Research on conflict handling mechanism of EPC project based on partnering mode

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Abstract. The concept of win-win cooperation emphasized by partnering mode can promote all parties of the project to achieve win-win, and can effectively reduce the conflict and controversy caused by the confusion of work interface, poor communication and coordination and other issues in the project. In this study, first of all, rough set method in conflict analysis theory is used to reflect the conflict degree of each participant on a certain problem and the main conflicts in the problem. Then, combined with the conflict level division and conflict ejection mechanism in partnering mode, a conflict handling mechanism of EPC project based on partnering mode is constructed, which provides a theoretical basis for conflict handling of EPC project according to and practical guidance.

1. Introduction

The mode of EPC has become the mainstream mode of infrastructure project construction in China because it can realize the deep intersection of design and construction. However, due to the influence of Chinese risk culture and trust environment [1], there are many problems in the practice of EPC projects, such as unclear management interface, constant disputes and conflicts, which need to be improved through project management methods. Partnering mode in engineering project is a kind of project management mode in which all participants of the project establish perfect coordination and communication mechanism by signing partnering agreement [2] to realize reasonable risk sharing and friendly conflict resolution [3], which has been well applied in solving conflict management problems of EPC projects in other countries [4].

At present, the application of Partnering Model to solve the conflict of construction projects is mainly focused on the conflict handling as one of the key factors, to explore its impact on the implementation effect of Partnering Model, few studies have established specific conflict handling procedures. Moreover, the existing conflict handling procedures fail to integrate with the typical partnering mechanisms such as partnering seminar, partnering agreement and conflict ejection mechanism. In addition, there are few studies using the conflict analysis theory and other mathematical methods to analyze the conflict of partnering project, which leads to the lack of scientific and reasonable decision-making of conflict processing.

In order to solve the conflict handling problem of EPC project, this study constructs the conflict handling mechanism of EPC project based on partnering mode. This study uses the principle of conflict ejection mechanism in partnering mode for reference, uses rough set method in conflict analysis theory to clarify the conflict degree and main conflicts, prevents and prevents the expansion of conflicts, solves the problem that conflict ejection mechanism can only occur fixed "ejection" according to personnel and time, in order to ensure the scientificity and rationality of conflict handling,
and serves as the conflict place of EPC project. Theory provides theoretical basis and practical guidance.

2. Conflict feature description of EPC project based on rough set method

In the study of conflict handling, some scholars try to combine sociology, psychology, logic and other knowledge, and use mathematical skills such as set theory to establish a set of standardized procedures and methods for conflict research\(^5\). Among them, rough set theory is a method proposed by Z Pawlak, a Polish mathematician, to deal with vague and imprecise information\(^6\). This method starts from the description information of the given problem, and finds the essential characteristics and laws of the problem. This is generally consistent with the actual situation of the conflict handling of engineering projects. The description of conflict characteristics is the pre work before entering the conflict handling procedure, which can provide support for the subsequent entry of the conflict into the appropriate handling procedure and the expansion of conflict prevention.

2.1. Analysis of the degree of conflict

Existing research shows that information systems can be used to represent the relationship between people and conflicts in the bureau\(^7\), and it is now applied to general contracting projects based on the Partnering model. Define the information system as \(S = (U, A)\), where \(U\) is a non-empty finite object set, \(A\) is a non-empty finite attribute set, and another function \(a: U \rightarrow V_a\), where \(V_a \in A\) and \(V_a\) is the range of \(a\). In terms of conflicts, the elements in \(U\) are all the players in the game, the elements in \(A\) are the problems of each conflict, and \(V_a\) is the attitude of the players in the game. Among them, \(V_a = \{+1, 0, -1\}\), +1, 0 and -1 represent pro, neutral, and opposition, respectively.

\[
\text{con}(a) = \frac{\text{card}(X_a^+) \times \text{card}(X_a^-)}{\text{int}(n/2) \times (n - \text{int}(n/2))} \quad (1)
\]

\[
\text{con}(A) = \frac{\sum_{a \in A} \text{con}(a)}{\text{card}(A)} \quad (2)
\]

In the conflict problem, the degree of conflict between \(a\) and \(n\) innings is defined as Equation (1), where \((X_a^+) = \{x \in U: a(x) = +1\}\), \((X_a^-) = \{x \in U: a(x) = -1\}\), \(\text{card}()\) represents the cardinality of the set, and \(\text{int}\) represents the rounding function. For the attribute set \(A\), the conflict degree can be defined as Equation (2), which is used to represent the conflict degree of the situation \(S = (U, A)\). By calculating the degree of conflict of a conflict problem or set in a general contracting project, the degree of conflict of each participant in the general contracting project based on the Partnering mode on the conflict problem or set can be defined. The degree of conflict reflected by \((U, A)\) provides decision support for referring conflict issues to appropriate levels and handling them through appropriate procedures.

2.2. Conflict matrix and conflict function

Due to the different sensitivity of multi-party subjects to conflicts in engineering projects, there are primary and secondary conflicts. On the premise of knowing the situation of conflict problem, using rough set theory to reflect the conflict relationship between people in the bureau can effectively distinguish the main conflict and the secondary conflict. It can not only lay the foundation for the timely settlement of the conflict, but also further determine the Inter player alliance in the situation.

From the information system established above, we can know that the relationship between the people in a game on a certain conflict problem can represent a kind of distance. The greater the distance, the greater the degree of conflict. According to this characterization, a conflict degree function can be established to indicate the degree of conflict between two players. By setting a threshold value, the alliance of players in a situation can be further determined, that is, the conflict relationship between players in the game is reflected. Under the \((U, A)\) information system, there is a relationship between \(B = \gamma B(x, y) = \{\sum \text{d}_a(x, y)\}\). The sum of the distances between the people \(x\) and \(y\) on the collision set \(B\) in the game can be expressed as Equation (3), and the collision function of the people \(x, y\) on \(B\) in the game can be expressed as Equation (4).
distance \((a, x, y) = \begin{cases} 
0 & a(x) = a(y) \text{ or } x = y \\
1 & a(x)a(y) = 0 \text{ and } a(x) \neq a(y) \\
2 & a(x)a(y) = -1 \text{ and } x \neq y
\end{cases}
\)

Therefore, the conflict \(\rho_B(x, y)\) can be expressed as the degree of conflict between the set \(x\) and \(y\) on the dispute set \(B\). On this basis, the B conflict matrix of S is defined as: 
\[
M(B) = (\rho_B(x, y))_{|U| \times |U|}.
\]

3. Conflict handling mechanism of EPC project based on conflict feature description

3.1. Conflict ejection principle of partnering mode

A perfect conflict handling program should be able to solve conflicts in the shortest time and in the most effective way according to the different intensity of conflicts. The conflict ejection mechanism can effectively solve the conflict processing problem by setting the conflict processing level and the time for each level to process the conflict, and its principle is shown in Figure 1. According to this, we can establish a conflict handling emergency mechanism based on partnering mode, which can solve the conflict in the shortest time and the most initial state while taking into account the interests of all participants [8].

Figure 1. Principle diagram of conflict ejection mechanism

Under the function of the conflict ejection mechanism based on partnering, the information about the conflict event itself is transmitted to the most appropriate decision-making level, so as to avoid the distortion of information transmission as much as possible. At the same time, the mechanism limits the time for the decision-making layer to resolve the conflict. If there is no agreement within the specified time, it will automatically "eject" to the previous decision-making layer.

3.2. Hierarchy of conflict handling in EPC project

The conflicts of different strength levels should be handled by matching the most suitable organization level to get good results. In partnering mode, the conflict level is divided into three levels: "dispute-conflict- controversy", which is handled by "operation level-management level-leadership level", and the difficulty of solution increases with the improvement of the level. In this study, the results of conflict resolution hierarchy of EPC project are obtained, as shown in Figure 2.
3.2.1. *Dispute layer*. The conflicts in this level are mostly caused by different opinions of various participants on the construction site activities, such as different opinions on a certain construction process or different arrangements for the construction schedule. However, as such conflicts are not destructive, they can be resolved through communication and consultation by the conflict subjects. In the EPC project, the owner employs the supervisor to strengthen the supervision of the construction process, and the supervisor issues instructions on behalf of the owner. The specific construction process is completed by the cooperation of all departments within the general contractor, so the supervisor and all departments within the general contractor are the main conflict subjects of the dispute layer.

3.2.2. *Conflict layer*. If the treatment at the dispute level fails to work, the problem will be transferred to the conflict level and solved by the personnel who manage the specific technical activities. At this time, the representative of the supervision unit and the head of relevant departments under the general contractor will hold a discussion meeting to negotiate solutions. The supervision unit is entrusted by the owner to carry out targeted management of the project, including cost, progress, quality and other objectives. The specific organization plan is assigned to the personnel of each department by the management of the general contractor. The supervisor and the general contractor management are the main conflict subjects of the conflict layer.

3.2.3. *Controversy layer*. If there is still no consensus after two-level treatment, the relevant responsible person including the owner shall hold a partnering seminar, and all parties shall put forward constructive opinions. This approach is similar to the DRB approach adopted by the world bank in mediating disputes over contracts between the owner and the general contractor, and the DAB approach in the 17th edition of FIDIC. The partnering workshop can continuously pay attention to the development of conflict events in time, and the conflict handling is more timely and effective.

3.3. *Conflict handling procedure of EPC project*  
According to the methods described in the previous chapters on conflict characteristics and the results of conflict resolution hierarchy of EPC projects, a conflict resolution program of EPC projects based on partnering mode is constructed, as shown in Figure 3. The conflict subject of EPC project seeks the best strategy of all parties in the standardized conflict handling procedure, so as to avoid the general conflict events developing to the point of litigation.
Conflict feature description

Whether the conflict is urgent

Solution proposed by Partnering working group

Conflict subject execution plan

Figure 3. Conflict handling procedure of EPC project based on partnering mode

After the conflict, firstly, calculate the conflict degree of the specific conflict problem or set, and judge the conflict degree and relationship of the conflict subject scientifically. When the conflict is more urgent, the partnering working group composed of representatives of the owner and the general contractor will hold a seminar to propose solutions. When the conflict is not urgent, the operation level, management level and leadership level shall first conduct short-term consultation among the parties after receiving the conflict to be handled, and determine in advance whether they are able to deal with the conflict. If the conflict cannot be effectively handled at this level, or if the resolution time at this level is too long, the problem shall be handled at a higher level. After reaching an agreement, the parties to the conflict can implement the solution, and the process and results of the conflict handling shall be retained in the form of text. If all three levels of conflict handling fail, the conflict will be handled by the third-party institutions such as arbitration institutions and judicial departments.

4. Verification of conflict handling mechanism based on Urban Rail Transit Project

4.1. Background of conflict event

Guangzhou Metro adopts the mode of general contracting, which is the fastest designed high standard Metro City Express Line in China. Before the implementation of the project, due to the
constraints of the surrounding environment of the river crossing section and the difficulties of shield machine construction turning, the S-shaped line has to be adopted for the river crossing section, which can only be completed with the cooperation of shield machine and many construction measures. The owner and the general contractor have agreed on the main construction equipment and measures in the contract, but the actual construction difficulty is beyond the expectation. In order to ensure that the subway can be operated on time, the general contractor shall rush to work at the request of the employer, and more than 40 Shield Machines shall be constructed at the same time during the construction peak.

4.2. Focus of conflict event

The general contractor has put forward optimization proposal for the original supporting equipment of shield machine to ensure long-distance normal driving in extreme composite stratum. After receiving the guarantee from the general contractor that the change will not affect the original technical indicators of the project, the owner approved the optimization proposal of the general contractor in the form of change and proposed to deal with the change according to the provisions of the contract. The general contractor believes that this change will not affect all kinds of technical indicators of the original project, and will help the project to be completed on time or even in advance, so it is proposed that the benefits brought by this optimization to the project shall be shared by both parties of the contract.

4.3. Analysis of conflict event

The general contractor optimizes the original supporting equipment of shield machine, which is helpful for the project to be completed on time or even ahead of schedule. It conforms to the rationalization suggestions or design optimization judgment of the contractor in the 17th edition of construction contract (model text) and the 17th edition of FIDIC silver book, but does not share the benefits brought by optimization with the owner as the premise of implementation optimization. The "fixed price contract" is adopted for the project. If the change is implemented according to the contract, the contract price shall be adjusted accordingly. However, the contract does not specify design optimization as the specific treatment method approved for the change, so the owner has reason not to share the benefits brought by design optimization. Both sides' views are supported by evidence, and the conflict resolution is in deadlock.

4.4. Process of conflict resolution

4.4.1. Conflict feature description. This project first calculates the degree of conflict between the design optimization revenue sharing problem by calculating the conflict degree of the design optimization revenue sharing problem. Secondly, construct a conflict matrix for each participant and set the threshold to analyze the alliance of each participant. In this project, there is a conflict between the owners (1), the general contractor (2), and the supporting equipment suppliers (3) of designing and optimizing revenue sharing. The set \( U(1,2,3) \) is used to represent the conflicting three-party subject, and the set \( A(a,b,c) \) is used to represent the three-party conflict problem. The conflict situation between the participants is represented by the conflict information system, as shown in Table 1.

Table 1. Tripartite conflict information system of the project

| Project parties | Design optimization revenue sharing between general contractor and owner (a) | Design optimization revenue sharing between general contractor and ancillary equipment suppliers (b) | Optimized revenue sharing between owners and equipment suppliers (c) |
|-----------------|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| 1               | -1                                                                       | 0                                                                                             | -1                                                                |
| 2               | +1                                                                       | -1                                                                                             | -1                                                                |
| 3               | +1                                                                       | +1                                                                                             | +1                                                                |
According to formula (1), the degree of conflict between the project participants on conflict problem a:

\[
\text{con}(a) = \frac{\text{card}(X_a^+) \times \text{card}(X_a^-)}{\text{int}(n/2) \times (n - \text{int}(n/2))} = 0.67
\]

Also calculate \( \text{con}(b) = 0.33 \) \( \text{con}(c) = 0.33 \)

According to formula (2), the degree of conflict of each participant in the conflict set A is:

\[
\text{con}(A) = \frac{\sum_{a \in A} \text{con}(a)}{\text{card}(A)} = \frac{0.67 + 0.33 + 0.33}{3} = 0.443
\]

According to formula (3), the sum of the distances between the owner and the general contractor on the conflict set A is:

\[
\gamma_A(x, y) = \left\{ \sum d_{a}(1,2) \mid \text{distance}(a, 1,1) \right\} = \{1 + 1 + 2\} = 4
\]

According to formula (4), the conflict function between the owner and the general contractor on the conflict set A is:

\[
\rho_A(x, y) = \frac{\sum_{a \in A} d_{a}(x, y)}{2|A|} = 0.83
\]

Also calculate \( \gamma_A(1,3), \gamma_A(2,3) \) to get the conflict matrix

\[
\begin{array}{ccc}
1 & 2 & 3 \\
1 & & \\
2 & 0.83 & \\
3 & 0.67 & 0.5 \\
\end{array}
\]

The degree of conflict among the participants in the project is relatively large, especially between the owner and the general contractor. As the supporting equipment supplier adopts new technology to improve the efficiency of shield tunneling, it needs to obtain this part of contract amount from the general contractor, so it will support the general contractor to share the benefits of optimization with the owner, and even is expected to share this part of benefits with the general contractor. Suppliers of supporting equipment are also included in the main conflict subjects.

4.4.2. Conflict handling mechanism. According to the calculation results of conflict degree, all participants of the project pay more attention to the sharing of design optimization benefits. Because of the large amount of construction work, the high proportion of machinery and equipment investment and the complex measures and schemes in the river crossing section, it accounts for a large proportion in the contract amount, which is an emergency conflict. Through the prediction of the project subject's ability to deal with the conflict, it is directly handed over to the project leadership for handling. The partnering working group organized a seminar for the owner and the general contractor, in line with the willingness of cooperation, to re sort out all the information of the conflict event and give their own constructive opinions. After the mutual concessions of both parties, the owner and the contractor finally gain benefits from the design optimization, and the project can be successfully delivered for use.

5. Conclusion

This study provides a theoretical basis and method for the conflict handling of EPC projects and the rapid development of EPC projects. In this study, rough set method is used to clarify the conflict characteristics, and the conflict level division and conflict ejection principle of partnering mode are used for reference. The conflict handling mechanism of EPC project is obtained, and the case of urban rail transit project is used for verification. Due to the constraints of objective conditions and personal capacity, there are still some limitations in this study. In this study, partnering team was established to assist in conflict resolution, but the composition and operation of partnering team were not analyzed in depth. Although partnering mode can effectively improve the opposition of all parties in the project, it still needs to be improved in combination with the current construction project management system in China, and the specific measures in the implementation of the conflict handling mechanism should be detailed.
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