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# Cash Flow Analysis of Construction Project Using Artificial Neural Networks

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***Abstract-*** Cash shortage is one of the most dangerous problems that may appear while projects are in progress. Inadequate cash flows force the companies to take short term or long term loans and in some cases companies end up being bankruptcy. In this study the planned and actual cumulative percentages of cash flows and work progress which are represented using S-curves are used as the basis for analyzing cash flows using artificial neural networks. The planned and actual cash flows are imported to MATLAB and are trained using the developed cash flow analysis model. The results of this analysis will assist the contractor in identifying the down fall of the cumulative percentage of actual cash flows with respect to the percentage of the work completed based on which the contractor can manage the cash flows to maintain work continuity, prevent interruption of project and take precautions to protect the company from being bankruptcy.

***Keywords-*** cash flow, cash flow analysis, Artificial Neural Network

## I. Introduction

Although there are various reasons of business failure, according to many construction management researchers the main reasons of the bankruptcy of the construction companies is the inefficient control and management of cash. The aim of this study is to develop an integrated cost schedule cash flow analysis model using S-curves and artificial neural network techniques and to assist the contractor in analyzing the actual cash flows of the project by obtaining a reliable cash flow analysis model which considers the planned and actual S-curves of cumulative cost versus time percentages.

## II. Methodology

Cash flow analysis is also called as the way of developing the cash budget as it assists in analyzing the down fall of cash flows. In construction industry cash flow analysis of a project is done using S-curves [1&2].

### A. *Cash Flow Analysis for Construction Project*

To generate s-curves baseline schedule and production schedule are generated in MS Project professional. The schedule data of the considered project is exported to MS Excel and the outputs are generated as base line s-curves and production s-curves [3&4]. The baseline s-curves are generated to represent the baseline man hours and time whereas the production s-curves are developed for targeted and actual man hours and time. A baseline schedule is required to generate a baseline s-curve and the calculations are performed for each task and all tasks and the results of these calculations are graphed as base line s-curve representing time versus man hours or cost. The production schedules is required to generate actual and target s-curves using production schedule and the calculations are performed for each task and all tasks and the results of these calculations are graphed as actual and target s-curves representing time versus man hours or cost. The generated percentage s-curves are used to analyze important project benchmarks on an ongoing basis which include Project percentage growth, Project percentage slippage, Actual percentage complete against target percentage complete to date and actual percentage complete against baseline percentage complete to date [5&6].

### B. *Cash Flow Analysis Model Using Artificial Neural Networks*

The cash flow analysis using artificial neural network techniques is done using MATLAB software as a platform. This model is developed using the GUIs and neural network tool box for a function fitting problem. The model is developed as shown in Fig.1. The first stage is to define the inputs and targets for neural networks, the second stage is to create a neural network, the third stage is to configure network parameters, the fourth stage is to configure training parameters, the fifth stage is to train the network and the final (sixth) stage is to see the plots and analyze the results of neural network and the given targets [7].

## III. Application of Case Study

The case study considered for this study is Villascapes which is located at Gandipet, Hyderabad. The cash flows and S-curves of planned and actual cumulative work progress and cost of the 49 villas of the villascapes project are considered as the main data for the case study. The cash flows that are generated are in cumulative percentages of planned progress of work to the cumulative planned cost percentage to be spent. Table 1 shows the planned cash flows of the 49 villas.

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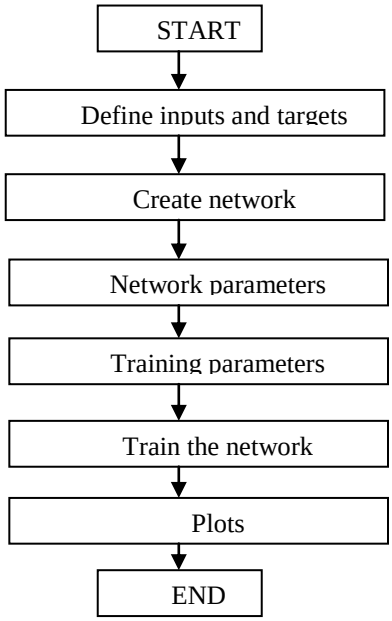


Fig.1 Flow chart of cash flow analysis model

Table 1 Planned cash flow of 49 villas

| Sl.No. | 1M | 2M | 3M | 4M | 5M | 6M | 7M | 8M | 9M | 10M | 11M | 12M | 13M | 14M | 15M | 16M | 17M | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months | Nov-10 | Dec-10 | Jan-11 | Feb-11 | Mar-11 | Apr-11 | May-11 | Jun-11 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Nov-11 | Dec-11 | Jan-12 | Feb-12 | Mar-12 | Total |
| Planned Cash Flow Percentages | | | | | | | | | | | | | | | | | | |
| Planned Percentage | 0.65 | 2.59 | 4.75 | 5.87 | 8.55 | 11.91 | 13.92 | 14.74 | 12.28 | 9.73 | 7.78 | 4.41 | 2.05 | 0.75 | | | | 100 |
| % Planned Cumulative | 0.65 | 3.25 | 8.00 | 13.87 | 22.42 | 34.33 | 48.26 | **62.99** | 75.28 | 85.01 | 92.79 | 97.20 | 99.25 | 100.00 | | | | |

The planned S- curves and cash flows for the 49 villas are generated using excel sheets. The planned S-curves for 49 villas are shown in Fig. 2.

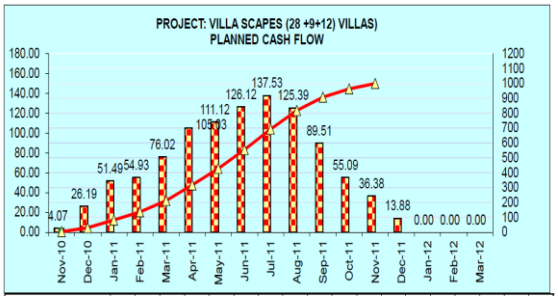


Fig. 2 Planned s-curves of 49 villas

The actual cash flows are generated using excel sheets for the 49 villas. The cash flows that are generated are in cumulative percentages of actual progress of work to the cumulative actual cost percentage to be spent. The duration is considered as 8 months for the actual cash flows for the reason that the percentage of actual work progress is 8 months. Table 2 shows the actual cash flows of the 49 villas.

Table 2 Actual cash flows of 49 villas

| Sl.No. | 1M | 2M | 3M | 4M | 5M | 6M | 7M | 8M | 9M | 10M | 11M | 12M | 13M | 14M | 15M | 16M | 17M | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months | Nov-10 | Dec-10 | Jan-11 | Feb-11 | Mar-11 | Apr-11 | May-11 | Jun-11 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Nov-11 | Dec-11 | Jan-12 | Feb-12 | Mar-12 | Total |
| Actual Cash Flow Percentages | | | | | | | | | | | | | | | | | | |
| Actual Percentage | 0.57 | 1.72 | 2.87 | 3.79 | 5.17 | 5.74 | 6.31 | 6.89 | | | | | | | | | | |
| % Actual Cumulative | 0.57 | 2.30 | 5.17 | 8.95 | 14.12 | 19.86 | 26.17 | **33.06** | | | | | | | | | | |
| Cumulative % Variance | -0.08 | -0.95 | -2.84 | -4.91 | -8.30 | -14.47 | -22.08 | **-29.94** | | | | | | | | | | |

The actual S- curves and cash flows for the 49 villas are generated using excel sheets. The actual S-curves are generated for work progress and cost percentages considering duration of 8 months for the reason that the percentage of actual work progress is 8 months. The planned and actual S-curves for 49 villas are shown in Fig. 3.

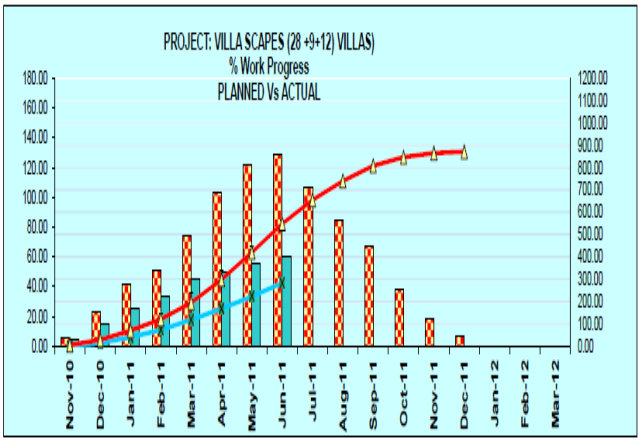


Fig. 3. Planned Vs actual s-curves of 49 villas

## A. *Defining Inputs and Targets*

The inputs and targets to be given for the neural network are the planned cash flows and actual cash flows that are considered as the main data for the case study. The inputs are the planned cash flows and the targets are the actual cash flows. It is given that the planned cash flows and actual cash flows are generated on excel sheets. Table 3 (a) shows the planned cash flows Table 3 (b) shows the actual cash flows All the values are in percentages which will become decimals after importing to MATLAB. After importing into the workspace the data is used for the further steps in the neural network technique.

Table 3 Inputs and Targets for cash flow analysis model

| Work Progres(%) | Cumulative Cost (%) |
|---|---|
| 0.65 | 0.65 |
| 2.59 | 3.25 |
| 4.75 | 8.00 |
| 5.87 | 13.87 |
| 8.55 | 22.42 |
| 11.91 | 34.33 |
| 13.92 | 48.26 |
| 14.74 | 62.99 |
| 12.28 | 75.28 |
| 9.73 | 85.01 |
| 7.78 | 92.79 |
| 4.41 | 97.20 |
| 2.05 | 99.25 |
| 0.75 | 100 |

(a)

| Work Progres(%) | Cumulative Cost (%) |
|---|---|
| 0.57 | 0.57 |
| 1.72 | 2.30 |
| 2.87 | 5.17 |
| 3.79 | 8.95 |
| 5.17 | 14.12 |
| 5.74 | 19.86 |
| 6.31 | 26.17 |
| 6.89 | 33.06 |

(b)

## B. *Creating the Network*

The type of network is by default a feed forward network when the neural network fitting tool is used. The learning parameters of the network include the tolerance limit, performance display at the selected number of interval, learning rate and the number of epochs. The hidden layer size is set 5, the performance display is set to 50 epochs, the learning rate is set to 0.05, the number of epochs is set to 1000 and the tolerance limit is set as 1e-8. The training of the network is stopped when either the tolerance limit is reached or the epochs or completed. The training function used is levenberg-marquardt back propagation training function. The performance function is mean square error. The dividing function used for the division of data for training, testing and validating is random dividing function. The dividing mode used is used is sample dividing mode which divides every sample of data. 70% of data is set for training, 15% of data is set for testing and 15% of data is set for validation using the dividing function and dividing mode.

## C. *Training the Network*

Once the network is created the neural network with 14 input layers, 5 hidden layers, 7 output layers and 8 outputs is also generated automatically in another new window. This is shown in Fig.4.

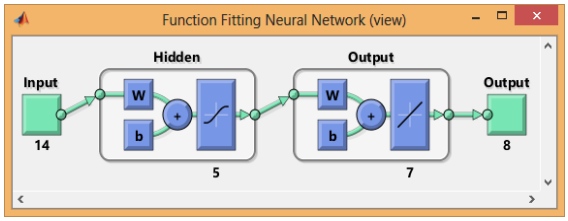


Fig. 4 Neural network diagram of the trained data set

If the results are not optimum the network can be retrained any number of times until the desired outputs are acquired. Retraining the network adjusts the weights every time when the network is retrained. For this case study the required results were achieved for the first training only. The network with weights of five hidden layers and their dot products is shown in Fig.5.

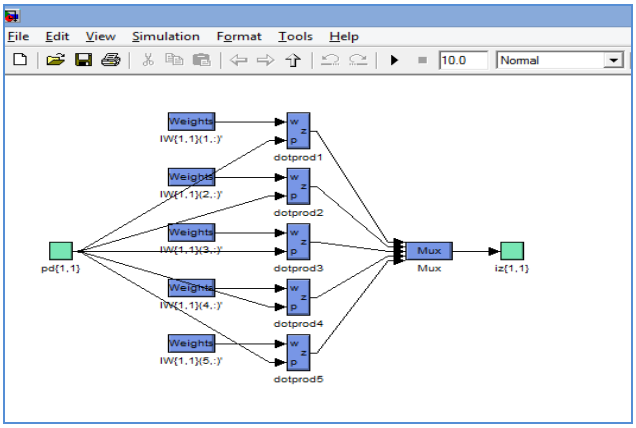


Fig. 5 Weights and dot product of the trained data set

## D. *Plots*

After the training is completed the mean squared error and regression are shown in the results pane of the network training and results window which is an auto generated window. Mean Squared Error (MSE) is the average squared difference between outputs and targets. Regression (R) values measure the correlation between outputs and targets. An R value of 1 means a close relationship, 0 means a random relationship. The mean squared error and regression values of the considered data of the case study are shown in the results pane of the Fig. 6. The training stopped when the tolerance limit is achieved. The tolerance limit is achieved at $5^{th}$ interval. The interval at which the best training performance is achieved is shown in the performance plot. This is shown in the Fig. 7. The response of the network can be analyzed from the regression plot. Regression means the correlation between the targets and outputs. The regression values are plotted on the regression plot which is shown in Fig. 8.

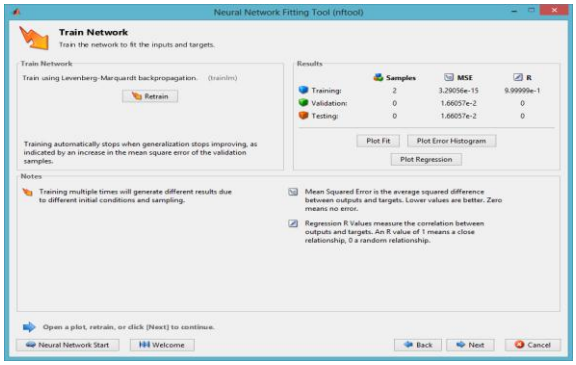


Fig. 6 Training and results of the imported

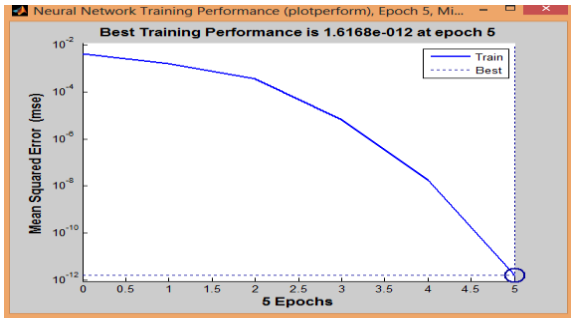


Fig. 7 Error performance plot of the trained data set

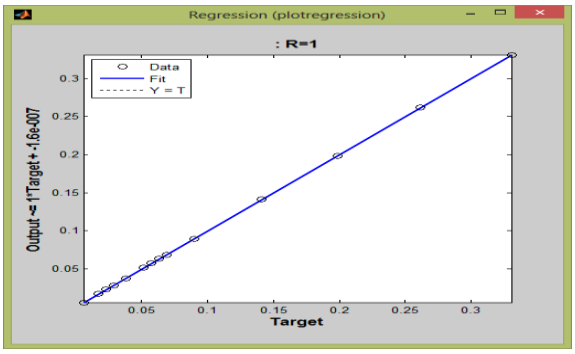


Fig. 8 Regression error plot of the trained data set

The outputs of the neural network and the errors between the targets and the outputs are shown in the Fig.9. The errors between the actual cash flows (targets) till the 8th month of the 49 villas of the considered case study are given by the developed cash flow analysis model. The errors are given for each target and output of the neural network and the histogram of each error are plotted in the error histogram plot. Each error is represented with respect to its iteration number or the instance at which the target is considered.

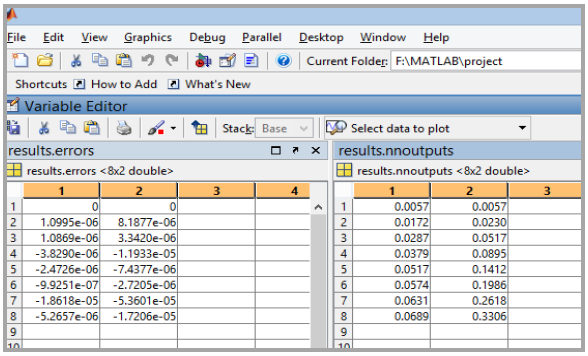


Fig.9 Neural network outputs and errors

## IV. Results

The mean square error of targets and outputs for training is 3.29, for validation is 1.6, for testing is 1.6. The mean square error for the training data is equal to the minimum retainage percentage of the contractor. The regression is zero for validation and testing. It is 0.99 for training. This shows that the inputs and outputs have a close relationship. The targets are fitted in almost a 45 degree line which shows that the fit is reasonably good for the case study. This is shown the regression plot. The zero error for training data is achieved at epoch 5.This is shown in the error histogram. The neural network outputs are almost equal to the targets. This shows that the actual cash flows are smooth till the 8th month of the project.

### A. *Comparison of Results*

The results of the artificial neural networks and the actual cash flows of 49 villas are compared to check the whether the actual cash flows are optimum are not. The comparison of the neural network outputs and the targets of the neural networks is shown in Fig. 10. From the figure it can be analyzed that the actual cash flows are correct as the error between the neural network outputs and the targets is very low.

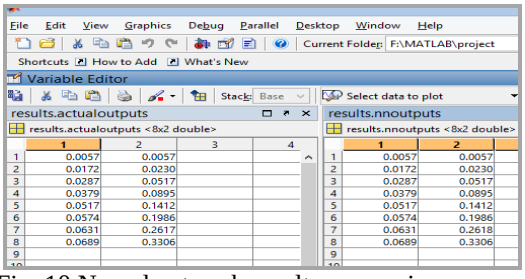


Fig. 10 Neural network results comparison

## V. Conclusions

From the results of the cash flow analysis using artificial neural networks model. It can be analyzed that, the cash flow analysis model using s-curves and artificial neural networks was demonstrated in this study. The cash flow analysis is provided with a reliable path for the analysis considering the planned and actual s-curves of cumulative cost versus time percentages by applying artificial neural network techniques. The planned and actual cash flows of the considered case study are imported to MATLAB and used as inputs and targets for the developed neural network model. The actual cash flows till the 8th month of the project are analyzed based on the mean square error and regression error of the developed neural network model. Analyzing the errors between the targets and outputs will assist in analyzing if the actual cash flows are in the correct direction and are profitable. The mean squared error of the targets and outputs is equal to the minimum retainage percentage of the contractor. But it is not much greater than the minimum retainage percentage. The error between the targets and outputs of the cash flow analysis model is negligible and acceptable. Taking the negligible error between the targets and outputs into consideration it can be concluded that the actual cash flows are smooth till 8th month of the project. The main advantage of the developed model is that the contractor can verify the actual cash flows of the project and also check if the minimum retainage percentage is maintained or not. The cash flow statement and S-curve

methods does not assist the contractor in identifying the actual cash flows and calculating the minimum retainage percentage.

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