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# Forecast of Ready Mix Concrete Operation by Neural Network

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**Abstract**—In construction concrete place a major role, as the demand increases there is necessity for ready mix concrete (RMC) industry to cope up the demand. The Ready Mix Concrete (RMC) industry is growing due to the superior technical properties over normal concrete, but the potential is still huge. Concrete must be batched remotely and delivered to site by transit mixers. The productivity of ready mix concrete (RMC) placing is therefore of great important to the productivity improvement of the whole construction industry. An efficient RMC (Ready Mixed Concrete) delivering process becomes important to RMC batch plants. Because of time limitation of RMC delivery, the RMC plant manager usually needs to consider both timeliness and flexibility while matching up the working processes at various construction sites that call for RMC deliveries. Concrete production scheduling and truck dispatching is mainly handled manually by experienced RMC batching plants staff.
Various supply chain parameters detail of ready mix concrete (RMC) batching plant are considered for the prediction of productivity of the plant. This thesis provides an alternative way of tool which is applied to ready mix concrete operations to analyze the utilization, assignment of production and transportation resources. Use of software based model using Artificial Neural Network enables the RMC operator and construction site to effectively utilize the delivery sequence for optimal performance.

## I. INTRODUCTION

The Ready Mix Concrete (RMC) industry in India is in its early stages with cement consumption of just 2-3 per cent of total production. It is very competitive and continuous improvement in the operation is essential for a ready mixed concrete producer to survive in this field. Productivity assessment is an important task in analyzing the effectiveness of the Concrete Batching Plant Operations (CBP). Concrete Batching Plant operations involve both Concrete Batching Plant and Transit Mixer operations together. Concrete Batching Plant owners have to produce the concrete and deliver their product to the site on time with minimum cost to keep their profit up in the competitive Ready Mixed Concrete industry.

The Ready Mix Concrete (RMC) industry is growing due to the superior technical properties over normal concrete, but the potential is still huge. Concrete Batching Plant owners have to produce the concrete and deliver their product to the site on time with minimum cost to keep their profit up in the competitive Ready Mixed Concrete industry. The time taken by Transit Mixer to deliver and return can be measured as part of the productivity assessment. The time taken by Transit Mixer to deliver and return can be measured as part of the productivity assessment. The Cycle time of a Transit Mixer is affected by many factors in Concrete Batching Plant operations, distance, Traffic conditions, etc.,

Cycle time of a Transit Mixer can be forecasted using the Artificial Neural Network (ANN). Cycle time predictive models can be developed using Regression and Correlations techniques, Monte-Carlo Simulation, Experts and Multi Criteria Decision making models. Essentially all these models require to assume the interrelationship between the factors before analyzing. Artificial Neural Network does not require any prior interrelationships to be assumed between the factors.

Artificial Neural Networks are very useful because of their functional mapping properties and ability to learn the relationships between the factors by learning the examples. Artificial Neural Network Systems has been found to be effective in the past studies than any other modeling techniques while there is no definite relationship can be derived between the factors. Since the relationship between the factors influencing the cycle time of a transit mixer is difficult to predict, Artificial Neural Network can be a best system to create the model to forecast the cycle time of a Transit mixer.

## II. DATA COLLECTION

The concrete batching plant situated in Chennai and was selected. These plants will have a large quantity of orders which will help to collect a large quantity of data from the concrete batching plant and construction site. This data collection includes the transit mixture trip details were collected and each trip details contain the following information, Concrete Type, Distance to Site, Truck Load, Concrete Pump Capacity, Time of Transportation (Plant outward, Site in, Site out). These data are collected for a few months by direct visit to the ready mix batching plant in personal.
Ramco ready mix concrete plants was identified, about 800 trip details were collected and each trip details contain the following information, Concrete Type, Distance to Site, Truck Load, Concrete Pump Capacity, Time of Transportation (Plant outward, Site in, Site out). The data collected sample are shown in the fig. 1



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**RAMCO READY MIX CONCRETE PLANT**
**Productivity-(NOV2016)**

Site: thiruvanmiyur

Member: 1st slab

Pump: SP1800

Grade: m20

Quantity intended (m3):25

Quantity supplied (m3):25

Date: 1.11.16

| site | no of mixers | Quantity (cu.m) | | Production time(hrs) | Received time(hrs) | pumping | | admixture | Slump (mm) |
|---|---|---|---|---|---|---|---|---|---|
| | | Each mixer | cumulative | | | Starting (hrs) | Finishing (hrs) | | |
| 1 | 4 | 6.5 | 6.5 | 3.44 | 4.30 | 4.40 | 4.55 | - | 120 |
| | | 6.5 | 13 | 4.03 | 4.50 | 5.00 | 5.15 | - | |
| | | 6 | 19 | 4.24 | 5.50 | 5.20 | 5.35 | - | |
| | | 6 | 25 | 4.43 | 5.30 | 5.35 | 6.00 | - | |

Site: Velachery

Member: column

Pump: SP1800

Grade: m40/m25

Quantity intended (m3):1/8.5

Quantity supplied (m3):1/8.5

Date: 1.11.16

| site | no of mixers | Quantity (cu.m) | | Production time(hrs) | Received time(hrs) | pumping | | admixture | Slump (mm) |
|---|---|---|---|---|---|---|---|---|---|
| | | Each mixer | cumulative | | | Starting (hrs) | Finishing (hrs) | | |
| 2 | 4 | 1 | 1(m40) | 13.34 | 14.15 | 14.30 | 15.12 | 100(ml) | 100 |
| | | 3 | 3(m25) | 14.17 | 14.45 | 1.25 | 16.32 | 250(ml) | 115 |
| | | 3 | 6 | 16.11 | 16.50 | 16.50 | 17.50 | | |
| | | 2.5 | 8.5 | 17.22 | 17.57 | 17.57 | 19.15 | | |

Figure 1: Sample Data Collection in Ramco Ready Mix Concrete Plant

## III. STATISTICAL ANALYSIS

This is useful in finding out the relationship between the variables and also this can be used to find out the existence of linear relationship between the variables.

Statistical analysis is primarily done in this project to list out the critical factors that has to be considered for the neural network analysis.

Statistical analysis has been done on the collected sample data set. The sample data feed in SPSS is shown in fig 2. Correlation Coefficient between the input variables and output variables are analyzed and results showed that there is a strong relationship between hauling distance and the total time to deliver a concrete.

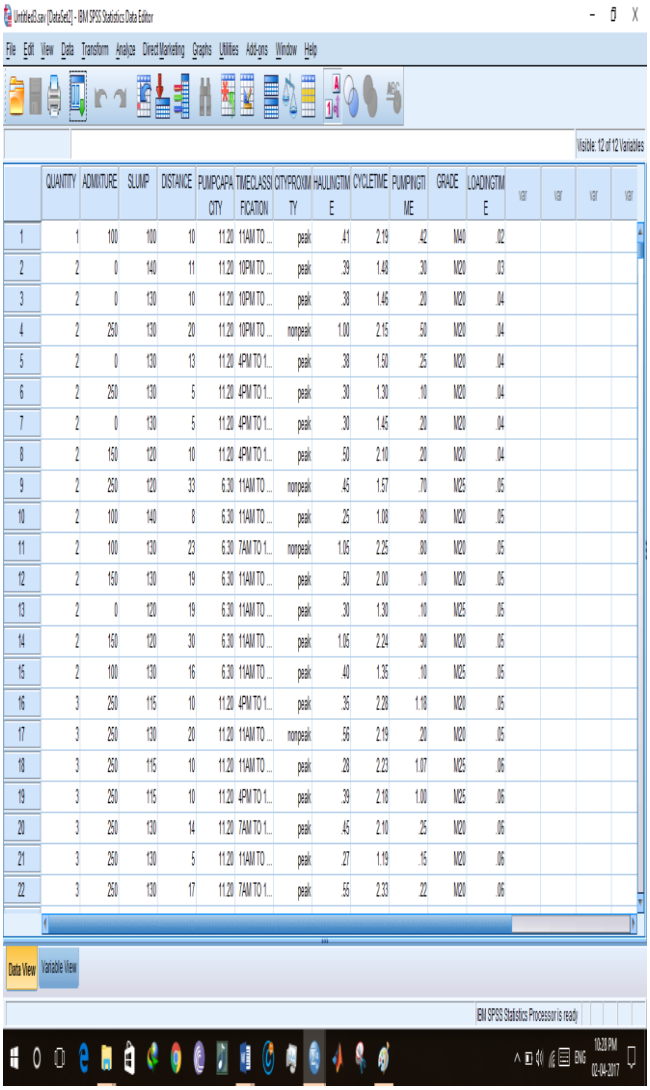


Figure2: sample data feed in SPSS

## A. CORRELATION COEFFICIENT ANALYSIS

Pearson Correlation Coefficient is found between the two 'Scale' type variables and the results are listed below.

Correlation coefficient has been found out between the following variables combinations to identify whether there is relationship exists between them.

- Distance Vs Hauling Time
- Pump Capacity Vs Unloading Time
- Slump Vs Unloading Time
- Grade Vs Cycle Time
- Truck Quantity Vs Loading Time

**Distance Vs Hauling Time**

Distance means the distance of construction site from the concrete batching plant. The results is as follows,

Rural region

- Correlation Coefficient – 0.625
- Significance Level – 0.000

Metropolitan region

- Correlation Coefficient – 0.137
- Significance Level – 0.000



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It shows that there is relationship exists between distance and Hauling time.

**Pump Capacity Vs Unloading Time**

Pump capacity means the capacity of pump used for concreting operations.
The result is as follows,
Rural region
- Correlation Coefficient – 0.037
- Significance Level – 0.511

Metropolitan region
- Correlation Coefficient – 0.223
- Significance Level – 0.000

It shows there is moderate relationship exists between unloading time and the pump capacity.

**Slump Vs Unloading Time**

Unloading time is the time taken to unload the concrete in site. The time spent by transit mixer at site. Slump is the slump value of concrete at site.
The result is as follows,

Rural region
- Correlation Coefficient – 0.075
- Significance Level – 0.187

Metropolitan region
- Correlation Coefficient – 0.017
- Significance Level – 0.623

It shows that there is no relationship exists between Unloading time and Slump value.

**Grade Vs Loading Time**
Grade means the grade of concrete being delivered.
The result is as follows,
Rural region
- Correlation Coefficient – 0.006
- Significance Level – 0.920

Metropolitan region
- Correlation Coefficient – 0.119
- Significance Level – 0.001

It shows that there is moderate relationship exists between Concrete grade and Cycle time.

**Quantity of Truck Load Vs Loading Time**

Loading time is the time taken to load the transit mixer at concrete batching plant and the Quantity of truck load means the quantity of concrete carried in the transit mixer. The correlation result between these two variables is as follows,
Rural region
- Correlation Coefficient – 0.995
- Significance Level – 0.000

Metropolitan region
- Correlation Coefficient – 0.953
- Significance Level – 0.000

It shows that there is strong relationship exists between loading time and the quantity of truck load.

**B.T-TEST ANALYSIS**
T test analysis is undertaken for finding out the correlation between the 'Nominal' type input variables and 'Scale' type output variables. The relationship between the variables are finalized using the significance level.

T – Test analysis has been done for the following combinations of variables to identify whether there is relationship exist between them, the combinations of variables for t-test are,

- Time of Transportation Vs Hauling Time
- Hauling Time Vs Proximity to City

**Time of Transportation Vs Hauling Time**

Time of transportation means the concrete is delivered at peak traffic time or non-peak time and the hauling time is the time taken by a Transit-Mixer to reach the construction site from batching plant.
The results of the t-test between Time of Transportation and hauling time is as follows,
Rural region
- T value – 37.554
- Significance – 0.000

Metropolitan region
- T value – 32.947
- Significance – 0.000

Since the significance level is 0.000, it can be assuming that the hauling time varies depends on the time of transportation.

**Hauling Time Vs Proximity to City**

Proximity to city means whether the transit mixer has to cross the city limit while delivering the concrete to the site. The t-test has been carried out for various combinations of variables and the results are tabulated as follows.

Table 1: Hauling Time Vs Proximity to City

| Peak/ Non-Peak | Significance level of Hauling time with proximity to City | Relationship Status |
|---|---|---|
| Peak/ Non-Peak | 0.000 | Hauling time varies depend on Proximity to City |
| Peak | 0.000 | Hauling time varies depend on Proximity to City |
| Non-Peak | 0.000 | Hauling time varies depend on Proximity to City |

## IV. ARCHITECTURE OF THE NEURAL NETWORK

The architecture used in this study is a fully connected two-layer Feed Forward network with Sigmoid Hidden neurons and Linear Output neurons



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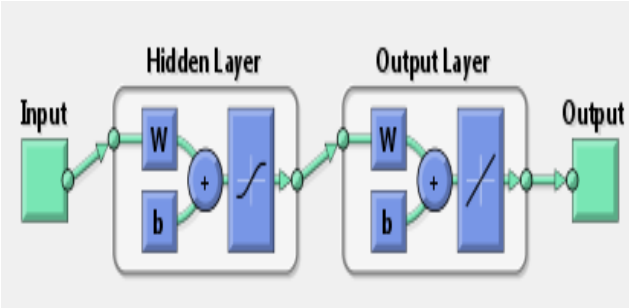


Figure 3:Levenberg–Marquardt Algorithm Architecture

**A. VARIABLES TO BE INCLUDED IN MODELLING:**

There were totally thirteen variables collected. The following variables were selected for neural network modeling based in the results of the statistical analysis.

The input variables are,

- Distance to Site from Plant
- Pump Capacity
- Truck Load
- Time of Transportation
- Proximity to City

The Output variables are,

- Loading Time
- Hauling Time
- Unloading Time
- Cycle Time

**B. DEVELOPMENT OF NEURAL NETWORK MODEL**

For this study a model with 5 neurons in Input layer and 4 neurons in Output layer have been developed with one hidden layer. To arrive at the optimum neural network model, the number of neurons in the hidden layer is varied from 5 to 26 and the results were analyzed.

Hundreds of neural network models have been developed during this training /testing of this project. The best model can be selected based on the R value (R values ranges between 0 to 1. One (1) means a close relationship, 0 means a random relationship).

The available data was fed into MATLAB neural network toolbox and the models were developed. The data allocation in neural network model development is 70%, 15% and 15% for Training, Validation and testing respectively.

The best model achieved was shown below. The correlation coefficient for the models prediction and the actual target is 0.98406 (1 means good relationship, o means no relationship).

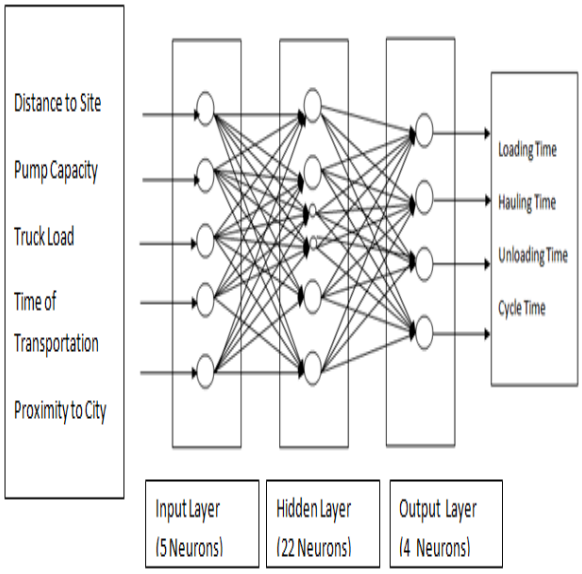


Figure 4: Neural Network Model

The regression result of the neural network model is shown below

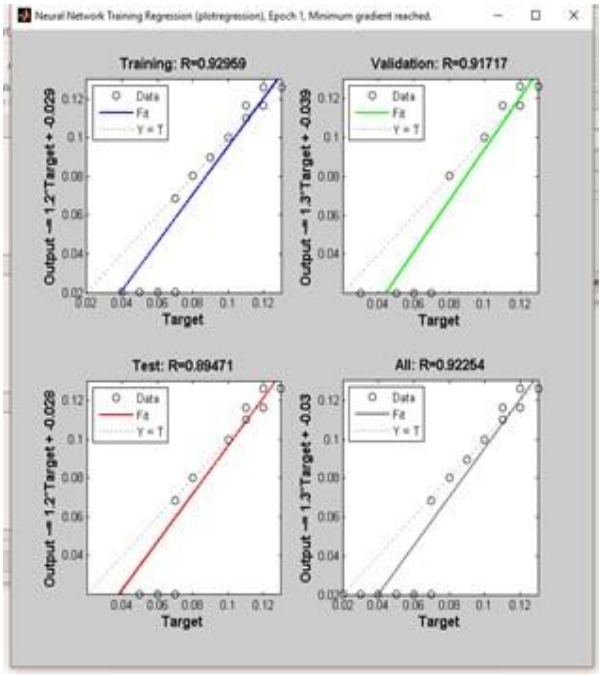


Figure 5: Regression Result Loading Time



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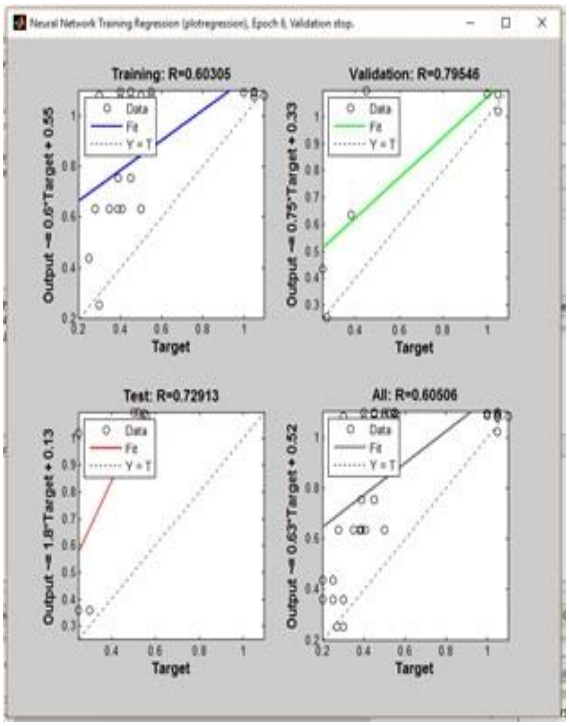


Figure 6: Regression Result Hauling Time

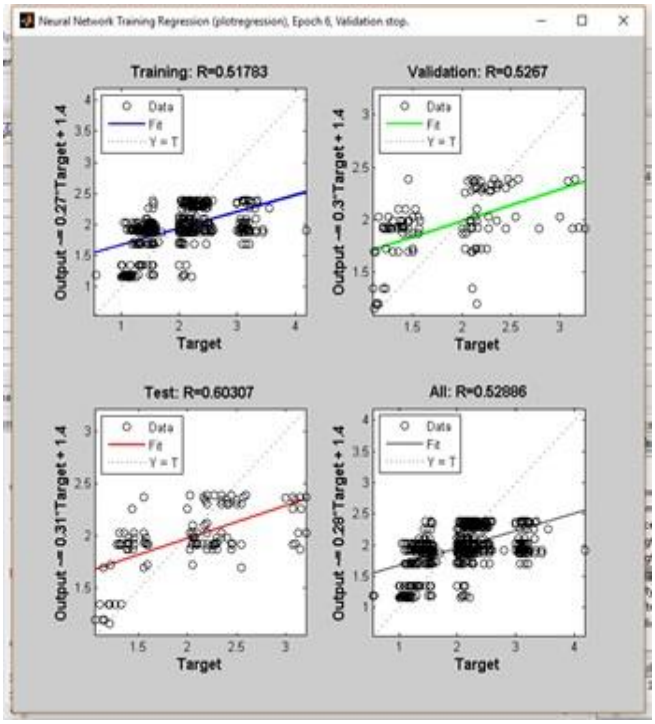


Figure 8: Regression Result Cycle Time

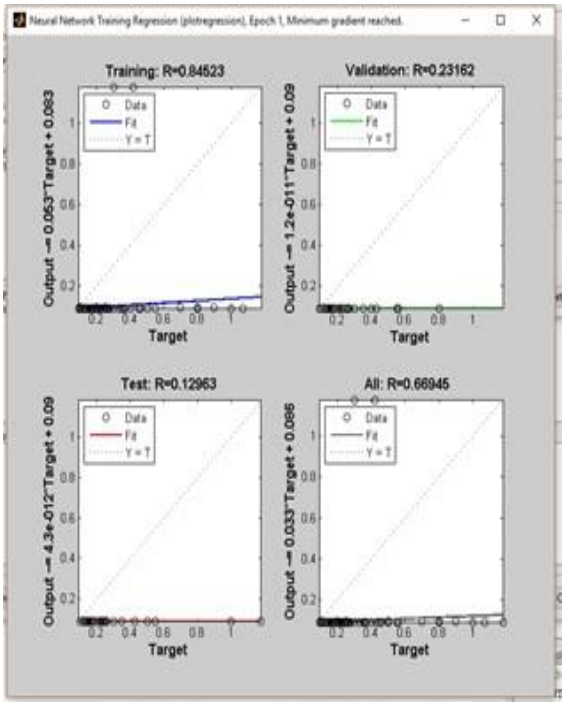


Figure 7: Regression Result Unloading Time

Table 2:Neural network model validation

| quantity (cu.m) | distance (kms) | Pump cpacity | Time classification | City proximity | hauling time (hrs) | | cycle time (hrs) | | Loading time (hrs) | | pumping time (hrs) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Actual | ANN | Actual | ANN | Actual | ANN | Actual | ANN |
| 2 | 11 | 6 | 2 | 1 | 0.30 | 0.46 | 1.30 | 1.57 | 0.05 | 0.05 | 0.10 | 0.06 |
| 2 | 12 | 6 | 3 | 1 | 0.35 | 0.48 | 1.30 | 1.57 | 0.05 | 0.05 | 0.10 | 0.06 |
| 2 | 18 | 6 | 3 | 1 | 0.50 | 0.56 | 1.50 | 1.70 | 0.05 | 0.05 | 0.08 | 0.05 |
| 2 | 15 | 6 | 2 | 1 | 0.50 | 0.56 | 2.00 | 2.02 | 0.05 | 0.05 | 0.10 | 0.06 |
| 2 | 29 | 11 | 2 | 2 | 1.05 | 0.85 | 2.24 | 2.17 | 0.05 | 0.05 | 0.09 | 0.05 |
| 2 | 30 | 11 | 2 | 2 | 0.52 | 0.57 | 2.09 | 2.08 | 0.05 | 0.05 | 0.10 | 0.06 |
| 2 | 19 | 6 | 2 | 1 | 0.45 | 0.53 | 1.50 | 1.70 | 0.05 | 0.05 | 0.12 | 0.07 |
| 2.5 | 22 | 6 | 2 | 1 | 0.50 | 0.56 | 2.00 | 2.02 | 0.06 | 0.06 | 0.10 | 0.06 |
| 2.5 | 23 | 11 | 3 | 2 | 0.38 | 0.50 | 1.51 | 1.71 | 0.06 | 0.06 | 0.25 | 0.14 |
| 2.5 | 18 | 11 | 2 | 1 | 1.05 | 0.85 | 2.27 | 2.19 | 0.06 | 0.06 | 0.07 | 0.04 |
| 3 | 9 | 6 | 3 | 1 | 0.20 | 0.40 | 1.05 | 1.41 | 0.07 | 0.07 | 0.10 | 0.06 |
| 3 | 20 | 6 | 2 | 1 | 0.45 | 0.53 | 1.50 | 1.70 | 0.07 | 0.07 | 0.10 | 0.06 |

The developed model has been tested by simulation. The inputs were supplied and the outputs were predicted using the developed neural network model. The following table shows the comparison between the actual output values and the values predicted developed neural network model.
The following graphs show the comparison between the actual output values and predicted output values



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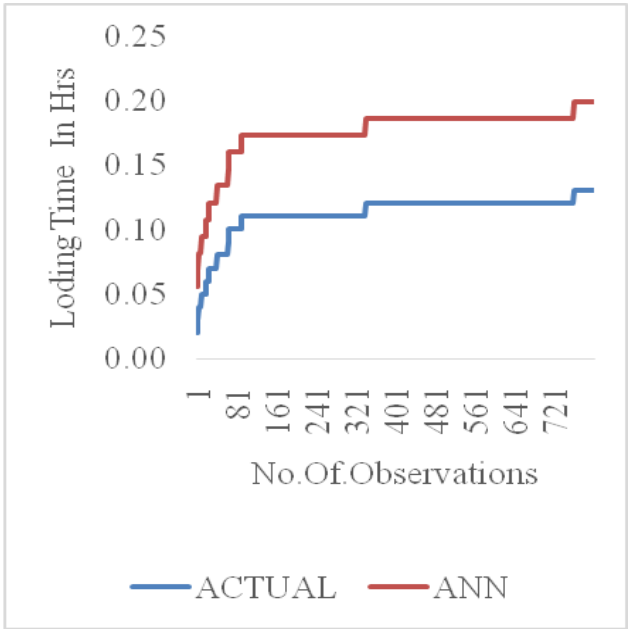


Figure 9:Comparison between Loading Time Actual VS Loading Time ANN

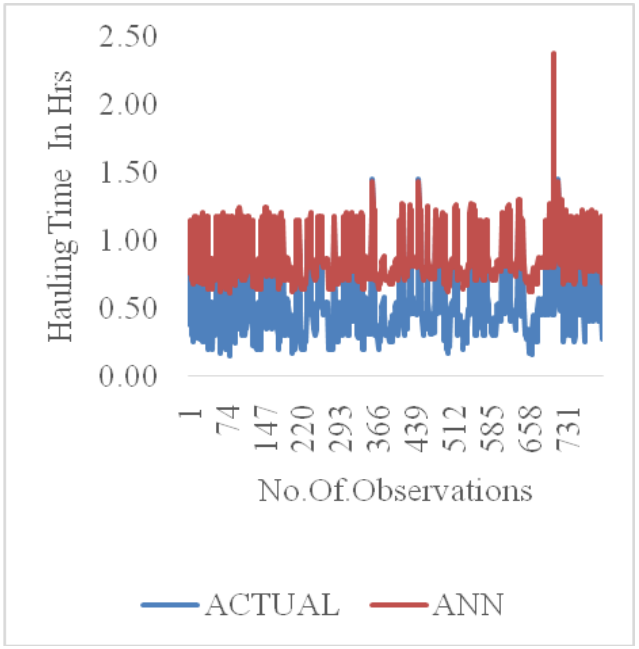


Figure 10: Comparison between Hauling Time Actual VS Hauling Time ANN

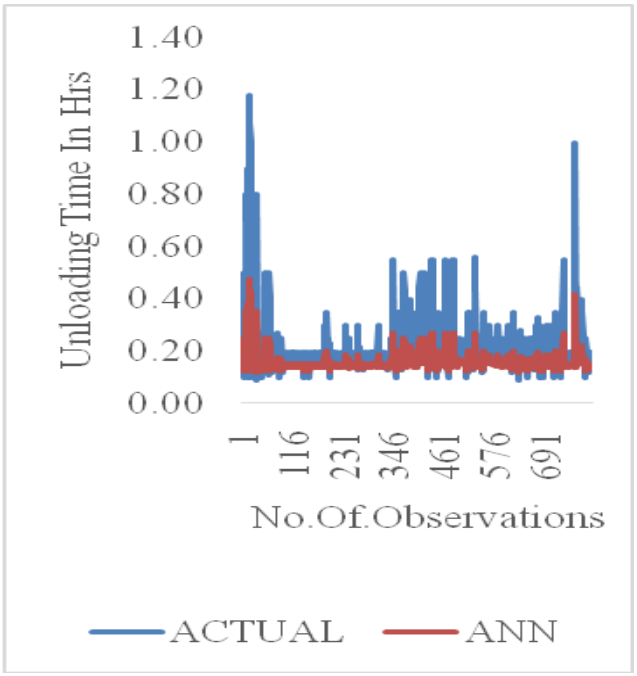


Figure 11: Comparison between Unloading Time Actual VS Unloading Time ANN

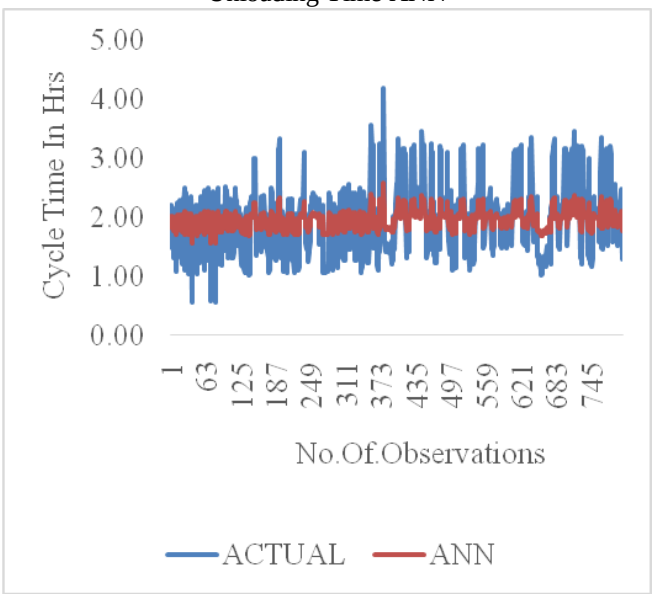


Figure 12: Comparison between Cycle Time Actual VS Cycle Time ANN – Metropolitan Region

The compassion between Actual and ANN from the output of neural network model is showed below

- Comparison between Loading Time Actual VS Loading Time ANN shows the Peak variation of time 0.13 vs 0.20
- Comparison between Hauling Time Actual VS Hauling Time ANN shows the Peak variation of time 1.45 vs 2.38.
- Comparison between Unloading Time Actual VS Unloading Time ANN shows the Peak variation of time 1.18 vs 0.48.
- Comparison between Cycle Time Actual VS Cycle Time ANN shows the Peak variation of time 4.18 vs 2.57.



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The values predicted by the developed neural network model are compared with the actual outputs and the average validity percentage of the forecast is done using the following analytical model (Zayed*et. al.*, 2005).

$$AIP = \left(\sum_{i=0}^{n} \left|1 - \left(\frac{Ei}{Ci}\right)\right|\right)/n \quad (1)$$

$$AVP = 1 - AIP \quad (2)$$

Where,
AIP = Average Invalidity Percent for validation data set
AVP = Average Validity Percent for validation data set
$E_i$ = Estimated Output Variable's value by ANN for data point i
$C_i$ = Actual Output Variable's value for data point i
n = Number of data points, i = data points
The Average Validity Percentage and the Average Invalidity Percentage for all the output variables are listed in the following

Table 3: Average Invalidity Percentage

| S.NO | OUTPUT | AVP |
|---|---|---|
| 1 | Loading Time | 99.9 |
| 2 | Hauling Time | 99.9 |
| 3 | Unloading Time | 99.9 |
| 4 | Cycle Time | 99.9 |

All the variables are predicted by ANN with the accuracy of above 90%. The cycle time of the transit mixer can be predicted with 94% accuracy. Since the Average Invalidity Percentage for all the output variables are less than 10 % the model can be adopted for transit mixer cycle time forecasting.

## V. RESULT AND DISCUSSION

### A. GENERAL

Ready mix concrete operation for different values of different variables is forecasted using the development of neural network model. In this analysis was forecasted for loading time, hauling time, unloading time, and cycle time.

There is a lot of variation in the cycle time of transit mixer for various distances is forecasted for the following combinations of values of different variables

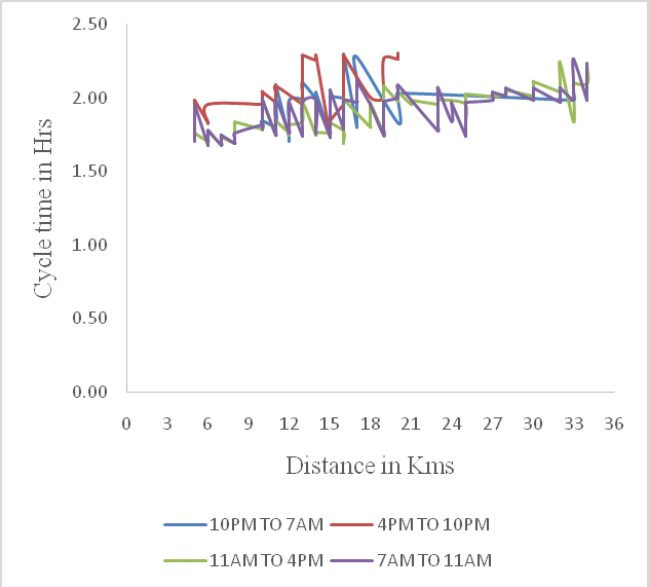


Figure 12: Distance VS Cycle time with the time of transportation

### B. DISCUSSIONS

The Cycle Time of Transit mixer for each trips were forecasted for the difference trips in between 7AM TO 11AM there is lot of variation in transportation time.

Statistical analysis was done by Statistical package for the social sciences and the relations between operation of ready mix concrete is showed

- There is relationship exists between distance and hauling time.
- There is moderate relationship exists between unloading time and the pump capacity.
- There is no relationship exists between Unloading time and Slump value
- There is moderate relationship exists between Concrete grade and Cycle time.
- There is strong relationship exists between loading time and the quantity of truck load.
- The hauling time varies depends on the time of transportation.
- Hauling time varies depend on Proximity to City.
- Neural network model was created using MATLAB for two regions and the actual and Artificial Neural Network (ANN) were compared.
- In the metropolitan region of Chennai, there is a lot of variation in between Cycle Time Actual VS Cycle Time ANN.

The Average Invalidity Percentage for all the output variables are less than 10 % the model can be adopted for transit mixer cycle time forecasting



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## VI. CONCLUSION

- Factors influencing the Cycle Time of the Transit mixer are identified. The list of factors are,
- Loading time and Unloading time depends on the concrete quantity being transported in Transit Mixer. Loading Time and Unloading Time increases for larger quantity and vice versa.
- Hauling Time increases with distance and vice versa.
- Transportation Time (Peak or Non-Peak) is more during the peak hours especially for the trips going inside the city limits.
- Unloading time is less when the Concreting is done using Concrete Pumps than manual concreting.
- Transportation Time is more for the trips going inside the city limits.
- Concreting operation in the city region are carried out in the night time. Carrying out the concreting activity during the night time for the sites within the city limit saves lot of time.
- The loading time in the metropolitan area was to be monitored to obtain maximum efficiency.
- The route of the transit mixer shall avoid the arterial roads if possible to avoid the delay.

There is variation in pumping of concert in between city and rural region. In the rural area pumping of concrete were to be monitored to obtain maximum efficiency.

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