Towards Automated Analysis of Ambiguity in Modular Construction Contract Documents (A Qualitative & Quantitative Study)

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Abstract

Modular coordination in building construction has become increasingly popular, particularly in Northern Europe and North America. Modular construction in Canada gained considerable attention over the last decade due to its positive impact on project constraints, safety, and preventing construction and demolition waste. However, the modular construction industry still adopts the same administrative procedures designed for the conventional construction industry even though the features of modular and conventional construction are different in terms of construction processes and methods. Due to this trend, ambiguities in administrative documents are widely occurred and are one of the main causes to generate conflict, disputes, and claims between owners and modular suppliers as general contractors. As a first step in the on-going research to overcome this challenge, the research team focuses on investigating the contents and structures of the current contracts, which are one of major confusion sources in modular construction, in order to mitigate and/or eliminate the ambiguities in the contracts based on the considering the features of modular construction processes and methods. In this respect, this paper presents a conceptual framework, which is: (1) to classify the major ambiguities in conventional and modular construction contracts; (2) to identify the similarities and differences between Canadian contract documents and benchmark countries. We use text mining to find top terms, including terms with high TF in each document, and high TF-IDF terms, which specifically occur in one document and not others then, we detect manually the three standard contracts and compare them with the output of literature review to identify the major issues that are common.

Keywords

Text mining • Taxonomy • Modular • Contract document • TF • TF-IDF

41.1 Introduction

'Modular Construction' is the ability to manufacture in different place and transport to the place of installation in one or more sections [1]. Modular coordination in the building became increasingly popular through countries which are located in geographically remote and cold areas such as Sweden and Northern Canada or where the feasibility of on-site construction is low [2]. This kind of construction was introduced to European and North American countries after World War II. Reports in 1996 show high precast levels in Denmark 43%, the Netherlands 40%, and Sweden and Germany 31% [3]. In the early 1970s, Eastern and Western Europe started using this method for construction of new suburbs, towns, and public buildings, thus, they set up specific standards for examining component specifications such as tolerance and installation standards [3]. Because of high demand and lower costs, this industry became popular in Asian countries as Malaysia and India. A Survey in 2003 shows 15% of construction in Malaysia was built, using the Industrialized Building System (IBS), therefore, the government started a program which insisted that all public projects must contain 70% IBS components [4].

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In North America, the Canadian construction industry has turned toward a new approach named Permanent Modular Construction (PMC) since the 1990s. Modular construction in Canada gained considerable attention over the last decade due to its positive impact on project constraints, safety, and preventing construction and demolition (C&D) waste. In 2002, the Canadian construction industry produced 3.3 million tons of Construction and Demolition (C&D) waste 30% of the total municipal solid waste deposited in landfills (Canadian Home Builders' Association, 2010). A workshop held at Concordia University in October 2015 to discuss about challenges and opportunities for modular construction in Canada. During this workshop, experts released some reasons, which have been determined as the barriers to off-site projects in Canada including standards, regulations, and procurement strategies that favor conventional construction technologies such as a value-based system [5]. Unfamiliarity with the transportation regulations and inability to convince the state government to allow transport the modules overstate highways caused $2 million US cost overrun for Kearl Oil Sand project in Canada [6]. In the U.S., the average cost per square foot of a manufactured home was $42, versus $86 for site-built homes, excluding land [1]. Furthermore, this new industry like other new industries, always hurdles and difficulties exist in the first steps such as lack of knowledge about the modular construction industry, design and construction culture [7]. Insufficiently grounded, qualitative, and quantitative research is another issue in the way of PMC [8].

The significant issues related to starting a modular construction are the site condition, inefficient standard contract documents, transportation conditions, local codes, skilled labor unavailability, design complexity, and organizational readiness [9]. Since the contracts have this ability to reduce the risk of the project in earliest stages, they have this potential to unfairly be abused by one of the parties to transfer the risk to other parties by using some unfair and unclear provisions or clauses. Therefore, the construction industry turned to use of standard contracts that are provided by experienced architects, contractors, owners, sub-contractors, engineers, and lawyers, and then approved by leading professional teams. Standard contract documents provide consistency and eliminating the ambiguities [6].

Many researchers have been studying the sources and effects of confusion in traditional construction contract documents, but there is not enough number of comprehensive research work for the modular construction contract. The present paper presents a conceptual framework for classification of the major sources of ambiguity in construction contracts (both general and modular), and applies it through text processing, to identify the similarities and differences between Canadian contract documents and some benchmark countries. Therefore, both of the literature review and our research shows that modular construction industry suffers from lacking of specific set of standard contract for itself that is one of the main sources of confusion in this industry.

41.2 Methodology

This study has two major phases; developing an analysis framework, and using text mining to analyze contract documents. In the first phase, an analysis framework was developed through a comprehensive review of the literature as well as existing standard contracts (Fig. 41.1). In this regard, publications related to the sources of ambiguity in (both on-site and off-site) construction contract documents, published since 1980 were reviewed and analyzed. That part of the study synthesizes results of 20 papers under five major categories (i.e. contract language, contract document, stakeholders, design-related issues, and external factors) as well as sub-categories. The results of that work are reported elsewhere, but, given the objective of the present paper, here we have limited our scope to the category called "contract documents". Sub-categories of this category in our conceptual framework, as well as some of the causes (reported in the literature) giving rise to each sub-category, are listed in Table 41.1.

In the second phase, we focused on standard contracts commonly used in modular construction in three English speaking countries (the US, UK and Canada), to investigate each of the subcategories (and causes) listed in Table 41.1. From the USA, the American Institute of Architects (AIA) standard contract was chosen and from the UK, the newest standard contract, New Engineering Contract (NEC3) Engineering and Construction Contract (ECC) was selected. We also chose the standard contract by Canadian Construction Documents Committee (CCDC), which is the most popular one in Canadian industry. Since the Design-Build (DB) delivery method is more commonly in use by the modular construction companies in those countries, we targeted standard DB contracts issued by the three organizations. Moreover, the studies indicate the Design-Build delivery method not only has more adaptability with the modular construction, but also the modular contract documents based on DB normally result in fewer ambiguities compared to other methods [10]. As a result, we selected the standard contracts: CCDC14 (Educational copy 2013), AIA141 (2014), and NEC3 (2013) as the input for this research. It should be noted that although NEC does not have a specific DB contract, according to our correspondence with the agency (http://www.nec-contract.com), the closest contract to Modular Construction is NEC3 Engineering and Construction Contract (ECC).

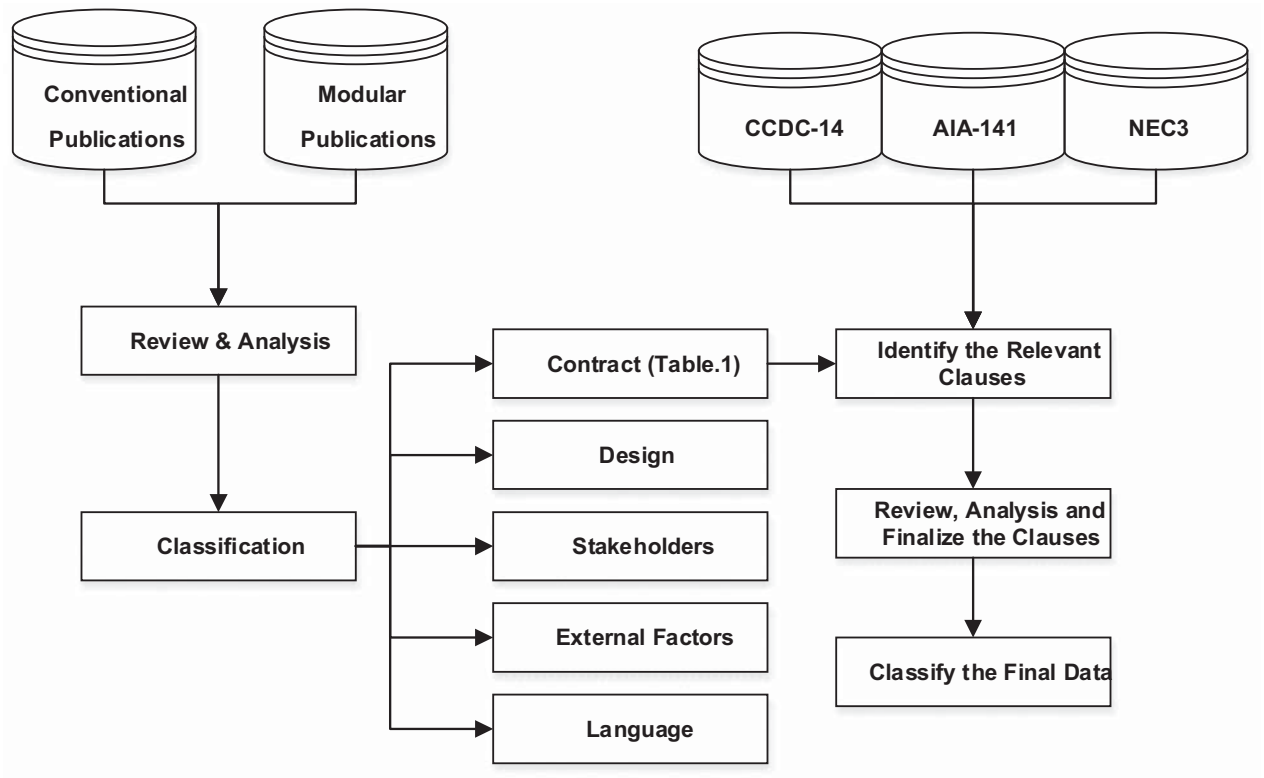

Fig. 41.1 Developing an analysis framework

We used text-mining tools, followed by interpretation of results, for a quantitative analysis and comparison of the three documents within our conceptual framework. More specifically, we evaluated similarities and distinctions among the documents, within the dimensions of our analysis framework, through evaluation of simple and basic text mining measures such as TF (Term Frequency) and TF-IDF (Term Frequency-Inverse Document Frequency). In this regard, we first classified clauses and terms in each contract, into the sub-categories shown in Table 41.1. From the 23 classes that we began with (one per each "cause" in Table 41.1), we had to exclude the ones for which we failed to find relevant clauses in all the three contracts. We also removed the classes for which the size of relevant clauses in the three contracts were significantly different; in this regard, we excluded the cases in which the size of text for one contract was 5 times less than the other two. As a result, we finally focused on seven classes, each of which associated with one major sources of confusion extracted from the literature review. Table 41.2 introduces those classes, and the size (i.e. the number of terms) of relevant clauses associated with them in each contract.

The collected text was mixed with unneeded information (including terms, characters, etc.) which must be filtered before the analysis. We converted all the collected texts into Unicode (since they were in different encoding formats), then used Regular-expression to remove unneeded characters as well as changing all the plural nouns to singular type (due to the aggressive nature of most stemmers available, which sometimes creates confusions in the final results, we decided to only turn the plurals to singular). Moreover, we used a stop list to clean the data from common words with no specific semantics (such as punctuations, conjunctions, articles, etc.). Next step of the preprocessing after the cleaning was tokenizing the input text (to their terms). In this regard, specific compound words which communicate semantics in the context of our study (such as 'Contract Price' and 'place of work'), as well as some specific terms (such as 'Design-Builder' and 'Federal Arbitration Act') were merged (to 'contractprice', placeofwork, 'designduilder', and 'federalarbitrationact' respectively). It is worthwhile emphasizing that merging such terms happened before applying the cleaning step. The cleaned and tokenized data were used as the input of text analysis.

We start text mining by evaluating frequency metrics, taking advantage of the Natural Language Toolkit (NLTK), which is a suite of Python libraries for symbolic and statistical natural language processing for English language. We focused on top terms in the corpus, including terms with high TF (frequency of occurrence) in each document (i.e. accumulation of

Table 41.1 Sources of confusion related to the "contract documents" and sub-categories according to the literature review

Sub-category	Cause	Code
Poor Draftmanship	False presentation of facts and other similar abuses [6]	1.1
	Not following guidelines and standards [11, 12]	1.2
	Lack of the knowledge and training by draftsmen [12, 13]	1.3
Missing Information	Being silent about construction method/technology [14]	2.1
	Being silent about production and installation machinery [11, 14]	2.2
	Lack of tolerance criteria [15, 16]	2.3
	Unclear Quality audit and control criteria [15]	2.4
Ambiguity of the Information	Complexity of Workers Compensation Board (WCB) [17, 18]	3.1
	Unclear scope definition [17–19]	3.2
	Unclear acceptance performance definition and criteria [20]	3.3
	Inconsistent statutory obligations [21]	3.4
	Unclear payment conditions [11, 19]	3.5
	contradiction and inconsistency between the warranty and contract [17]	3.6
	Errors and mistakes in technical specifications [15]	3.7
	Dispute resolutions complexity [5]	3.8
	Inconsistencies and contradictions among different documents [20]	3.9
Redundant Information	Contradictory and erroneous info. In the mass of documents [22, 23]	7.1
Lack of Local Regulations and Best Practices Contingencies	Poor Project integration [11, 17, 18, 24]	4.1
	Poor Project financial planning [13, 23, 25]	4.2
	Lack of familiarity with local force majeure [4]	5.1
	Lack of contingency planning strategies [17]	5.2
	Inadequate bonds and insurance to cover failure of the parties [18]	5.3
Mismatch between Project Delivery Method and the Contract Type	Difference of terminology for contracts used in different delivery methods [16, 21, 26]	6.1

related clauses from each contract in each topical class), and high TF-IDF (high frequency of occurrence, uniquely in each document). Therefore, if term i appears fij times in document j, then [27]:

$$\mathrm{TF}_{ij} = \frac{f_{ij}}{m_j} \tag{41.1}$$

in which $m_j = \max(f_{ij})$ and if n shows the number of documents to be compared, then:

$$\mathrm{IDF}_i = \log(n/1 + d_i). \tag{41.2}$$

TF-IDF is then calculated for each term in each document as the product of its TF and IDF.

Terminology difference in different countries was one of the challenges in this research. Even-though all three contracts were selected from English speaking countries; differences in the names used to refer to the same concept in the three countries, caused confusion in our text-mining engine and the results. For instance, NEC3 uses the term 'employer' to refer to the 'owner', as called by CCDC14 and AIA141. As another example, the term 'place of the work' in CCDC14 is the same as the term 'site' in AIA and NEC. In this regard, we had some limitations of the work such as lack of systematic method also, TD-IDF limitations in terms of detecting the synonyms, proverbs, compound words, expressions, etc. (For large document collections, this could present an escalating problem). In order to resolve this issue, we applied some post-processing, where we systemically detected synonyms among terms with high TF or TF-IDF, and replaced them by uniform equivalents. In this paper, we selected CCDC14 as the basis for synonyms and changed terms of other two contracts to their synonyms in CCDC14. We iteratively performed the TF and TF-IDF process, followed by the post-processing until the no synonyms were left among top TF and/or TF-IDF words. Figure 41.2 shows the process of our method.

Table 41.2 Major causes of confusion in contract documents investigated in this study, and the associated size of relevant clauses in the three standard contracts studied

Feature (topical class)	Standard Contracts (count*)			
	Codes (Link to Table 41.1)	AIA 141	CCDC 14	NEC3
Acceptance performance and criteria	3.3	1149	306	563
Payment conditions	3.5 and 4.2	2533	1829	2245
Claims and dispute resolution	3.8	1743	2362	2194
Quality, inspection and tests	2.4 and 3.7	372	269	346
Contingency strategies and delays and extension of the time	5.2	289	386	319
Bonds and insurance	5.3	2172	829	541
Job site condition and information (storage space, accessibility etc.)	3.2 and 5.1	493	115	184

*Size is based on the total number of words in each class

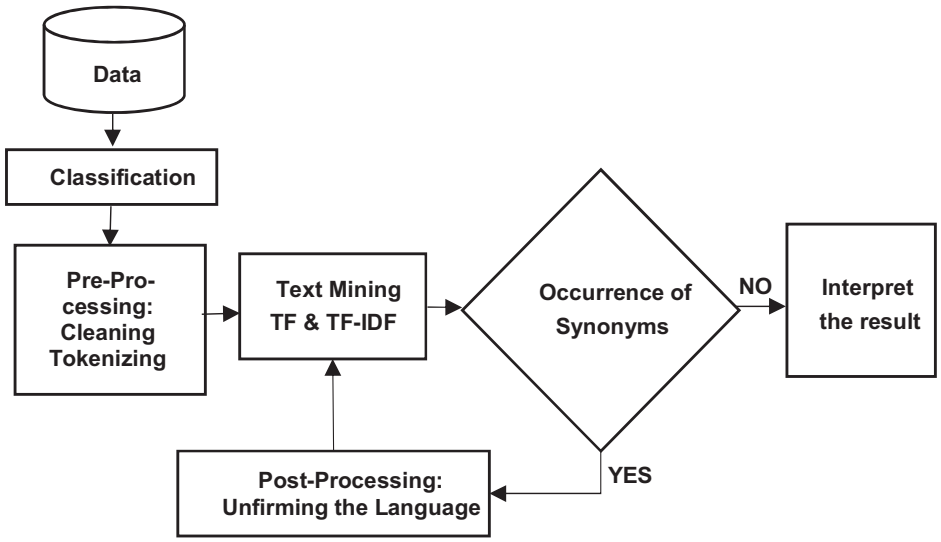

Fig. 41.2 The process of text mining

By trial and error, we decided to select the top 25 TF and TF-IDF terms for each of the seven topical classes, in each contract. This number was set so that the terms in the lists have meaningful frequencies (more than one) in the text they come from. This is due to the fact that the chance is low for a term with frequency of one, to have an important semantic role in a document. The lists of high TF and high TF-IDF terms, although being good indicators, providing at starting point for interpretation, are not enough for making a meaningful comparison among the texts. Therefore, after finishing TF and TF-IDF analysis, we searched for the instances of occurrence of those terms in the documents, and manually reviewed those parts, to complete the comparison between standard contracts. The following section summarizes the results of the study.

41.3 Results

We started the comparison among standard documents by looking at different actors and roles in the three documents. Table 41.3 summarizes the major roles in each document; as shown, while AIA141 and CCDC14 introduce the same roles (with the same terminology), NEC3 uses a different terminology. For example, 'Employer' instead of 'Owner', 'Contractor' instead of 'Design-Builder' and 'Supervisor' instead of 'Consultant'. More importantly, NEC3 introduces an additional role, the 'Project Manager', whom is hired by the owner, and is given a high level of authority to communicate with the contractor and the supervisor. This alteration might be partially due to the fact that NEC3 is inherently different from the other two contracts, and is not specifically a DB contract (but the closest one to that delivery method). Moreover, a project manager with high experience with modular construction hired by owner can be beneficial for items such as 'project integration

Table 41.3 Different roles in three standard contracts

AIA141	CCDC14	NEC3
Design-builder	Design-builder	Contractor
Owner	Owner	Employer
–	–	*Project manager*
Consultant	Consultant	Supervisor
–	*Payment certifier*	–
Insurer	Insurer	Insurer

Table 41.4 Main roles related to dispute resolution in the three standard contracts

AIA141	Freq. of occurrence	Size of document	CCDC14	Freq. of occurrence	Size of document	NEC3	Freq. of occurrence	Size of document
Mediator	1	1743	Project Mediator	7	2362	adjudicator	95	2194
Arbitrator	4		Arbitrator	0		Arbitrator	4	
Joinder (Person)	4		–	–		–	–	

(codes 4.1 and 4.2)', 'Dispute resolutions complexity (code 3.8)', 'contingency planning strategies (5.2)'. In addition, CCDC14 has the additional role of 'Payment Certifier', assigned by the owner to review and certify the Design-Builder's application for payment and issuance the certificates of payment. A 'Payment Certifier" can be help to reduce the effect of items 'Unclear payment conditions (code 3.5)' and 'Poor Project financial planning (code 4.2)' shown in Table 41.1. As mentioned in the literature review, one of the issues in modular construction is organization readiness.

On the other hand, as shown in Table 41.4, the process and roles involved in the dispute resolution procedure are different among the three standard contracts. The major roles defined include 'adjudicator' in NEC3 and 'joinder person' in AIA. From the comparison of related clauses in the two contracts, it appears that 'adjudicator' in NEC3 has the same role as 'project mediator' in CCDC14, but with more detailed responsibilities. Occurrence frequency results for terms such as 'project mediator' in CCDC14 (and 'mediator' in AIA141), compared to 'adjudicator' and 'arbitrator' in NEC3, could indicate that the North American contract contracts would recommend resolving disputes through negotiation than judicial authorities.

In terms of the schedule, Units for measuring the time are different in these contracts. AIA141 uses the term 'day' (mean Calendar Day) and NEC3 uses the 'week' as the time unit. On the other hand, CCDC14 is using its two different units of time for different parts of the contract. It uses the term 'Working Day' for part 6 (changes in the contract), part 7 (right to suspend or terminate), and part 8 (dispute resolution) while it is using the term 'Calendar Day' for part 5 (payment), part 11 (insurance and contract security), and part 12 (indemnification, limitation of liability, waiver of claims, and warranty). This can be an indicator of providing more objectively and clearly defined duration units by CCDC14 (for both windows of submitting new claims and reasons for more disputes).

The concept of "defect certificate", suggested by NEC3 contract, helping to monitor the defected portion of the work, does not exist in CCDC14 and AIA141. This certificate is either a list of defects, provided by the supervisor (who is issuing his certificates to the Project Manager and the Contractor), to be corrected by the contractor during a defect correction period; or a statement that there are none, at the end of the defect correction period. This term is specifically used for some of the categories mentioned in Table 41.1, such as performance acceptance criteria (code 3.3), payment criteria (code 3.5) and bond and insurances (code 5.3). NEC3 has some clauses about the delay, and associated responsibilities or extra costs due to repeating the tests and/or inspection. However, there is only one sentence in AIA141 indicating that the cost of additional tests and inspection shall be at the design builder's expense. In this matter, CCDC14 has only one clause, saying that delays by "common carriers" entitle the design-builder for extra time.

AIA141 has a clause mentioning the acceptance and payment for materials, equipment, and products stored outside the place of the work must be approved in advance by the owner, at a location agreed upon in writing. Similarly, in CCDC14, the payment certifier approves the products delivered to the place of work as of the last day of the payment period. More considerably, NEC3 has a clause mentioning that the materials and plants, which are outside the site, are not allowed to be transported to the site before approval of tests and inspections (as required by contract in the work information). These

Table 41.5 Dispute resolution steps in three standard contracts

AIA141	Freq. of occurrence	CCDC14	Freq. of occurrence	NEC3	Freq. of occurrence
Initial Decision	14	Negotiation	6	Adjudication	10
Mediation	19	Mediation Negotiation	5		
Arbitration	25	Arbitration	14	Arbitration	6
Court	8	Court	5	Tribunal	24
Litigation	1	–	–	–	–

findings are specifically important for modular construction projects, as they normally have large amounts of modules built off-site in the factory. Lack of information regarding terms and conditions of transportation, inspection, acceptance and payment for such modules is normally one of the main sources of ambiguities reported in the literature. This paragraph can be related to items 'Unclear payment conditions code (3.5)' and 'Unclear scope definition (3.2)' as shown in Table 41.1.

Based on the literature review, lack of efficient local codes is one of the major issues for modular construction contract documents. The term 'Quebec', as a Canadian province with fundamentally different standards, rules and regulations, has been mentioned nine times in CCDC14. The Canadian standard contract tries to support cross-provincial projects (i.e. companies based outside Quebec, planning to work in this province or Quebecer companies, willing to use a Canadian standard contract). The information provided include the duration of holdback amount for the design-builder, sub-contractor and suppliers, Quebec sales tax, Quebec pension plan and different civil code for substantial performance of the work. This can be an evidence of providing support for the lack of local regulations and best practices, reported in our conceptual framework (subcategory 4, Table 41.1).

Finally, in the category of "claims and dispute resolution", on our findings (summarized in Table 41.5), shows considerable differences among the three standard contracts. The difference, partially has roots in terminology difference of the documents, and partially shows variations in the process of claim and dispute resolution. In CCDC14 dispute, resolution is suggested to solve the problems with amicable negotiations at first, if unsolved, then to proceed with mediation by assigning a 'project mediator', and at the end, it offer the arbitration process. In AIA141, 'initial decision' (inherently similar to 'negotiation' but with a longer procedure) is explained, and the details of communication between parties to manage the dispute are elaborated. Initial decision is followed by 'mediation' and then either 'arbitration' or 'litigation'. Lastly, NEC3 offers different terminology and process. In this contract, 'adjudicator' has the main role for the dispute resolution. Disputes are referred to the adjudicator in accordance with an 'adjudication table'. If the parties cannot resolve the disputes through the adjudication process, they then go to the 'tribunal' as the last step of dispute resolution. Administrative tribunals are set up to be less formal, less expensive, and a faster way to resolve disputes compared to the traditional court system.

41.4 Conclusion

The features of modular and conventional construction are different in terms of construction processes and contract documents then, ambiguities in administrative documents are widely occurred and are one of the main causes to generate conflict, disputes, and claims between owners and modular suppliers as general contractors. Our findings based on comparison among 'Dispute Resolution' parts of these three contracts show considerable differences in this subject among three standard contracts. (Shown in Table 41.5) The different words which showing differences in the process of the claim and dispute resolution also different names of the main actors (See Table 41.4). In case of Modular Construction, Dispute resolution becomes more complex and sensitive because of either new types of modular disputes or different types of stakeholders in this method such as 'Manufacturer', 'Transporter', 'Installer', 'Machinery suppliers', etc. (as shown in Table 41.1. Code 3.8)

Among our findings from the comparison of these three standard contracts, we found some clauses related to the transportation, the inspection and payment criteria for stored material and equipment outside of the site, which is essential for our case, which is modular construction and majority of the work, should be done off-site and deliver to the site.

The differences between measures for the time among these contracts is important since one of the three main scopes of each project is time and if the measures of the time are not clear, drive the project to more claims and disputes.

Even though all three contracts are from English speaking countries but our findings show that there are considerable differences among these three based on the names, idioms, measures, processes of dispute resolution, payment criteria, etc.

While the scope of this research was determined by the level of analysis needed to answer the questions posed earlier, future work can add more insights by looking at more resources among more benchmark countries. In term of text analysis, going beyond single terms into bi-grams and tri-grams in the feature extraction may add into the meaning of these results. In addition, testing analyses with a different scope (adding more benchmark countries) can help to verify or add to the findings of this paper. Finally, adding private modular construction contracts helps this research to take the outputs into a new level and shed more light on the content of the modular contract.

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