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Selection of Key Management Targets for Claim Causes through Relational Analysis on the Causes of Change Order Claims

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Abstract: **:** As various stakeholders are involved in construction projects, disputes between the parties are more likely to occur, which is a very important issue for the participants in the projects. Claims in construction projects, however, are very complex and thus difficult to manage. In particular, as the cause of a claim in the preceding stage that has not been resolved in a timely manner has an effect on the cause of a claim in the following stage, it is difficult to find a point of compromise regarding a claim caused by the relationship between the causes that occur in the preceding and following stages. In this regard, this study sought to examine the rules for the generation of change order claims, which occur most frequently among the construction claims, and thus to select the key management targets through the analysis of the relationship between the causes of claims arising in the preceding and following stages for the efficient management of claims. It is expected that the use of rules for the generation of change order claims as well as of representative and similar cases will help the construction practitioners in judging claims, considering the relationships among the causes of the claims. Meanwhile, in this study, association analysis was conducted regarding the causes of the occurrence of change order claims in a design-build delivery method, and therefore, it is necessary to verify the effectiveness of the method when applied to other delivery methods.

Key words: Claim management, change order (design change), text mining,, association rule analysis, social network analysis

1. INTRODUCTION

In construction projects, there is a high probability of the occurrence of disputes among the parties concerned due to the participation of various stakeholders in the projects, and the claims resulting from

these disputes are very important issues for the project participants [1]. As construction claims take a very complex form, however, it is difficult to manage them [2]. In addition, multiple causes affect one another within the claims, making it more difficult to prevent them [3]. This phenomenon is expected to even be intensified given that the construction industry is gradually becoming larger and more complicated [4]. Recognizing the importance of claim management, many domestic and foreign researchers have made efforts to reduce the occurrence of claims. Most of the relevant studies, however, have been conducted on a single cause to analyze the complex structures of construction claims [5]. Therefore, they pose limitations in preventing claims from numerous causes due to the characteristics of the construction claims. In particular, as the cause of a claim that arises in the preceding stage that has not been resolved in a timely manner affects the cause of a claim that arises in the following stage, it is hard to find a point of compromise regarding a claim caused by the relationship between the causes that occur in the preceding and following stages [6]. In addition, the causes of claims are obtained through texts, which are unstructured data such as a judicial statement and an arbitration statement, and are used as the bases for the judgment made by the managers [7]. It is not easy to examine a huge amount of unstructured data, however, and as such, there is a need to use a technology that can support these tasks more efficiently [8]. Therefore, this study sought to investigate the rules for the generation of change order claims, and thus to select the key management targets through the analysis of the relationship between the causes of the claims arising in the preceding and following stages for the efficient management of the claims.

In this study, the research scope was limited to the change order claims, which account for the largest proportion [9] of the claims occurring in the construction projects. In addition, it is limited to the design and construction method which is severely damaged during the construction project

below are the research methods that were used.

(1) Investigate the present status of the claim management work at the construction site, examine the studies on claims, and derive the limitations of the previous studies.

(2) Construct a database of the judicial precedents, arbitration statements, and authoritative interpretations from the Ministry of Strategy and Finance.

(3) Derive keywords by performing text mining to analyze the target of the causes.

(4) Analyze the keywords derived earlier, and select the meanings that are considered the causes of design change among the analysis results.

(5) Perform association rule analysis and social network analysis by utilizing the causes of the claims derived through text mining.

(6) Select the order of priority based on the results, and identify the key management targets to prevent the occurrence of claims.

2. PRELIMINARY CONSIDERATIONS

2.1. Concept of Claims

Claims are broadly defined as complaints, warnings, or disputes. In the construction business, the term “claim” refers to a demand for compensation if a business entity or construction company causes its contractual partner to incur economic damages and time loss due to the former’s breach of the existing contract or taking of improper measures. In addition, claims are inevitably generated in the course of a construction project, and they are factors that are directly related to the profitability of the project or to the benefits that will be received by the parties concerned [10].Therefore, claim management is a prerequisite to the prevention of claims.

2.2. Review of Analytical Techniques

2.2.1. Text mining

Text mining is based on the natural language processing technologies for discovering new knowledge by finding useful patterns or relationships from unstructured large document data [11]. The purpose of text mining is to discover hidden knowledge and not just to retrieve data from a vast amount of unstructured text data [12].

In this study, keywords were derived by performing text mining to analyze the target of the causes.

2.2.2. Association rule technique

Association rule analysis is done to acquire new knowledge from existing habits or accumulated materials [13].It has the advantages of enabling various results to be derived and of allowing the interpretation to be diversified due to the author's post-processing technique. When particular behaviors occur several times, the association between such times is represented as X→Y (i.e., "if X, then Y"), where X and Y are the items, and the association measure of the two items is explained by the three concepts of support, confidence, and lift.

Support is the probability of the occurrence of cases where X and Y occur simultaneously in the case of X→Y. The equation is shown below.

$$Support = P(X \cap Y) = The\ number\ of\ transactions\ containing\ both\ X \text{ and } Y \quad (1)$$

The confidence represents the conditional probability of Y when X occurs in the X→Y relationship, and it can be said to be the probability that Y will occur when X occurs.

$$Confidence = P(Y \mid X) = \frac{P(X \cap Y)}{P(X)} = \frac{The\ probability\ that\ X \text{ and } Y\ will\ occur\ at\ the\ same\ time}{The\ probability\ that\ X\ will\ occur} \quad (2)$$

The lift is the increase rate of the probability of the occurrence of item Y when item X is given, as compared to the probability of the occurrence of item Y when item X is not given. The larger this value is, the greater the influence of whether or not to purchase item X on whether or not to purchase item Y.

$$Lift = \frac{P(Y \mid X)}{P(Y)} = \frac{P(A \cap B)}{P(A)\ P(B)} = \frac{The\ probability\ of\ the\ occurrence\ of\ Y\ when\ X\ occurs}{The\ probability\ that\ Y\ will\ occur} \quad (3)$$

This study analyzed the keywords derived through text mining, and selected the meanings that were considered causes of design change among the analysis results.

2.2.3. Social network analysis

A social network can be defined as a set of socially relevant nodes connected by one or more relation t ypes —i.e., a set of actors. This network is also composed of nodes and links. Through the analysis, it i s possible to identify the meaningful configuration between the nodes, the structure, and the relative im portance of the nodes [14]. Especially in various indicators, one of the most important concepts and m ost commonly used measures is centrality [15], and this study attempted to derive the key points by usi ng the centrality values.

2.3. Review of Previous Studies

2.3.1. Analysis of the causes of construction claims

Studies on the causes of claims have constantly been conducted to prevent the occurrence of and resolve construction claims. The investigation of the causes of construction claims is a necessary step to manage the claims, and related studies are examined herein.

The contents of the previous studies on the analysis of causes for construction claims and factors are summarized in [Table1].

Table 1. Previous studies related to analysis of the causes of construction claims

Author	Title	Research contents
Lee	Effective Resolution of Construction	A survey was conducted to increase the effectiveness of

Hong-chae (2010)	Disputes in the Execution Phase	alternative dispute resolution (ADR), and improvements were suggested using the derived factors.
William R. Wildman (2012)	Class Arbitration and the Construction Dispute: Analysis of the Current Jurisprudence and Practical Tips for the Construction Practitioner	The potential risk factors that occur when the relationships among the various participants in construction projects are taken into account were derived, and the derived factors were suggested.
Ryan Griego (2017)	Premature Construction Start Interruptions: How Awareness Can Prevent Disputes and Litigations	Under the assumption that the causes of the claims that occur at the beginning of a construction project lie in the design drawings, the causes resulting from the drawings were presented in terms of degree of damage and severity.

The previous studies mainly dealt with the derivation of the causes of claims and the estimation of the effects at the design and contract phases, and with the relationship between a single cause and a single outcome. Even in the study conducted regarding the relationships among the causes, an analysis was conducted using the data obtained from the survey instead of empirical data. This poses limitations in investigating the relationships by reflecting the characteristics of the construction industry data generated in countless numbers over time.

2.3.2. Causes of change orders and factors

The current section investigates change order claims, the subject of this study. The previous studies on the change order claims are shown in [Table 2].

Table 2. Previous studies related to the causes of change orders

Author	Title	Research contents
JeongJi-deok (2011)	Risk Analysis for the Core Design Change Factors in Hospital Projects Based on FMEA	The design change factors in the design phase of hospital projects were analyzed. Then the potential factors were derived, and the risk for each construction type was estimated.
Yoon Seok-min (2013)	Identification of Claim Elements for Design-Build Projects Using the FMEA Method	In design-build projects, the claim elements that cause construction delays and increase the construction costs were derived through the previous researches, and the risk was calculated by analyzing 36 cases.
Jeong Woo-seung (2016)	Research on the Improvement Measures for the Design Changes of Military Facility Projects Based on Factor Analysis	Considering the specificity of military facility projects, the factors for only such projects were derived by comparing their contract status with those of public institution facility projects and apartment housing projects.

The contexts of the previous studies discussed in this section were similar to those of the preceding researches on construction claims, and there were few studies that analyzed the design changes considering the relationships among the causes, or that suggested management methods. In addition, although both construction claims and change order claims are based on unstructured data, no research has been conducted to provide an efficient means of analysis. Therefore, in this study, the causes related to design change were derived through a judicial precedent, and the patterns in the generation of change orders were investigated considering the relationship between the causes generated at the preceding and following phases so that the patterns of the generation of change order claims could be utilized by managers for the efficient management of such claims.

3. RESEARCH AND ANALYSIS OF DESIGN CHANGE DATA

3.1. Design Change Data Survey

This study utilized 250 cases of design change, such as precedents and arbitration statements in South Korea. The collected data correspond to construction projects and are from the design changes that occur during the tender, design, and construction phases, and they were based on the cases that could be used as the judgment criteria. Text mining analysis was conducted based on a total of 250 change order claims in the design-build delivery method, and the meanings of the top 10 keywords were analyzed to derive the causes of design changes. Then the derived causes of design changes were utilized in the association rule analysis and social network analysis.

3.2. Text Mining Analysis Procedures

This study sought to utilize a text mining technology to find a certain pattern and derive new knowledge and facts. Then the meanings of the derived words were subdivided to grasp the usage of the words in the text.

3.3. Analysis of Design Change Keywords

3.3.1. Keyword analysis

In accordance with the procedures mentioned above, text mining of design change claim data was performed to derive the top 10 keywords for each phase. In the tender phase, the top 10 words (i.e., plan, design book, bidding guide, person-in-charge, investigation, site description, design guidelines, review, responsibility, and condition) were extracted as keywords. In the design phase, the top 10 words (i.e., design drawings, bidding notes, estimates, application areas, business cooperation, deliberations, environmental rights, statements, period, and standard) were derived as keywords. In the construction phase, the top 10 words (i.e., site conditions, construction delays, permission delays, construction method change, missing expense items, contract change, price fluctuation, requirements, civil complaints, and equipment) were analyzed as keywords.

3.3.2. Keyword meaning analysis

As mentioned above, the derived keywords cited in the previous section are words that imply the overall contents of the text, but their meanings are diverse. Therefore, additional analysis is required.

In this regard, the derived keywords were analyzed in greater detail, and the detailed meanings of the top 10 keywords.

3.3.3. Derivation of causes through meaning analysis

In this section, the causes of change order claims are derived by analyzing their meanings in detail.

Text mining was performed by dividing the stages into three phases (i.e., tender, design, and constructi on phases), and the meanings of the derived keywords were analyzed in detail. If the keyword was use d with a single meaning, it was classified as a single cause, and the keywords that had multiple meanin gs were subdivided and classified as causes of change order claims even if they were the same keywor ds. In addition, if the keywords were different but their meanings were similar or difficult to distinguis h, they were categorized as the same causes.

4. EXAMINATION OF THE CHANGE ORDER CLAIM GENERATION RULES

4.1. Analysis of the Relationships among the Causes of Claims

This section analyzes the relations of the data by utilizing the association rule analysis technique based on vast amounts of change order claim data, and seeks to derive the rules for the generation of change order claims. In this study, actual cases were analyzed, with 250 precedents and arbitration statements collected based on domestic cases. For the analysis, the documents were classified into those of three phases (tender phase, design phase, construction phase) based on the causes of change order claims derived in Chapter 3, section 1 above.

The rules for the generation of change order claims were investigated using the association rule analysis technique based on the constructed case data. The association rule analysis technique can identify the generation rules that the data have in terms of probability, and which elements frequently occur together. In addition, as described in Chapter 2, the results derived through the association rule analysis technique can be explained with the support, confidence, and lift values.

Finally, 40 rules were derived through the above process. The derived 40 rules were divided into the rules for tender-design and design-construction projects based on the preceding-following stages.

4.2. Derivation and Analysis of the Change Order Claim Generation Rules

The association rule analysis was utilized to obtain the support, confidence, and lift values, and the lift value, which is a conditional probability, was used as the probability of occurrence between the causes of change order claims to derive the rules between the causes of the change order claims that can occur in the following stage when the cause of the change order claim occurs in the preceding stage. In addition, as there is a need to derive the relevant causes of change order claims to identify the rules for the generation of such claims in addition to the probability of their occurrence, the association between the causes was determined through the lift value. The association rule analysis technique generates a large number of association rules, and not all the generated rules are significant. To derive rules that correspond to the study, the rules that can be used in this study were selected through the data mining post-processing technique. The presented indicators were set by the researcher according to the purpose of the study, and were used to select the rules for the generation of change order claims that appeared through the research. In this section, the support value is ignored. The support value indicates the probability that two items will occur at the same time. In this study, as there is a tender phase-design phase-construction phase flow, and as various causes of claims form complex relationships, the probability that change orders will occur simultaneously, together with the support value, is extremely small. Therefore, in this study, the minimum confidence value was not set, and all the support values were determined to be useful. In the second step, the secondary selection task was performed to select the rules that exceeded the minimum confidence value. In the previous studies, the minimum confidence was set by the researcher according to the purpose of the study when the association rule analysis technique was used. In this study, 0.5 was selected as the minimum confidence value to derive meaningful rules in a relatively small number of samples. Finally, among the rules selected through the two steps, those where the lift value exceeded 1 were derived by utilizing the lift value.

(1) Rules between the causes of the change order claims arising in the tender and design phases

A total of 10 kinds of rules were generated through 11 causes of claims in the tender phase and 8 causes of claims in the design phase by means of the association rule analysis techniques. The results values indicate the top 3 rules with a higher degree of lift, as shown in [Table 3] below.

Table 3. Relationship between the causes of the change order claims arising in the tender and design phases

Rule	X (Tender phase)	Y (Design phase)	Support	Confidence	Lift
1	Insufficient investigation	Different drawing contents	0.004	0.675	1.935
2	Change in bidding guide	Double works	0.027	0.627	1.913
3	Inadequate level of design book	Insufficient time for reviewing drawings	0.003	0.693	1.700

(2) Rules between the causes of the change order claims arising in the design and construction phases

A total of 30 kinds of rules were generated between 8 causes in the design phase and 11 causes in the construction phase through the association rule analysis technique. The results values indicate the top 3 rules with a higher degree of lift, as shown in [Table 4] below.

Table 4. Rules between the causes of change order claims arising in the design and construction phases

Rule	X (Design phase)	Y (Construction phase)	Support	Confidence	Lift

1	Unreasonable requirement for quality	Defective materials	0.011	0.608	1.826
2	Change in conditions	Period for application of price fluctuation	0.041	0.631	1.814
3	Change in conditions	Different site conditions	0.043	0.597	1.811

As the design change management in the existing construction industry is a very sensitive issue, proper base and evidence materials cannot be provided. In addition, considering that the combination of causes of change orders is a factor affecting design change responsibility and amount of damages, it is difficult to manage without a basis. In Chapter 4,section 1, the rules and probability of change order claims were derived through the relation values between the causes of change orders with the use of the association rule analysis technique. These rules generally allow a probabilistic prediction of what causes are affected in the later stage by the causes of change orders identified in the preceding stage when the construction project is conducted in the order of the tender/design/construction phases, help in recognizing the causes in the preceding stage that were not resolved in a timely manner when the change order claims occurred, and thus can be utilized as bases for the claims that cannot be established due to the construction culture. As the analysis, however, was conducted simply by considering the frequency, insignificant rules irrelevant to the purpose of the research can be derived, and the flow of time cannot be taken into consideration, as mentioned above. Therefore, many rules derived through the association rule analysis technique were classified through the post-processing technique, and 40 significant rules were derived.

4.3. Selection of Key Management Targets Using Social Network Analysis

4.3.1. Criteria and procedures for the selection of key management targets

(1) Selection criteria for key management targets

It is difficult to prevent claims resulting from various causes by managing only one cause. For prevention, it is important to control all the factors involved in the occurrence of defects, but as these causes are very diverse, it is difficult to manage all the causes in the field. As such, efficient management practices should be implemented through the selection of key management targets.

In this regard, this section seeks to derive the cause that has the greatest influence on the probability of occurrence of other causes by utilizing the lift values of the causes of the generation of claims, and thus to select key management targets for each phase.

(2) Selection procedures

In this study, the degree-centrality analysis technique of social network analysis was utilized to select key management targets among the causes of change order claims derived by phase. The major nodes in the network can be distinguished by analyzing the degree of influence and the number of links that each node has. In this section, the degree of influence is defined as the lift, which is the result analyzed in section 1.

4.3.2. Selection of key management targets for each phase

a. Relationship between the causes of the change order claims arising in the tender and design phases

In the relationship between the causes of the change order claims arising in the tender and design phases, the cause with the biggest degree of influence on the occurrence of the other causes was “lack of ability of the person-in-charge, followed by “insufficient time for reviewing the drawings” and “different amount of money.”

Below is the relationship between the causes of the change order claims arising in the tender and design phases.

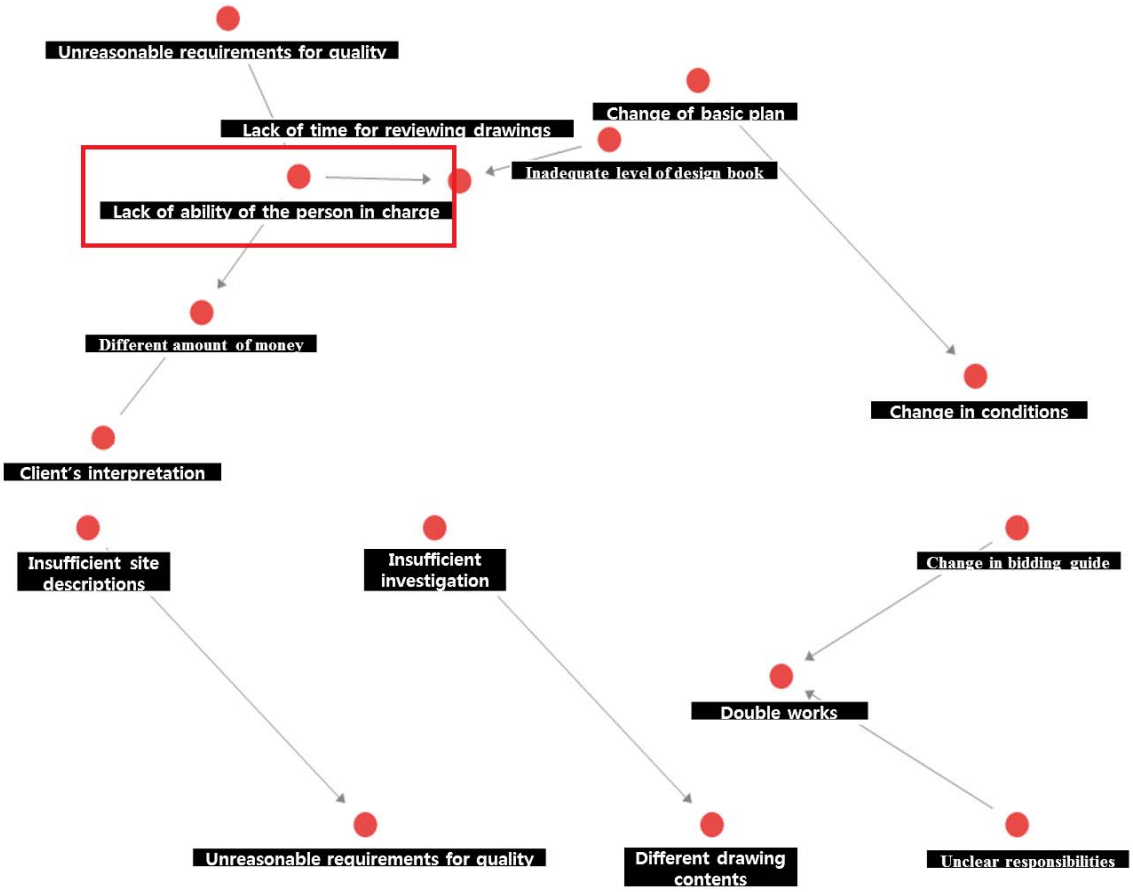

Fig. 1. Relationship between the causes of the change order claims arising in the tender and design phases

With respect to the centrality value and the order of management priority, the top 3 causes with higher centrality are shown in [Table 5] below.

Table 5. Priority order of the causes of the claims arising in the tender and design phases

Rank.	Cause	Centrality
1	Lack of ability of the person in charge	2.302
2	Insufficient time for reviewing drawings	2.014
3	Different amount of money	1.936

b. Relationship between the causes of the change order claims arising in the design and construction ph ases

In the design phase, the cause with the biggest degree of influence on the occurrence of the other causes was "change in the conditions,"followed by "insufficient time for reviewing the drawings" and "different amount of materials."

Below are the relationships between the causes of the claims that occur in the design and construction phases.

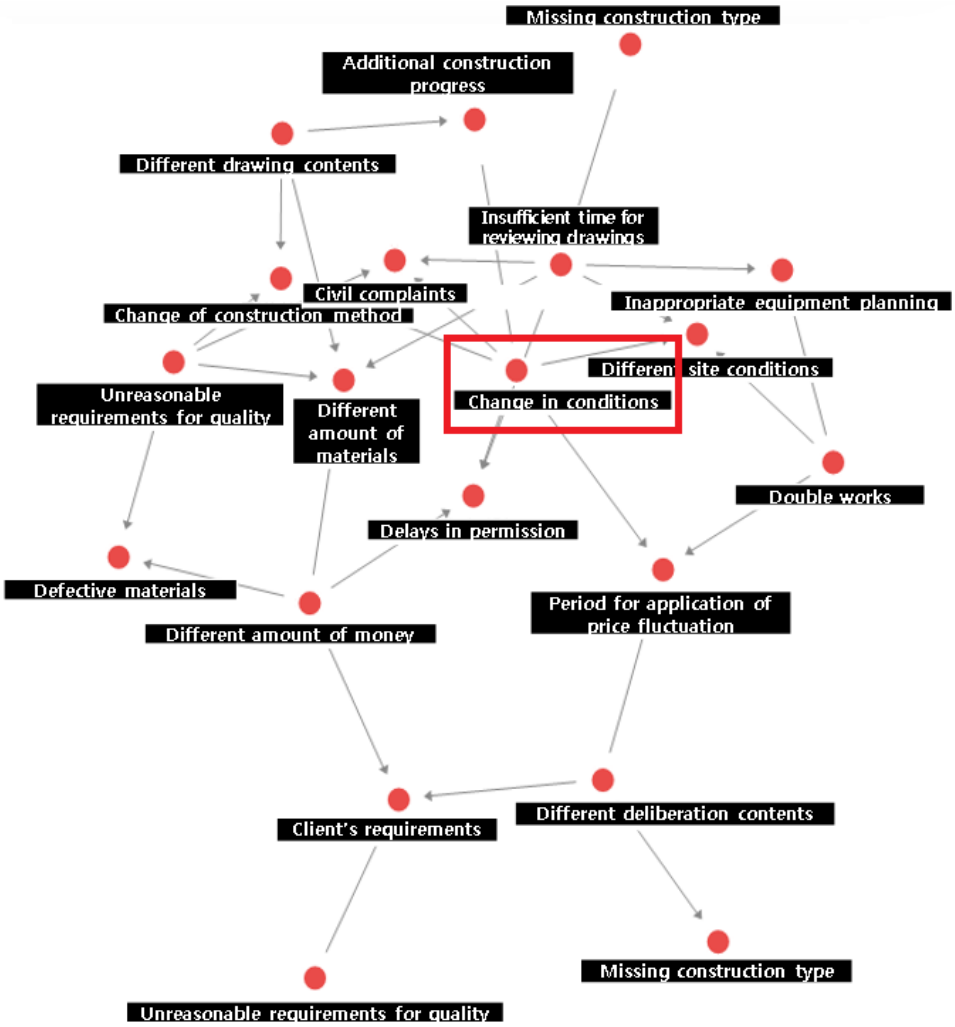

Fig. 2. Relationships between the causes of the claims arising in the design and construction phases

With respect to the centrality value and the order of management priority, the top 3 causes with higher centrality are shown in [Table 6] below.

Table 6. Priority order of the causes of the claims occurring in the design and construction phases

Rank.	Cause	Centrality
1	Change in conditions	2.168
2	Insufficient time for reviewing drawings	1.923
3	Different amount of materials	1.794

In accordance with the above-mentioned contents, the causes of change order claims are determined to be the factors affecting the prevention of the occurrence of claims, and it is expected that the probability of the occurrence of claims can be lowered by managing the key management targets.

5. CONCLUSION

Claims are considered very important factors directly related to the success of a construction project from its commencement. In addition, as change order claims account for most of the construction claims, management measures are needed to be taken to prevent the occurrence of claims. As such, this study examined the relationships among the causes of change order claims by deriving such relationships, and presented data that could help practitioners manage such claims efficiently by selecting key management targets considering the complicated claim structure.

Below is a summary of the contents and results of this study.

First, 250 precedents of change order claims in design-build projects were analyzed to derive the causes of change order claims. For the analysis method, analysis of the meanings of the keywords derived through the text mining technique was performed, and 30 causes of change order claims were derived

based on the results. Second, association rule analysis was conducted based on the derived causes of change order claims, and then 40 rules for the generation of change order claims that can occur in the following stage due to the cause generated in the preceding stage were derived. Third, key management targets were selected by utilizing the social association network analysis technique based on the identified 40 change order claim generation rules.

The rules for the generation of change order claims presented in this study were examined by considering the relationships among the complex causes of claims that occur throughout the preceding and following stages, unlike in the existing change order claim management methods, and the key management items for change order claims are expected to be helpful in efficient claim management.

Meanwhile, in this study, the causes of the change order claims that occur in the design-build delivery method were derived, and their relationships were investigated. Therefore, there is a need to verify the effectiveness of this technique when applied to other delivery methods.

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