION

The present study demonstrates a successful application of Genetic Algorithm (GA) model to suggest an un-interrupted dispatching schedule of RMC trucks. The results, shows the efficiency of the Genetic Algorithm User Interface (GAUI) model for reducing interruptions always to zero and net saving in the TWT from 6% to 60%. It also gives the

FUTURE SCOPE

The present study is the demonstration and optimization for a “Single plant Multi-sites” situation. The same logic can be worked out for “Multi-plant Multi-sites” situation also.

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AUTHERS PROFILE



Mr. Gaikwad A. K M.Tech., Research Scholar, DYPIoT, Pimpri, Pune, (Mh), India Associate Prof., PCCoE, Pune, (Mh), India. Civil Engineering Department 11 Publications gaikwadajayk@gmail.com



Dr. S. B. Thakare PhD, Professor, DYPIT, Pimpri, Pune Civil Engineering Department Principal, APCOE, Pune (Mh), India 25 Publications. prof_sbthakare@gmail.com