Interrelationship Analysis between Causal Factors of Construction Defect Using Association Rule Mining

Lee, Sang-Deok[1], Han, Sang-Won[2] and Hyun, Chang-Taek[3]

Abstract: Construction defect which can causes economic damage such as schedule delay, cost overrun is a considerably important factor in construction industry. In general, a construction defect features a difficulty to find out causes precisely because it occurs when several interrelated causes combine. Yet, studies have tried to understand the interrelationships between factors are limited. In addition, despite of a tremendous amount of construction data, it's not still enough to analyze them, but tends to depend on experience or know-how of practitioners. Thus, it is necessary to identify underlying causes in influential factors by utilizing related data. This paper analyses Interrelationships between causal factors using Association Rule Mining to discover root causes of construction defects. Confidence and Lift that can be used for presenting the interrelationships of the causes were extracted from 1241 cases in 30 projects in Korea. It is expected that this paper allows the construction managers to discover key factors and make right decisions to reduce occurrence of construction defects. Furthermore, analysis of interrelationships can improve understanding of structural patterns of construction defects.

Keywords: Defect management, Interrelationship, Root Cause Analysis, Data Mining, Association Rule Analysis

I. INTRODUCTION

Construction defect which can causes economic damage such as schedule delay, cost overrun, poor quality is a considerably important factor in construction industry. Additionally, construction defect has been regarded as a factor which has to be prevented for successful accomplishments of projects as needs of owners and users improve. According to related studies, the cost of defects occurring during production is stated to be 2-10% of the cost of production [3,4]. And, in cases of LH(Land and Housing corporation, Korea) apartments[2], importance of defect management has emerged because the number of defect per household a year has rapidly increased from 11 to 32 over the last five years(2010-2014).

Considerable efforts have been made to reduce defects in construction fields. Although managers try to find out causes and take care of them to prevent potential economic damage, they still occur constantly in various types. In general, a construction defect features a difficulty to find out causes precisely because it is not an outcome of a single cause, but rather occurs when several interrelated causes combine[1]. Yet, studies that have tried to understand the interrelationships between factors are limited. Many studies have tried to find out underlying causes of construction defect based on statistical analysis. They wanted to know only the frequency of causes and regarded the cause that have the most frequency as the most important target for preventing construction defects.

However, this way cannot reflect the feature that defect occurs when several causes combine and consider complex interrelationships between those causes.

In addition, projects have produced numerous data in construction industry. In spite of a tremendous amount of construction data, it is not still enough to analyse them, but tends to depend on experience or know-how of practitioners. But using past data can obtain more exact analysis and results relatively. Thus, to prevent the occurrence of construction defects, it is necessary to identify underlying causes and discover interrelationships in a number of influential factors by utilizing related data. Data mining can extract useful information and previously unknown patterns on construction defect management from data. Traditionally statistical analysis ways are used to test the past cases, while data mining technology, especially Association Rule Mining(ARM), is aimed at finding unexpected relationships.

Therefore, This paper analyses Interrelationships between causal factors using Association Rule Mining to discover root causes that contribute to defects in construction projects.

II. LITERATURE REVIEW

Studies that have tried to analyze defect causes are reviewed. They aimed at getting frequency of causal factors and knowing importance of the factors by studying cases and survey, but had limits in examine interrelationships between influential causes.

[1] M.S. Candidate, Dept. of Architectural Engineering, Univ. of Seoul, Seoul 130-743, Korea, mgr_leesd@naver.com

[2] Associate Professor, Dept. of Architectural Engineering, Univ. of Seoul, Seoul 130-743, Korea, swhan@uos.ac.kr (*Corresponding Author)

[3] Professor, Dept. of Architectural Engineering, Univ. of Seoul, Seoul 130-743, Korea, cthyun@uos.ac.kr

The 6ᵗʰ International Conference on Construction Engineering and Project Management (ICCEPM 2015)
Oct. 11 (Sun) ~ 14 (Wed) 2015 • Paradise Hotel Busan • Busan, Korea
www.iccepm2015.org

TABLE I. PREVIOUS PAPER REVIEW

Author	Description	Result
P.-E. Josephson et al. (1999)	Categorizing causes by analyzing defects in 7 projects	Knowledge, Information, Motivation, Stress et al.
K.N. JHA et al. (2006)	Identifying positive and negative causes of quality performance	Negative attitude of PM, Poor human resource et al.
Jinrong Cui (2011)	Identifying causes and influences of defects in 27 cases	Inadequate Investigation, Poor Program, Poor Values et al.
Hamzah Abdul-Rahman et al. (2014)	Analyzing causes and management costs of defects	Lack of Training, Insufficient skill levels et al.

III. INTERRELATION ANALYSIS BETWEEN DEFECT CAUSES

A. Process

ARM is one of the Data Mining methods and can find out a useful structure in tremendous data. In construction industry which produces a number of drawings and reports, ARM has an advantage that can analyze quickly defects caused multi factors.

The process applying ARM to examine occurrence patterns of construction defect is as follows :

1) Constructing database contains defect cases or reports related a defect.
2) Conducting ARM to draw rules between defect causes. The result would shows Support, Confidence, Lift of each pairs of the causes
3) Making correlation matrix and filling Lifts into the matrix. Lift means rising ratio of occurrence probability.
4) Using Design Structure Matrix, clustering causal factors and find occurrence patterns of defects

The process above shows useful patterns to select primary management factors in construction project.

B. Case Study

This paper use data derived from 1241 defect cases in 30 projects in Korea. According to the process above, to find out primary management factors, database was built first. And then, ARM was conducted based on the database and rules were drawn as TABLE II.

TABLE II. Drawn RULES OF DEFECT CAUSES

Rule	Support	Confidence	Lift
Damage by other activities → Labor's Fault	0.082	0.870	1.531
Inadequate drawings → Untrained labors	0.078	0.826	1.521
Damage by other activities → Inadequate drawings	0.086	0.913	1.489
…	…	…	…

This cases have 21 kinds of causes. And through ARM analysis, 367 rules were drawn. Support means frequency of each pair of causes. Confidence is occurrence ratio of cause on the right hand side when the cause on the left hand side occurs.

To analyze DSM, correlation matrix filled by Lift were constructed. After that, to select primary management factors and rank the factors in order of impact, 21 causal factors were clustered as FIGURE I.
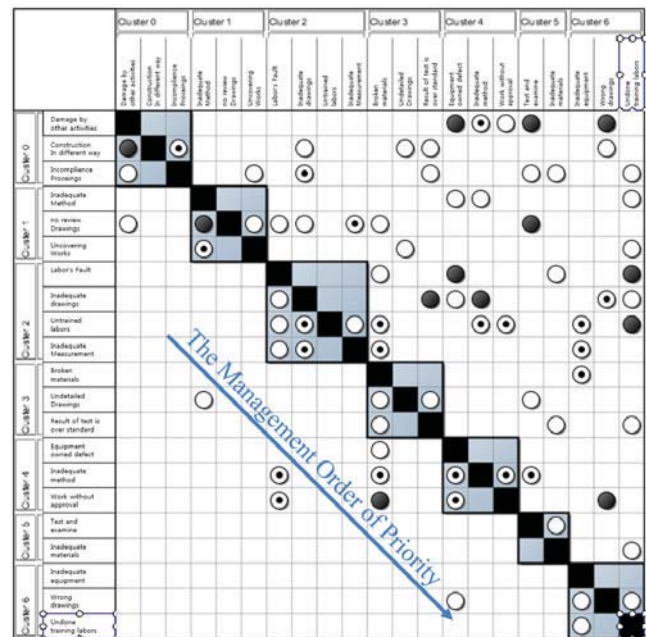

FIGURE I. CLUSTERING CAUSES IN CORRELATION MATRIX

The result of clustering causes shows the rank that construction managers could utilize to do efficient work. The group of causes on the top and left hand side has the most impact to the others. It means that the occurrence probabilities of the others would decrease if construction managers control it.

IV. CONCLUSION

This paper proposed the process and studied defect cases to select primary management factors. The process could show useful patterns describing database related defect cases. Considering the features that construction defect is occurred by a variety of causes, this process using ARM can be an effective way to identify underlying causes of construction defect. Furthermore, the result would help construction managers to make right decisions and work more efficiently.

REFERENCES

[1] Aljassmi, H. and Han, S., "Analysis of Causes of Construction Defects Using Fault Trees and Risk Importance Measures", *Journal of Construction Engineering and Management,* vol. 139, no. 7, pp. 870-880, 2013.
[2] Josephson, P.-E. and Hammarlund, Y., "The causes and costs of defects in construction: A Study of seven building projects", *Automation in Construction,* vol. 8, no. 6, pp. 681-687, 1999.
[3] Kim, T., Parliamentary inspection of the Land and Housing corporation, 2014
[4] Mills, A., Love, P. and Williams, P., "Defect Costs in Residential Construction", *Journal of Construction Engineering and Management*, vol. 135, no. 1, pp. 12-46, 2009