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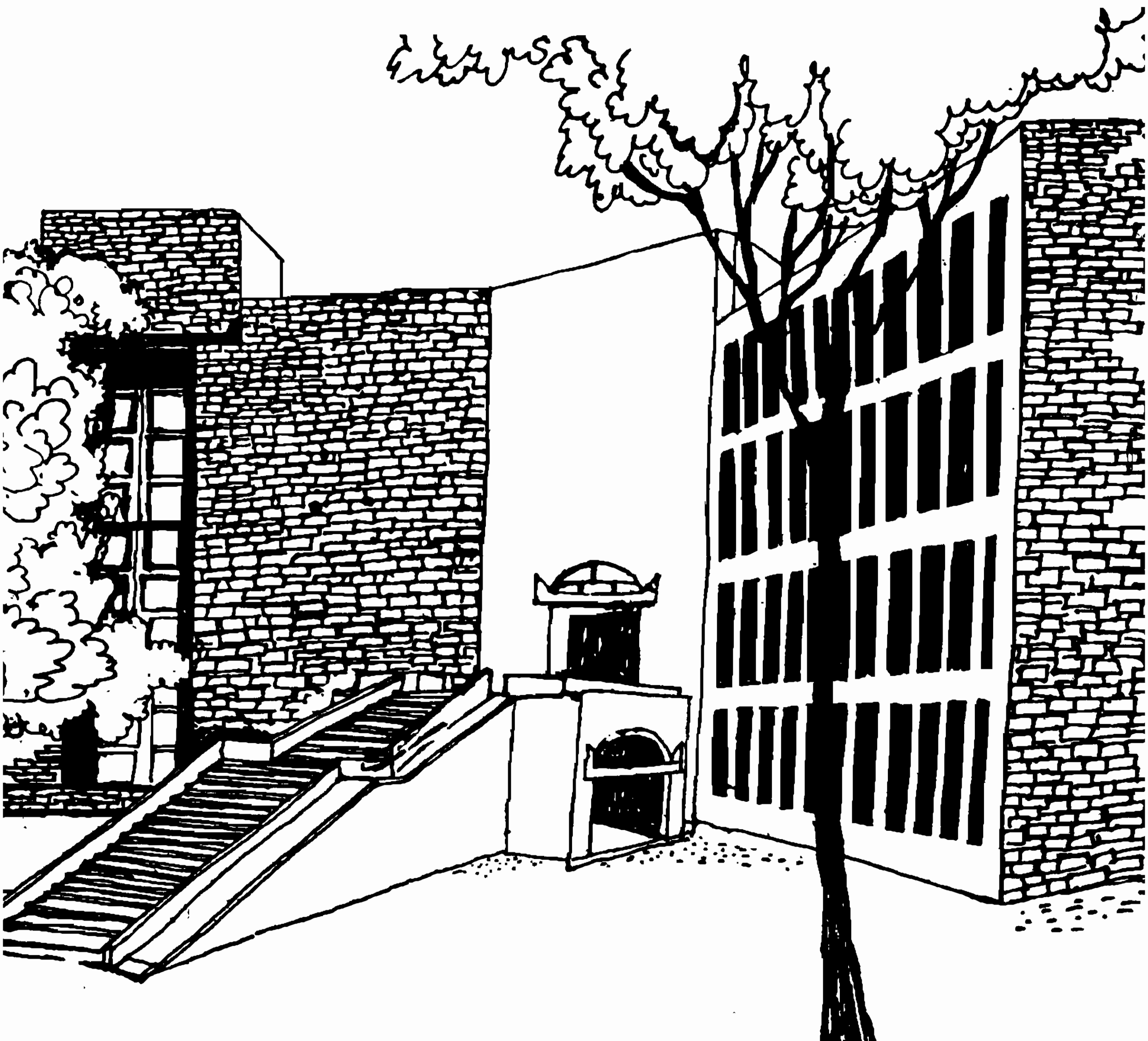

SIMULATION: A DECISION MAKING TOOL FOR CONSTRUCTION MANAGER

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SIMULATION: A DECISION-MAKING TOOL FOR CONSTRUCTION MANAGER

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Abstract

Simulation study of concreting operation for canal lining was carried out, to take a decision on the most appropriate number of Transit Mixers for the efficient working of batching plant.

Introduction

The problems faced by the present day's construction managers are growing in size and complexities. The technologies, scale of operation and uncertainty in construction process make it increasingly difficult to rely on intuition and/or experience alone to take important decisions. Simulation has emerged as a powerful tool for management of complex projects. Project managers could be aided with tools, which can effectively handle problems at various levels of construction.

Simulation is the duplication of the essence of a real system in form of mathematical-logical model, which is manipulated on a computer. This manipulation is then used to study the nature of the real system. Simulation can be used to describe a current system, to study a hypothetical potential system, and to improve the design of an existing system. It is used to play relatively inexpensive "what if" games and to test new ideas without a real world implementation. In this way, users can experiment with design of construction operations and evaluate the economics and productivity of competing construction methods.

There has not been much application of simulation in construction earlier, as there was lack of consistent approach that clearly defines all the steps and aspects. Moreover it became very difficult for the practitioners to understand and acquire expertise in these concepts. Now progress made in use of certain methodologies suitable for construction operations with focus on input stages that makes it easy and attractive to understand and apply simulation to the inexperienced and infrequent users. This was accomplished by enabling the user to enter a simulation model graphically and interactively on a computer. Special computer packages developed for construction simulation are available (CYCLONE and DISCO), that reduce much of computer time efforts and make simulation accessible to the decision-makers in construction. Standard programming languages like Pascal, COBOL, FORTRAN, BASIC, C or special simulation languages like SIMULI, SLAM can also be used for computer simulation as is illustrated in this work.

A number of successful applications of simulation have been recorded in the recent studies. [1] One of the prime applications of simulation is at process level. Apart from this, simulation has also been used as a means of alternative dispute solution.

Some of the applications of construction simulation are:

- Process Modelling and Simulation
- Claims Analysis and Dispute Resolution
- Project Planning and Control
- Process Integration and Linear Scheduling
- Modelling Learning Development using Simulation
- Reliability and Maintainability Assessment using Simulation

Construction operations are subjected to a wide variety of fluctuations and interruption. Varying weather conditions, learning developments on repetitive operations, equipment breakdowns, management interventions and other factors may have an impact on the production process in construction. As a result of such interference, the behaviour of construction process becomes random. This necessitates the modelling of construction operations as random processes during simulation.

Steps Involved in Simulation Modelling

The simulation process can generally be divided into the following stages of development:

1. **Problem Formulation:** In this stage, the definition of the problem to be studied including a statement of the objectives in context of the surrounding environment is formulated.

2. **Model Building:** In this stage various work tasks and resources involved are identified, then based on this a preliminary model which can be either graphical or pseudo coded is developed. The objective of this stage is the abstraction of the real system into mathematical logical relationships in accordance with the needs of problem formulated earlier.

3. **Input Modelling:** Here the data required for carrying out simulation experiment is collected (e.g. activity duration data, inter-arrival time of resources, idle times, etc.)

4. **Model Translation:** This stage includes the preparation of the model for computer processing. For model translation a large number of tools are available. Various programming languages are used to perform this task.

5. **Verification:** This process establishes that the computer program executes as intended.

6. **Validation:** This is the process of establishing a desired accuracy or correspondence that exists between the simulation model and the real system, which is done by comparing estimated parameters to the recorded or observed results from the real system.

7. **Experimentation:** Simulation model is exercise to obtain answers to the questions posed by construction managers.

8. **Analysis of Results:** It is a process of analysing the simulation outputs to draw inferences and make recommendations for problem resolution.

9. **Implementation and documentation:** In this stage the decisions resulting from the

simulation study are implemented and the model and its uses or applications are documented in detail.

We present in this paper a case study, which tests the suitability of simulation in a construction project.

Concreting Operation of Canal Lining

The concreting operation of canal lining was studied using the simulation technique. This canal is a part of Narmada Main Canal (package number 8), which extents 6 km. on either side of Sabarmati river near Ahmedabad - Gandhinagar highway. Sabarmati River divides the total canal length of 12 km. into two equal parts, which are planned separately out of which one section was taken for this study. The project duration was 48 months. The main construction activities were excavation, canal lining, and construction of structures (like bridges, drainage siphon, etc.) which come in the alignment of canal. Once the earthwork (excavation) is complete for a segment, the subgrade is prepared, on which the canal lining is laid. For the subgrade preparation two motor graders were employed so subgrade preparation was not a problem. Concrete of canal lining was the critical activity and timely completion of the project depended on the progress of this activity. Hence this activity was taken for the Simulation study.

Problem

Here the management wanted to take a decision on how many Transit Mixer (TM) to be employed for the existing batching plant so that project is completed on time. Another query was, what would happen if the number of TM are increased or decreased. The main objectives were:

1. To determine the appropriate number of hauling units required for efficient working of batching plant.
2. To quantify the effect of number of hauling units employed and project completion time, and thereby enable the management to decide how many TM to employ.

Model Building

In the existing system one batching plant was serving five hauling units (i.e. TM) These TM after getting loaded, transport the concrete to the paver units, dump the concrete and then return to the batching plant, thereby completing one cycle.

In all, there are three paver units. The concreting operation runs round the clock when the work is in the full swing. One paver unit works in the day shift, the other in the night and the third one is a stand by in case there is a shifting or a breakdown in any of the paver units. All the equipments used for the concreting work were newly purchased for this site so that there were very less breakdowns, except the problems due to initial setting of equipment.

The hauling route is shown in the Fig.1. The route is uneven, rugged and at a gradient along the alignment of canal. The paver unit was located at a distance of about 3 km. from the batching plant. The average concrete producing capacity of the batching plant was 48 m^3 per hour and TM could load 4.00 m^3 of concrete.

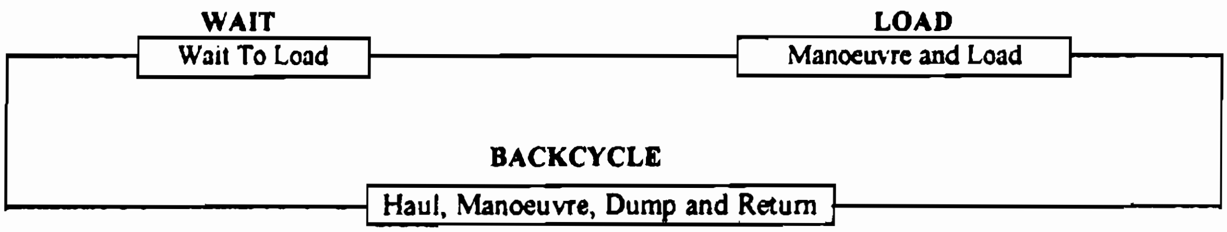


Fig 1. Schematic Diagram of Concreting Operation.

The entire canal length of 6 km. is divided in 6 phases of 1 km. each for the purpose of modelling. The road approaching the batching plant from the canal divides the canal into two equal halves of three phases each. Only three phases have been considered since on the other side it would be repetition of the first three phases.

Once the batching plant starts working, on an average it takes 5 min. to load one transit mixer. After the transit mixer is loaded, it hauls to the paver site where it discharges concrete and returns back to the batching plant. On an average it takes 30 min. to finish one Backcycle. After returning, if the batching plant is idle, it immediately goes for loading; otherwise it waits in the queue for loading.

Concreting is done in three bands of about 22 m each. The remaining width would be done along with the slopes. As the concreting operation progresses the paver unit moves ahead, in turn increasing the distance of the paver unit from the batching plant which causes increase in the Backcycle time. For the purpose of modelling it has been assumed that the parameter of Backcycle time remains the same in each phase and changes only when a phase is completed. It has been observed that the change in parameter of Backcycle (i.e. minimum time, most often time and maximum time) are 4, 5 and 10 min. respectively.

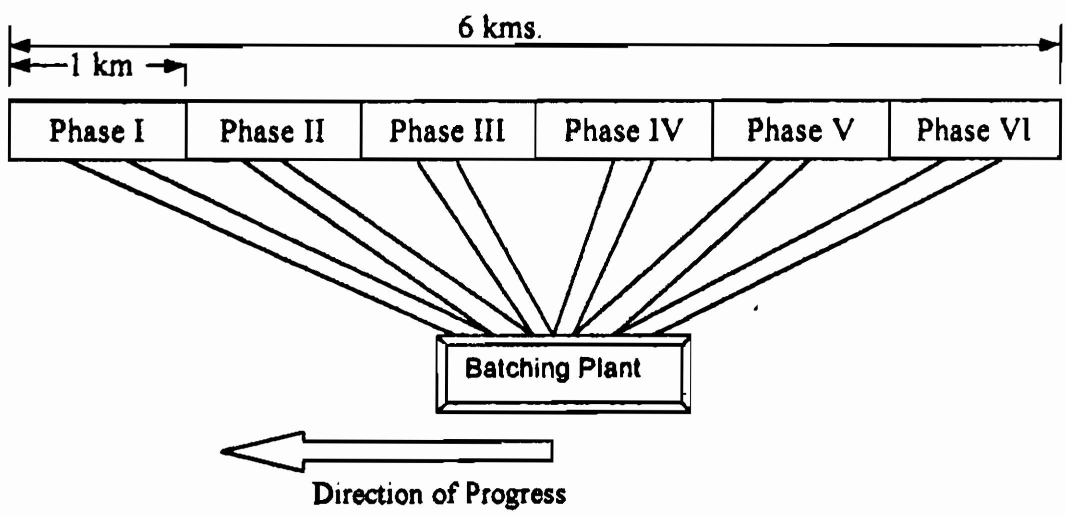


Fig. 5 Layout of the Canal Lining Project.

The total amount of concrete required for the canal in each phase is 7000 m^3, and if each transit mixer carries 4.00 m^3 then it would require 1750 trips of the transit mixer to complete one phase. Accordingly, in each simulation run for each phase 1750 trips of transit mixer are made so as to complete the concreting of each phase.

If the production rate of the paver units, concrete loading time, inter arrival time and hauling time of the TM are kept constant or deterministic duration are assigned to them, it would be fairly simple to determine the most economical number of hauling units for the project. However, the situation in the real life is quite different. There may be times when several number of TM are waiting to be loaded at the batching plant or waiting to discharge concrete at the paver unit or the paver unit is waiting for TM. All these situations which are normally neglected may result in loss in production. In simulation studies such randomness or variation can also be incorporated.

Input Modelling

Data was collected using random sampling techniques. At the batching plant data in form of activity duration was collected by stopwatch studies.

Arrival Time ($At_{1,2,3..}$) (clock)	Time at which the TM number 1,2,3 and the successive TM arrives at the batching plant.
Loading Start Time ($LSt_{1,2,3..}$) (clock)	Time at which the TM number 1,2,3 and the successive TM starts getting loaded with concrete.
Exit Time ($Et_{1,2,3..}$) (clock)	Time at which the TM number 1,2,3 and the successive TM leave the batching plant for the paver unit.
Waiting Time (duration) **($At_{1,2,3..}$ - $LSt_{1,2,3..}$)**	The time each transit mixer waits before loading concrete.
Loading Time (duration) **($LSt_{1,2,3..}$ - $Et_{1,2,3..}$)**	Time taken by each transit mixer to manoeuvre and load concrete.
Backcycle Time (duration) **($Et_{1,2,3..}$ - $At_{1,2,3..}$)**	The time consumed by a TM after loading from batching plant, hauling to paver unit, discharging concrete and then returning back to the batching plant.

This data was then sorted and grouped in the form of frequency distribution, to statistically analyse and find out various parameters and identify the distributions. The Frequency curves developed from the sample observations reflects the possible shape of probability density function of the distribution as shown in the flow chart below.

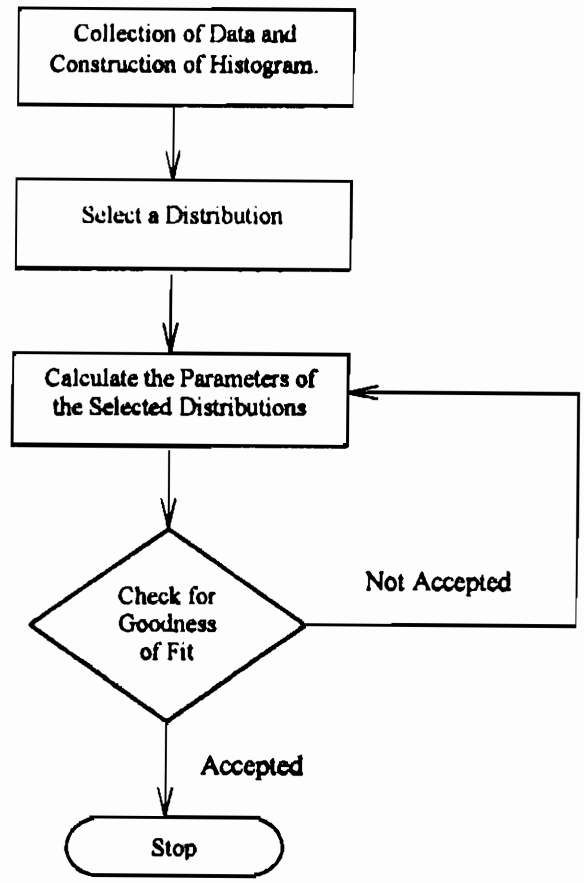


Fig. 2 Development of Input Model for Simulation Experiments. [1]

Loading Time Distribution

The objective is to estimate the underlying distribution of the random process. Beta distribution was used in modelling this duration, as suggested by AbouRizk and Halpin [2] as the best candidate for modelling activity duration for most of the applications in construction

Sample Statistics for Loading Time Data

Mean	5.12	Kurtosis	27.42
Median	5	Skewness	4.60
Mode	5	Minimum	3
Standard Deviation	1.72	Maximum	17
Sample Variance	2.98	Count	118

Moment matching method was used to calculate the shape and size (a and b) parameters [3] As these parameters obtained were not reflecting the underlying distribution accurately, further optimisation was done using Macro function in Microsoft Excel. Best fit was selected by changing the shape and size parameters, and change in the shape of the curve observed. The parameters that gave best fit were selected.

Table 1 Test of Fit with Beta Distribution (Loading Time)

CLASS INTERVAL (min.)		CLASS MARK (x)	OBSERVED FREQUENCY	CUMULATIVE	F(x)	CHI-SQUARE
0	3	1.5	0	0	0.0	
3	4	3.5	4	2.6	2.6	
4	5	4.5	28	31.6	29.0	0.0049
5	6	6.5	65	97.2	65.6	0.0050
6	7	7.5	13	110.7	13.5	0.0200
7	8	9.5	4	117.5	6.8	
above	8	13	4	118.0	0.5	0.0666
		Total	118		118.0	0.0966

The beta Probability Density Function is defined on the range L.U for lower and upper limits, respectively with the shape parameters 'a' and 'b' given by

$$f(X,L,U,a,b) = \frac{\Gamma(a+b)}{\Gamma(a)(b)} \quad \frac{(X-L)^{a-1}(U-X)^{b-1}}{(U-L)^{a+b-1}}$$

$U \leq X \leq L$ $\qquad a,b, > 0$

$\Gamma(\eta)$ = the Gamma function define by :

$$\Gamma(\eta) = \int_0^{\infty} t^{z-1} e^{-t}\, dt \qquad \text{for all } \eta > 0$$

Parameters

L = 3 $\qquad \chi^2$ computed = 0.0966

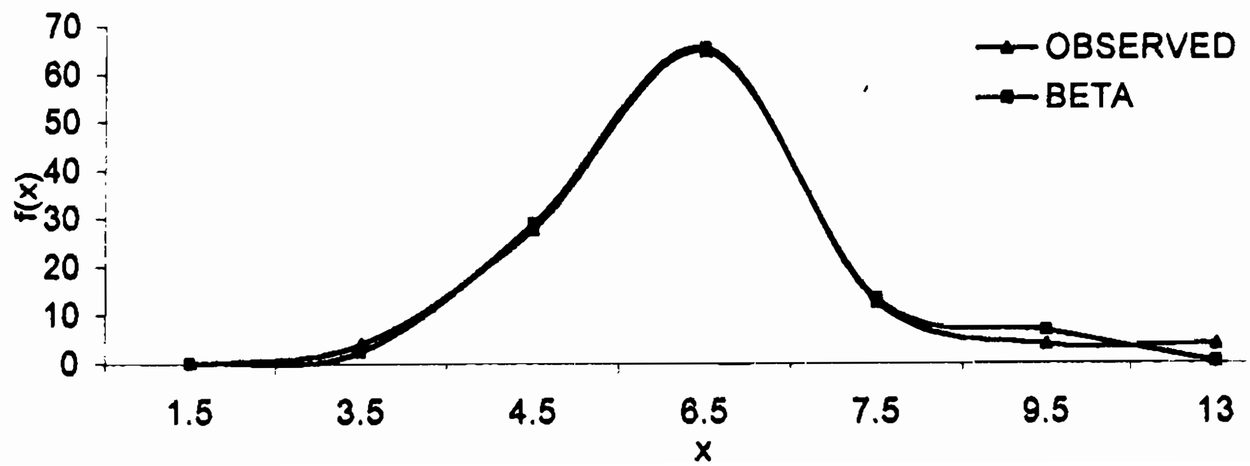
U = 17 $\qquad \chi^2_{1,0.9}$ = 2.7060

Hence, the fit is acceptable.

Shape and Size Parameters

a = 2.9 $\qquad$ b = 14

Fig. 3 Loading Time Distribution



Analysis of Backcycle Data

Backcycle Time (At- Et) is the time duration which the TM takes to once it exits the batching plant for the paver units to discharge concrete and return to the batching plant Beta distribution was used for modelling this duration, as it is the best candidate for modelling activity duration in construction. [2] Similarly as in case of loading time, shape and size parameters were calculated for Backcycle data.

Sample Statistics for Backcycle Time Data

Mean	25.82	Skewness	1.16
Median	23	Range	49
Mode	16	Minimum	11
Standard Deviation	10.30	Maximum	60
Sample Variance	106.17	Count	94
Kurtosis	1.07		

Table 2 Test of Fit with Beta Distribution (Backcycle Time)

CLASS INTERVAL (min.)		CLASS MARK (x)	OBSERVED FREQUENCY	CUMULATIVE BETA	f (x) BETA	CHI-SQUARE $(O-E)^2/E$
0	10	5	0	0.00	0	
10	14	12	3	4.09	4.094	
14	18	16	17	21.89	17.8	0.1638
18	22	20	20	41.78	19.88	0.0007
22	26	24	17	58.90	17.12	0.0009
26	30	28	11	71.92	13.02	0.3123
30	34	32	7	80.98	9.064	0.4700
34	38	36	7	86.83	5.853	0.2247
38	42	40	3	90.34	3.511	
42	46	44	4	92.29	1.948	0.43472
46	50	48	1	93.28	0.99	
50	54	52	2	93.73	0.453	
54	58	56	1	93.92	0.182	
58	62	60	1	93.98	0.062	6.5039
		Total	94		93.98	8.1103

Parameters

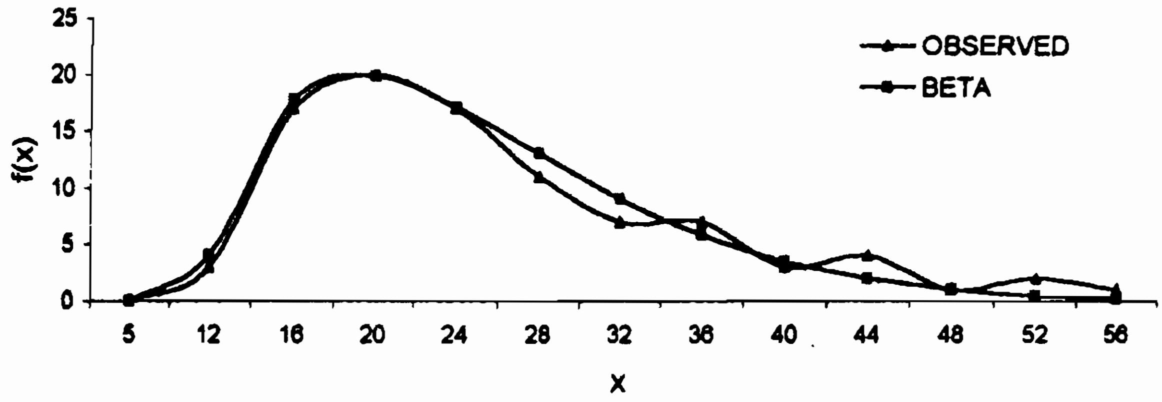
L	=	10	χ^2 computed	=	8.110
U	=	80	χ^2 5,0,9	=	9.236

Hence, the fit is accepted.

Shape and Size Parameters

a = 1.75607 b = 7.8312

Fig. 4 Backcycle Distribution



Assumptions

Following assumptions were made:

1. The concrete carried by each transit mixer is 4.00 m^3
2. All TM are available at the beginning of the day.
3. Queue discipline is on first come first serve basis.
4. Subgrade preparation work is complete.

Model Translation

To achieve the aforesaid objective simulation of the system was done using SLAM II.[5] The various numbers of transit mixers (entities) were included in the system using CREATE node Then the entity waits till it is loaded in a queue, using QUEUE node. As the batching plant starts, it loads processes each transit mixer, which marks delay for the entity, which is incorporated using an ACTIVITY node. This activity duration data was marked with beta distribution with upper and lower limits being 3 and 17 min. the shape and size parameters 'a' and 'b' were estimated to be 2.9 and 14.2 respectively. After loading there is a GOON node from which two branches are emerging. Here the entities are duplicated and one branch goes to TERMINATE node, which keeps account of number of entities processed and terminates all entities as the mark number is reached. Here entities are terminated as 1750 entities are processed. This GOON node also connects the loading with backcycle.

After the entity is processed, it hauls, discharges concrete and returns, marked by the ACTIVITY node backcycle. The parameter of these delay are marked by Beta distribution with minimum and maximum time taken as 10 and 80 min. respectively the shape and size parameters 'a' and 'b' being 1.756 and 7.931 respectively. However due to problems in programming, the loading time and backcycle time were marked by triangular distribution taking minimum, mode and maximum value as its parameters.

Triangular distribution in place of Beta distribution would not greatly effect the results as the accuracy of the distribution fitting in construction simulation greatly depends on the application involved and statistical measure of performance required [4.] A study by Abou Rizk showed that if the parameter sought from the simulation is a mean measure of performance. (E.g. mean project completion time or cost) the use of triangular, lognormal or beta distributions as input models in the simulation experiment could yield close values of the estimated mean as long as the mean of the input model are the same.

Once the back cycle is complete the entities are routed back to the QUEUE node. This repetitive process goes on as long as the desired number of trips are made (1750 trips). Statistics are collected for loading time and backcycle time using COLCT nodes.

Computer Programme

```
    GEN, MANISH TRIVEDI, CANAL LINING, 11/11/1995,10,,N,,N,,72;
    LIM,1,1,600;
    NETWORK;
    CREATE,0,,,4,1;                      Create T.M.
Q1  ASSIGN,ATRIB(2)=TNOW;
    QUEUE(1);                            Queue for loading
    ACT(1)/1,TRIAG(3,5,17);              Loading
    COLCT,INT(2),LDTME;                  Collect loading time
    GOON,1;
    ASSIGN,ATRIB(1)=TNOW;
    ACT/2,TRIAG(10,16,80);               Backcycle
    COLCT,INT(1),BKCYC                   Collect back cycle time
    GOON,2;
    ACT,,,Q1;
    ACT;
    TERM,1750;                           Terminate T.M.
    END;
    MONTR,SUMRY;
    FIN;
```

Experimentation

Simulation runs for each phase were carried out independently. In each phase the number of TM employed were changed and statistics, in form of project completion time, average waiting time per trip, average backcycle time and average loading time collected from the simulation experiment as shown in the Table 3 (Appendix I)

Analysis of Results

Analysing 10 Simulation runs for 1 Transit Mixer for Phase III, we observe that the Transit Mixer does not have to wait for the loading of concrete. But it takes 159 days to finish this phase, which is not desirable as far as the completion time of the activity is concerned. In the process the batching plant has to wait for the Transit Mixer, thus making the plant under utilised. Hence there is a need to increase the number of Transit Mixers.

The variation in the completion time for 10 simulation runs is about 3 days. This is because activity duration is assigned random values from the fitted probability distribution.

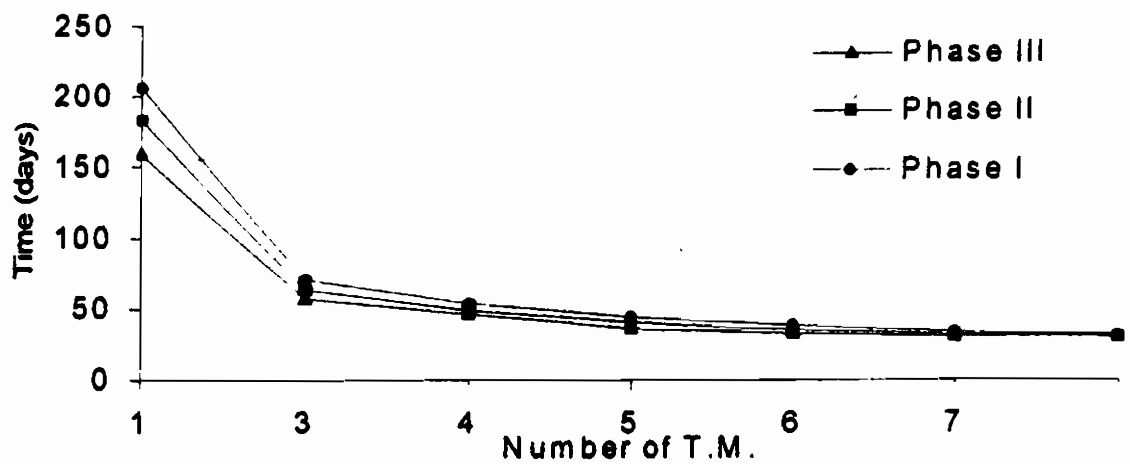
The average backcycle and loading time are fairly constant. This could be explained, as numbers of observations are very high, the average of the same from all the simulation runs would give more or less a constant value. From the 10 simulated runs for 1 Transit Mixer, it is observed that the average loading and backcycle time is 8.3 and 35.3 min. respectively. For the input modelling, loading time and backcycle time is 8.3 and 35.3 min. respectively. The input data model for loading time and backcycle time are defined by a triangular distribution with parameters being 3, 5 and 17 and 11, 16 and 80 (minimum, most likely and maximum) respectively. After studying the results of simulation runs, we find that, the average loading time and backcycle time are not same as the most likely values given by the input parameters, the reason being a skewed triangular distribution in both the cases.

As the number of Transit Mixers is increased to 3, we see that the activity completion time is reduced to one-third the time required by 1 Transit Mixer. There is now some queue formation at the batching plant and on an average each Transit Mixer has to wait for about 2 min. for loading. There is no significant variation observed in average loading time as well as the backcycle time here due to reasons same as applicable in case of 1 transit mixer.

When one more Transit Mixer is added to the same system, it is observed from the simulation runs that, the reduction in the completion time is not significant when compared to the earlier runs. This could be explained by studying the average waiting time for each Transit Mixer, which has increased to 3.75 min. thus, each Transit Mixer takes more time to complete a cycle, thereby increasing the completion time.

As we increase the total number of transit mixers in the system to 5, we see that, the activity completion time is 36.63 days. By increasing the number of transit mixers, the change in the completion time is also decreasing which could be better noted by studying the Fig.6 The reason for this decrease in the change is same as above. We observe that now each transit mixer has to wait for 6.5 min. before it is loaded with concrete. The average loading and backcycle time remains constant.
When 6 transit mixers are used in the system, we observe that, again there is a further decrease in the rate of change of completion time. As now, each transit mixer has to wait for about 10 min.. With 7 transit mixers in the system, we see that there is almost no variation in the rate of change of completion time. But, the transit mixers have to wait for about 16 min. As 1 more Transit Mixer is added, the completion time remains the same but the waiting time increases to 30 min., which is considerably a long waiting time. Hence, it would be undesirable to increase the transit mixers to 9 numbers, as the average waiting time goes as high as 30 min..

Fig.6 Completion Time versus Number of T.M.



A similar trend is observed in the analysis of phase II and I results [3]. Here, as haul length increases, it takes longer time duration to complete the respective phases otherwise the trend observed by increasing the number of transit mixers is almost similar to that in phase III.

Hence from the study done as above we can conclude that, for phase III and phase II, 3 numbers of Transit Mixer would be best suited. For Phase I the most suitable number would be 4 TM.

Conclusion

The study carried out clearly indicates that the computer simulation technique, is a tool, which can be effectively applied to construction projects for analysing and solving process-planning problems. It can also analyse or control a construction operation, equipment planning or manpower planning.

Simulation of the canal lining of Narmada main canal leads us to the following inferences:

1. The appropriate numbers of hauling units (TM) to the capacity of the batching plant are identified using simulation. This otherwise was a problem, resulting in an uneconomical and delayed concreting schedule.

2. With the help of simulation we could review the project completion time by varying the number of hauling units with the given batching plant. This could help us in taking an appropriate decision considering our priorities for the project.

The above results lead to the conclusion that for concreting operation with a given haul length, the completion time decreases upto a certain extent, as the number of TM in the system increase, after which there is no significant change in terms of the completion time of the activity.

Reference:

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3. Manish Trivedi, "Use of Computer Simulation in Construction ", Guide: Girja Sharan, Final Year Thesis School of Building Science and Technology.
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5. Pristsker A.B.B., "Introduction to Simulation and SLAM II".

Appendix I

Table 3 Results of Simulated Model for Phase III
Total number of trips = 1750

Sr. No	Phase Number	Run Number	Number of T.M.	Completion Time (Days)	Av. Waiting Time Per Trip (Min)	Av. Back Cycle Time (Min)	Av. Loading Time (Min)
1	Phase III	1 of 10	1	159.58	0	35.4	8.37
2	Phase III	2 of 10	1	158.92	0	35.2	8.35
3	Phase III	3 of 10	1	161.08	0	36	8.2
4	Phase III	4 of 10	1	160.17	0	35.7	8.24
5	Phase III	5 of 10	1	158.40	0	35	8.46
6	Phase III	6 of 10	1	161.63	0	36	8.35
7	Phase III	7 of 10	1	158.88	0	35.3	8.23
8	Phase III	8 of 10	1	159.88	0	35.5	8.4
9	Phase III	9 of 10	1	157.75	0	34.9	8.37
10	Phase III	10 of 10	1	157.29	0	34.8	8.3
	AVERAGE			**159.36**	**0.00**	**35.38**	**8.327**
11	Phase III	1 of 10	3	55.94	2.06	35.7	8.35
12	Phase III	2 of 10	3	56.23	2.175	35.8	8.225
13	Phase III	3 of 10	3	55.48	2.136	35.1	8.214
14	Phase III	4 of 10	3	55.60	2.059	35.4	8.341
15	Phase III	5 of 10	3	56.13	2.17	35.6	8.33
16	Phase III	6 of 10	3	56.60	2.148	36.1	8.352
17	Phase III	7 of 10	3	55.13	2.096	35	8.304
18	Phase III	8 of 10	3	55.69	2.165	35.2	8.435
19	Phase III	9 of 10	3	55.46	2.346	34.9	8.354
20	Phase III	10 of 10	3	55.31	2.177	35	8.323
	AVERAGE			**55.76**	**2.152**	**35.38**	**8.3226**
21	Phase III	1 of 10	4	43.54	3.07	35.7	8.93
22	Phase III	2 of 10	4	43.65	3.95	35.6	8.35
23	Phase III	3 of 10	4	43.21	4.049	34.9	8.451
24	Phase III	4 of 10	4	43.51	3.748	35	8.252
25	Phase III	5 of 10	4	43.90	3.558	36.3	8.242
26	Phase III	6 of 10	4	43.77	4.021	35.5	8.479
27	Phase III	7 of 10	4	43.08	3.77	35.2	8.23
28	Phase III	8 of 10	4	43.50	3.799	35.5	8.401
29	Phase III	9 of 10	4	43.00	4.257	34.4	8.443
30	Phase III	10 of 10	4	43.06	3.29	35.3	8.71
	AVERAGE			**45/92**	**3.7512**	**35.34**	**8.4488**
31	Phase - III	1 of 10	5	36.77	6.946	34.9	8.454
32	Phase - III	2 of 10	5	36.67	6.556	35.4	8.344
33	Phase - III	3 of 10	5	36.54	6.548	35.1	8.152
34	Phase - III	4 of 10	5	36.27	6.338	35.0	8.362
35	Phase - III	5 of 10	5	36.98	6.408	36.0	8.292
36	Phase - III	6 of 10	5	37.02	6.875	35.4	8.425
37	Phase - III	7 of 10	5	36.25	6.658	34.8	8.342
38	Phase - III	8 of 10	5	36.81	6.381	35.6	8.419
39	Phase - III	9 of 10	5	36.54	6.289	35.5	8.211
40	Phase - III	10 of 10	5	36.29	6.445	35.0	8.255
	AVERAGE			**36.63**	**6.5444**	**35.27**	**8.3256**
41	Phase - III	1 of 10	6	33.15	10.684	35.4	8.336
42	Phase - III	2 of 10	6	32.81	9.994	35.6	8.306
43	Phase - III	3 of 10	6	32.96	10.813	35.9	8.387

44	Phase - III	4 of 10	6	32.83	10.614	35.0	8.386
45	Phase - III	5 of 10	6	33.00	10.114	35.8	8.286
46	Phase - III	6 of 10	6	33.38	10.805	35.6	8.395
47	Phase - III	7 of 10	6	32.85	10.826	35.8	8.374
48	Phase - III	8 of 10	6	32.85	9.872	35.8	8.328
49	Phase - III	9 of 10	6	32.75	9.941	35.6	8.259
50	Phase - III	10 of 10	6	32.44	9.933	35.1	8.267
	AVERAGE		**6**	**32.90**	**10.3576**	**35.58**	**8.3324**
51	Phase - III	1 of 10	7	31.25	16.1	35.5	8.3
52	Phase - III	2 of 10	7	31.08	15.874	35.4	8.526
53	Phase - III	3 of 10	7	31.42	16.947	35.3	8.453
54	Phase - III	4 of 10	7	31.08	16.205	35	8.395
55	Phase - III	5 of 10	7	31.15	15.64	35.7	8.36
56	Phase - III	6 of 10	7	31.52	16.447	35.4	8.453
57	Phase - III	7 of 10	7	30.98	16.103	35.1	8.197
58	Phase - III	8 of 10	7	31.38	16.095	35.7	8.405
59	Phase - III	9 of 10	7	30.90	15.371	35.4	9.229
60	Phase - III	10 of 10	7	30.58	15.053	35.3	8.247
	AVERAGE			**31.13**	**15.9835**	**35.38**	**8.4565**
61	Phase - III	1 of 10	9	30.52	31.29	35.6	8.31
62	Phase - III	2 of 10	9	30.38	31.017	35.5	8.383
63	Phase - III	3 of 10	9	30.38	32.866	34.7	8.534
64	Phase - III	4 of 10	9	30.71	32.455	34.8	7.745
65	Phase - III	5 of 10	9	30.23	30.178	35.9	8.322
66	Phase - III	6 of 10	9	30.96	32.267	35.4	8.533
67	Phase - III	7 of 10	9	30.46	31.758	34.8	8.342
68	Phase - III	8 of 10	9	30.52	31.153	35.6	8.347
69	Phase - III	9 of 10	9	30.15	30.399	35.5	8.31
70	Phase - III	10 of 10	9	30.13	30.64	35.2	8.26
	AVERAGE			**31.13**	**31.4023**	**35.3**	**8.3077**