

# *Application of Time Management to Minimize Costs when Analyzing Construction Variances*

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**Abstract** — *Minimizing construction costs by reducing construction variances improves a company's competitive advantage, especially in a complex market. Using data from a construction company in the Dallas-Ft. Worth metropolitan area, variances were identified by studying a bar chart produced using a tool created with Visual Basic programming language that organizes data obtained from KOVA, a construction management software. Ninety percent (90%) of the time management spend organizing and filtering data was reduced using the tool. Consequently, Simple Linear Regression and Normal Distribution were used to distinguish variances and create projections for future data. Statistical methods in conjunction with programming language and construction management software were proven to be a useful combination of resources to reduce construction variances, minimize costs and improve managements productivity.*

**Key Terms** — *Cost Control, Construction Variances, Time Management, Visual Basic Programming*

## **INTRODUCTION**

Urbanization, inflation, COVID-19, and low interest rates are some of the variables that have impacted cost of materials and as a result cost of homes throughout the United States of America. One of the areas that has been impacted is Texas, specifically the Dallas Fort Worth (DFW) metropolis.

In recent years there has been an upsurge of population in DFW; consequently, there is a home shortage and prices have increased dramatically. Competition has risen amongst residential homebuilders and to gain competitive advantage control of variances is imperative. Project cost

control became a critical issue for the construction projects under global recession [1]. The same is occurring at this moment, but with inflation.

History Maker Homes (HMH) is one of the homebuilders located in DFW and whose business is booming. HMH owns four lines that cater to single family, luxury single family, town homes and rental homes. The production homebuilder has been in the market since 1949 and are targeting to build 1,000 homes annually.

To gain competitive advantage and increase the number of homes built annually in an inflated market, it is important to study and analyze variances to lower them as much as possible.

There is limited research of the impact of using Visual Basic (VBA) programming language, statistics combined with construction management software to lower cost variances and reduce the time spent to trace variances.

This paper focuses on completion within cost targets with special attention to material quantities. Organization and identification of data obtained from construction management software and identification of variances are found by using a tool created with Visual Basic programming language. The tool is applied to data obtained from KOVA construction software and later analyzed using statistic methods to compare data and find variances. The tool is used to reduce 25% to 50% of the time management spends organizing data. The goal is to save management time organizing data obtained from KOVA software and produce statistical graphs to pinpoint areas of possible errors. The tool focuses on material quantity specific to a location, plan, specifications, and materials. Meaning that when comparing data throughout months it is expected to see no fluctuations of quantities in data unless it has been

noted otherwise. Gaps or changes in data when compared throughout the months will help pinpoint areas of unexpected variances.

## **LITERATURE REVIEW**

### **Project Variances and Programming Language used for Cost Control**

There are three different types of homebuilders: production, speculative and custom. Production homebuilders have a set number of plans and they utilize them repeatedly changing as minimum as possible depending on the project location requirements. The main idea behind production homebuilding is to have lower variances because of the repetitive nature of the construction process; resulting in larger profits and a low difference between target costs and actual costs. Therefore, production homebuilders' approach is to mimic an assembly line and to do so implementing software is a solution. Variability in manufacturing systems leads to many operational inefficiencies such as higher rework costs, poor quality, lower throughput, higher work in process, longer cycle times and reduced labor productivity. Identifying the causes of variability, assessing their impact, and eliminating them is central process improvement efforts [2]. History Maker Homes found a solution to mimic an assembly line hence manufacturing system by implementing a construction software called MiTek KOVA.

KOVA software streamlines the construction process by transferring information and data throughout the entire construction process and within departments. KOVA has proven to be useful to monitor costs, implement processes, lower construction time, increase productivity and grow volume of homes built. The key elements that are common to all projects include [3]:

- Timely completion.
- Completion within cost targets.
- Matching the quality parameters.
- Adherence to the technical parameters.

Completion within cost targets includes many processes to obtain results as close to estimates as possible. Effective cost monitoring and controlling has received much attention in the construction industry due to excessive growth woefully profit margin of some contractors [4].

As it occurs with numerous construction software's there are difficulties locating variances and pinpointing errors within KOVA. Using programming languages such as Visual Basic Program is a powerful tool to minimize the time spent locating variances, but little to no research has been made regarding this topic. Finding variances and correcting errors can have a large impact in project cost control. The absence of a well conventional effective system for monitoring and controlling project cost has caused failures to many contractors in the construction industry [4].

### **Statistics Methods to lower Variances**

History Maker Homes as well as other homebuilders have an estimating department focused on producing accurate project costs and research cost variances. It is common for contractors and homebuilder to underestimate a project cost because of considerations regarding markup and contingency. These approaches, however, do not accurately indicate the possible ranges of cost variations that a single estimate may assume [5]. Because of mistakes during takeoffs, increase in overhead costs and lack of time for project document evaluation all together result in a poor cost control of the construction project [1]. It is important to effectively apply an Earned Value Analysis for cost control as well as document variance analysis methods by starting from the simplest one [1]. Managers can later make corrections and change methods to highlight points in their cost control application [1].

Depending on the size of the project as well as the entity that is in charge is the statistical method used if any. For example, for highway projects in the United States of America unit price estimates are used to budget findings and to evaluate bid projects. Statistical approach variance and simple

regression based on historical data can identify the quantities to develop predictable consistent unit price estimates [6]. Statistical approaches can be used to find dispersion of the data and thus identify areas where there is a variance once identified corrections can be made. Trends and relationships between price and quantity can be established by using statistical analysis [ 6]. These methods are best applied when there is historical data available for quantities and costs. This paper will focus on only one material and its quantity throughout different communities, plans and elevations to identify of variances using statistical methods.

## **ANALYSIS APPROACH**

### **Visual Basic Code as a Tool for Data Organization**

Data was obtained for one material using KOVA construction software. The material selection was one type of brick and its units of measurement were square feet. The brick has been used in multiple homes throughout the DFW area by History Maker Homes. Quantity information for the brick was obtained by extracting reports from KOVA. The data was then pasted into a spreadsheet that contained the VBA Code. The Visual Basic Code was created to organize the data dependent on the user’s needs. The user is to select the community, plan, and elevation they would like to obtain results for. Once the user clicked on the run button the code would filter through the data obtained from KOVA and as a result all the information for the material specified would be obtained in a separate spreadsheet with a bar graph.

An experiment was performed to study the amount of time a user would take to filter through the data obtained from KOVA instead of using the tool. Three tests were done filtering the same exact data with and without the use of the tool to see its effectiveness.

### **Project variances and Cost Control integrated with KOVA**

Once the bar graphs were obtained, using the tool managers the data can be analyzed and quickly see if there are any variances within the data. Managers should have knowledge on identifying variances and to be successful will need information regarding changes made in analysis.

### **Statistic Methods and graphs to pinpoint areas of deficiencies.**

Once the tool organizes the data this data can be used for further studies using it combined with statistical methods to predict future data

To analyze the Normal Distribution, the Mean ( $\bar{x}$ ) and Standard Deviation ( $\sigma$ ) of the data is calculated. Adding and subtracting three time the standard deviation to the brick square footage values and calculating its own probability density results in values that can then be used to graph a bell curve.

## **RESULTS**

### **Time Management**

The tool can organize the data by community, material, plan, and month. Three tests have been run using the tool. The test was done using two different approaches. First organization of data by hand. The average time in minutes that it takes to organize the data without including the time to download the data from KOVA is on average 24.33 minutes. This is compared to the time it takes for the tool to organize the data an average of 2.33 minutes. Results show that the tool increases efficiency more than what was expected. The tool increased efficiency by 90%.

**Table 1  
Time spent in minutes organizing data**

Test	Time in minutes without tool	Time in minutes with tool
Test #1	40	3
Test #2	18	2
Test #3	15	2

### Graph Method to find Variances

To keep company information confidential Community and plans have been labeled as A, B and C. The blue bars represent the brick square footage per area of the home. The VBA code in the tool automatically creates bar graphs once the data is sorted. The bar graphs are a visual representation of the data form KOVA reports and can be used to pinpoint variances. Figure 1 shows a quantity of 777 square feet in the months of February and March but shows zero in the month of April. This is a demonstration of a variance where data is missing.

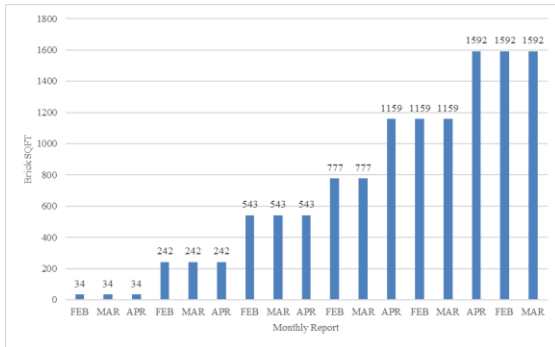


Figure 1

Brick SQFT by Monthly Report for Community C, Plan B and Elev. A

### Simple Linear Regression Analysis for Variance Determination and Projection

The objective is to find statistic relationships of the monthly data to project the quantity data that is to be expected in the future. Therefore, using this information will help forecast the brick square footage in the upcoming month. Forecasting helps pinpoint areas that may have a current variance that needs to be corrected and a prediction of future values in the upcoming months. The linear regression offers a formula and a trend of what is to be expected in the upcoming month. Months have been labeled in numerical order starting with January as one, February as two and consequently. From the data gathered by using the tool and once the data is graphed a negative linear regression is seen and month 3 data is missing, refer to Figure 2.

This is variance that will need to be flagged and researched for correction.

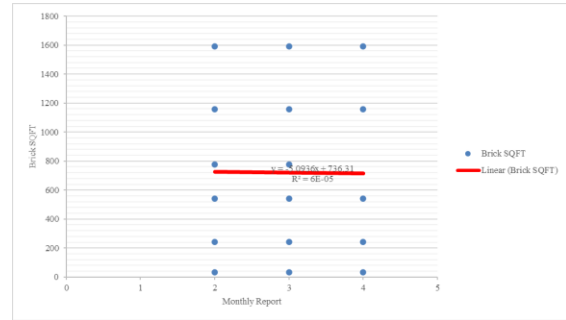


Figure 2

Simple Linear Regression Analysis for Brick SQFT by Monthly Report for Community C, Plan B and Elev. A

### Normal Distribution

Normal distribution is a statistical method used to verify if the data is acceptable. The center of the normal distribution represents the mean of the data. 34.13% to the right or to the left of the mean for a total of 68.26% where most of the data should be included. If the data surpasses the 68.26% area, there is a high chance of a variance. Therefore, when analyzing data using normal distribution it is expected to have a bell curve that is not spread out as seen in Figure 3. Notice how the mean is 2904 and a -34.13% would result in 2903. This quantity is not correspondent to the cumulative square footage for any of the months. Meaning that the mean has been moved because of a variance. Table 2 shows the month of April having a lower total of square footage than February and March. The variance affects the Mean and as a result the values are not within 68.26% in the bell graph.

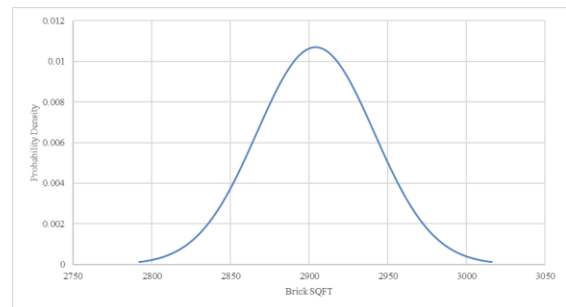


Figure 3

Normal Distribution for Community A, Plan A and Elevation A

**Table 2**  
**Brick SQFT by Monthly Report for Community A, Plan A**  
**and Elevation A**

Monthly Report	Total SQFT
FEB	2926
MAR	2926
APR	2861
Mean	2904
SD	37.273

### DISCUSSION

Visual Basic in conjunction with construction software are a great combination granting the user access to sort data in a short amount of time for variance analysis. When searching for variances it is important to utilize the same properties every month for comparison of data.

Combining Programing language and project management software with statistics analysis is helpful to pinpoint problematic areas where variances occur saving the company unnecessary costs and increasing their competitive advantage. The combination of tools is also helpful in forecasting future variances, quantities, and errors.

### CONCLUSION

Using Visual Basic to create a tool that organizes data and creates bar charts to pinpoint variances has found to be a powerful resource that increases management productivity. 90% of time management spends organizing and filtering data is reduced using the tool.

Simple Linear Regression and Normal Distribution in conjunction with programing language and project management software are useful in locating variances.

Because of the repetitive nature of production homebuilding, statistical approaches are easier and effective implementation to locate variances. Further research of the present methods is to be made to determine the best statistical approach to apply to projects within the United States of America with focus on the Homebuilding Industry for speculative and custom homebuilders.

### REFERENCES

- [1] Hasan Bozkurt Nazilli and Nicolae Postavaru, "Review of Variance Analysis in Unit Price or Lump-Sum Basis Contracts for a Construction Project." *Internal Auditing & Risk Management*, vol. II, no. 2(26), June 2012, pp.103-115.
- [2] Steven J. Erlebacher and Medini R. Singh, "Optimal Variance Structures and Performance Improvement of Synchronous Assembly Lines." *Operations Research*, vol. 47, no. 4, July-August 1999, pp.601-618.
- [3] Mee-Edoie M. Andawei, "Project cost monitoring and control: A case of cost/time variance and earned value analysis." *Journal of Engineering*, vol. 04, no. 2, February 2014, pp.22-25.
- [4] Alfaj N. Shaikh, Prof. T.B. Dhavale and Prof. A. P. Khatri, "Application of Variance Analysis in Construction Cost Monitoring and Controlling." *International Journal of Engineering*, vol. 05, no. 6, June 2016, pp.256-259.
- [5] Du Y. Kim, Seung H. Han, M.ASCE, and Hyoungkwan Kim, "Discriminant Analysis for Predicting Ranges of Cost Variance in International Construction Projects." *Journal of Construction Engineering and Management ASCE*, 2008, pp.398-408.
- [6] Middleton, Lloyd Medford *Variance Analysis of TDOT Highway Construction Prices for Modeling Estimates*. 2006.