4th Construction Specialty Conference
4e Conférence spécialisée sur la construction

Montréal, Québec
May 29 to June 1, 2013 / *29 mai au 1 juin 2013*

Introducing the Concept of Green Performance Bond and Its Application in Managing Greenhouse Gas (GHG) Emissions in Construction Projects

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Abstract: With growing concern about global warming and climate change, the construction industry, as a major contributor to greenhouse gas (GHG) emissions, has begun to realize its essential role in improving the environment by reducing emissions through the life cycle of buildings and infrastructure. While a considerable amount of prior research has been devoted to assess the environmental impacts of sustainable design alternatives and post-construction operations, there is an increased awareness of, and demand for, managing greenhouse gas (GHG) emissions during the building process. One approach suggested by previous researchers is to adopt an innovative competitive bidding system which includes the estimated environmental cost incurred during the construction phase as one of the evaluation criteria in addition to cost and schedule. The main problem with this practice, however, is that there are no enforcement mechanisms to guarantee the performance of GHG emissions. As a result, it may induce contractor's opportunistic bidding behaviour which could lead to many issues such as abnormal low bids and poor environmental performance. To address the problem, this research proposed a framework which adds another dimension to the traditional project management structure and investigates the possibility of applying a green performance bond to insure against the risk of discrepancy between the actual and expected performance of GHG emissions during construction. Drawing an analogy from the construction performance bond, a conceptual model is presented to illustrate how to utilize this innovative surety product to manage embodied carbon in the building process. The result shows that from the owner's perspective it is a way to encourage contractors to improve their environmental performance through financial means.

1 Introduction

Burdened with a stressed budget and tight schedule, most development in the construction industry in the past decades was mainly guided by short-term economic considerations (Singh 2007). However, the imperative is a strong focus to deal with the pressing issues of sustainability such as carbon footprint at each stage of a building's life cycle. While it is difficult to determine the extent of climate change driven by the Greenhouse Gas (GHG) effect, there is little scientific debate on the fact that the global concentration of carbon dioxide in the atmosphere has far exceeded its natural range (EIA 2004), presenting itself as one of the most significant risks that could lead to serious social and economic consequences (Epstein 2000, McMichael et al. 2003, IPCC 2007, ISO 2007). Since 1997, various efforts have been made to catalyze upon global action to curb GHG emissions and promote sustainability (Cui and Zhu 2011).

In response to other industries that strive to improve their environmental performance, the construction community has recently begun to realize its leadership role in promoting environmental stewardship. While a considerable amount of prior research has been devoted to assess the environmental impacts of sustainable design alternatives and post-construction operations (Vale and Vale 1996, Guggemos and

Horvath 2006, Peschiera et al. 2010), there is an increased awareness of, and demand for, managing greenhouse gas (GHG) emissions during the building process. According to the EPA (2009), the construction industry produced approximately 1.7% of the total U.S. GHG emissions in 2002, placing itself as the third highest GHG emitting sector. Although a single construction process does not produce as much GHGs as the operations of other industries, such as chemical or steel manufacturing, the sheer number of construction projects results in a significant amount of aggregate emissions (EPA 2009). Further projections illustrate that among seven industrial sectors, the construction industry is predicted to have the highest average annual rate of increase in GHG emissions from 2011 through 2030 (EPA 2009).

The problem with current practices in managing GHG emissions during the construction phase is that existing government regulations and standards for construction emissions are limited to hazardous air pollutants (HAPs), such as CO, NOx, PM, volatile organic compound (VOC) and SO2, with no focus on GHGs (Peña–Mora et al 2009), despite the fact that GHGs are also defined as a pollutant under the Clean Air Act, ruled by the U.S. Supreme Court in 2008 (EPA 2008). As a result, although the government is providing incentives for carbon reduction, there are no enforcement mechanisms to guarantee the performance of GHG emissions if the contractors consider the reduction measurements to be economically unattractive. On the other hand, even if contractors strive to follow the pre-determined emissions goal, there always exists the risk of "over-emissions" resulting from inefficient construction methods, field rework, and improperly sized equipment, among others. To deal with this unwanted situation, there is a broad agreement that the key policy is to put a price on GHG emissions (CBO 2008). One example is the popular cap-and-trade policy in Europe and Asia, where each firm in the system is assigned an overall quota, or cap, on the total amount of CO2 they are allowed to emit. Firms that "over-emit" must purchase an extra quota from those organizations that emit less than their allowance, so as to keep the total amount of emissions in the system to a certain limit (Tietenberg 2003). However, despite the vigorous debate of introducing the cap-and-trade program into the US, there is currently no system in existence. Hence, there is a need to explore other possible methods on managing GHG emissions during the construction phase. Green contracting in construction projects, especially highway projects, has been recognized by researchers as an innovative strategy to tackle climate change and decrease GHG emissions of construction activities (Cui and Zhu 2011). Next section discusses different green contracting strategies in more detail.

2 Green contracting through alternative bidding methods

While there is still no universally agreed upon definition of green contracting in construction, it can be thought as any strategic consideration in construction contracts which makes construction practices more energy efficient and more environmentally friendly. More precisely, green contracting can be defined as contract provisions, contracting methods, and delivery strategies which aim 1) reducing GHG and other emissions and enhancing adaption to climate change, 2) benefiting the environment, and 3) creating economic, ecological, or social benefits to improve the public lives' quality (Cui and Zhu 2011). These objectives are aligned with the main goals in the executive order 13514 (2009) titled "Federal Leadership in Environmental, Energy, and Economic Performance" issued by the US department of energy which emphasizes the environmental consideration in federal procurement. Specifically, this executive summary asks for ensuring that 95% of new contracts are energy and water efficient, and environmentally friendly. This study focuses on green contracting strategies as contributors to energy use reduction and emission mitigation. They can help achieve this purpose either directly through installing diesel emission retrofit devices, replacing or upgrading engines, using alternative fuel, minimizing equipment idle time, etc or indirectly through using reclaimed asphalt pavement (Cui and Zhu 2011).

Different green contracting strategies have been practiced by public agencies such as contract specifications, contract allowances, and alternative bidding methods (ICF 2005). Contract specifications mandates either using construction equipment certified by EPA or installing diesel emission retrofit devices (Ahn et al 2012). However, contract specifications, the mostly used form of green contracting in public projects (Cui and Zhu 2011), may not be socially optimal (and fair) by excluding financially small companies from bid participation for green projects because of the need for relatively expensive investment on upgrading equipment and purchasing emission control devices (ICF 2005). Contract allowances allow the owner to partially or totally reimburse the initial contractor's investment on green equipment and technologies to stimulate the utilization of greener construction equipment. Finally, applying alternative bidding methods is another green strategy that can create incentives for contractors to identify and quantify construction emissions and implement greener construction practices. Generally, alternative bidding methods have been devised by owners to overcome weaknesses in traditional single-criterion competitive bidding system. These methods may embed more than one evaluation criterion in process of contractor selection as A+B without bonus and lane rentals or may consider rewards and penalties for the gap between the actual completion duration and the expected completion duration as incentives/disincentives provisions and liquidated savings or may combine both previous techniques as A+B with bonus (Ellis et al. 2007). To incorporate the estimated environmental cost incurred during the construction phase as one of the evaluation criteria in addition to cost and schedule, Ahn et al. (2012) suggested an innovative competitive bidding system called A+C (or A+B+C) bidding method that requires each contractor to bid on not only the total construction cost, A component, (and the total number of days needed to finish the project, B component) but also the environmental cost caused by their estimated construction emissions and energy use, C component. The lowest total combined bid, calculated by the following formula (Ahn et al. 2012), will determine the winning contractor.

Bid award cost = A + {B × Road User Cost} + {C × weight}

where A: the cost estimate in dollars, B: the time estimate in days, the Road User Cost: the daily road user cost in dollars per day, C: the estimated environmental cost, and the weight of the C component decreases/increases the bidding preference for a green contractor.

To define the environmental cost, Ahn et al (2012) used the concept of eco-cost, introduced by Vogtländer et al. (2001), which combines the environmental cost of emission generated and energy used by construction activities. The main reason supporting the idea of A+C (or A+B+C) bidding method is the successful implementation of the A+B bidding method in highway projects; This method has reduced project duration and no report has pointed out any negative effect on cost or quality (MnDOT 2006; Ellis et al. 2007; Anderson and Damnjanovic 2008). Providing a fair level for contractors with different financial capabilities to compete is another advantage of alternative bidding methods. These methods may be reinforced incentive/disincentive provisions to secure the expected performance by contractors. In this study, we focus on A+C bidding method, discuss some challenges in implementation of this method and introduce a mechanism which helps owners tackle those challenges.

3 Problem statement

As discussed earlier, A+C bidding method is applied to promote sustainability in the construction industry. However, there are some problems which cast doubts on this practice. When there is always risk of over-emission resulting from inefficient construction methods, field rework, and improperly sized equipment, among others (Song and Peña-Mora 2012), owners want to prevent it as much as possible. An appropriate mechanism first eliminates incompetent contractors from the bidding process or at least decrease their chance of success in order to protect public interests for long term. The above mechanism also has to discourage contractor's opportunistic bidding behaviour. Ho and Liu (2004) defined opportunistic bidding as *"a contractor's intentional ignorance of possible risks involved that may significantly increase costs or decrease profitability, such as the use of the most optimistic cost estimation for the bid price"*. In A+C or A+B+C bidding methods, this behaviour can emerge as a contractor's intentional ignorance of optimism in the submitted mitigation plan or inconsistencies between the submitted mitigation plan and the contractor's equipment, staff, management capability, previous performances, etc. This mechanism lastly has to compensate owners in case of over-emission in a project.

As an example, consider the following theoretical bid tabulation using A+C bidding method (Table 1). Contractor 3 and 4 have LEED certificate while contractor 1 and 2 are just regular small sized companies.

Contractor 1's mitigation plan is to use diesel oxidation catalysts (DOC) which reduce the total eco-costs by 0.9% through controlling diesel emissions from equipment. Contractor 2 does not have any specific plan for mitigating emissions. Contractor 3 has promised to use a selective catalyst reduction (SCR) in addition to diesel oxidation catalysts (DOC); together they reduce the total eco-costs by 7.6%. Contractor 4's mitigation plan includes substitution of biodiesel fuels for petroleum diesel which reduces the total eco-costs by 4.8%. The weight of "C" is set at 1 by the owner of this project. Submitting the reasonable mitigation plans, presented in Table 1, will lead to awarding the project to the contractor 1. However, contractor 2 can be the winner if he submits another mitigation plan (2a: Hybrid Equipment) instead of the realistic one (2: None). Considering contractor 2's financial capabilities and past performances, the replacement with hybrid equipment, which may save total eco-costs 21.8%, seems impractical. Contractor 2 submits the mitigation plan including hybrid equipment just to increase his competitiveness for winning the bid. This behaviour will lead to an inefficient procurement since first, from economic perspective, the project is awarded to the wrong contractor and second, from environmental perspective, this project most likely experiences poor environmental performance. Just devising financial consequences for the opportunistic contractor's over-emission in the contract is not a solution to this problem because if this trend (submitting an unrealistic mitigation plan whether intentionally or unintentionally) continues by other contractors, implementation of A+C bidding method will not serve its purpose. A right solution for this problem has to include a supervisory, preventive mechanism before bidding process which discourages contractors from submitting unrealistic mitigation plan by reducing their competitiveness. It is worth noting that plan 2a is financially equivalent to plan 2b (where contractor 2 submits a lower bid on construction cost with a realistic mitigation plan) in A+C bidding process but has different consequences.

Table 1. Bid Tabulation Using A+C Bidding Method (Theoretical)

Contractor	Construction cost (A) ($)	Bid gap with the lowest ($)	Submitted Mitigation plan	Total eco-cost ($)	Weighted environment cost (C) ($)	Total combined bid (A+C)	Bid gap with the lowest ($)
1	10,556,872	386,215	DOC	974,418	974,418	11,531,290	424,562
2	10,318,643	147,986	None	983,267	983,267	11,301,910	195,183
3	10,854,984	684,327	SCR+DOC	908,539	908,539	11,763,523	656,796
4	10,170,657	0	B20	936,070	936,070	11,106,727	0
2a	10,318,643	147,986	Hybrid Equipment.	768,915	768,915	11,087,558	-19,169
2b	10,104,291	147,986	None	983,267	983,267	11,087,558	-19,169

4 Methodology: Insurance vs. Suretyship

The suretyship and the insurance are two effective risk management mechanisms on construction projects. Risk of over-emission and other associated challenges in implementation of A+C (or A+B+C) bidding method may be handled by one of these two mechanisms. Song and Peña-Mora (2012) suggested the emissions liability insurance for managing GHG emissions by drawing an analogy from the construction professional liability insurance. However, applying suretyship seems more practical for this problem. In this section, these two mechanisms are briefly introduced, and then reasons for choosing suretyship are provided.

4.1 Insurance

Insurance is essentially a two-party indemnity agreement between the insurer and the insured whereby the insurance company agrees to pay the insured directly for the loss incurred. From the risk management perspective, the insured transfers the economic risk of failure to the insurance company (Reference). In insurance theory, the underlying assumption is that there will be losses whose size can be significant for the insured. Through looking at data which documents the frequency and the severity of past losses of an individual, the expected future losses and accordingly the premium for insurance can be calculated by actuaries according to the law of large numbers (Russell 2000). Finally, it is worth noting that losses are not generally recoverable; the insured who incurs a loss is not expected to repay the insurance company. To avoid moral hazard, insurance companies charge a percentage of losses called the deductible to the insured. In construction projects, contractors and owners, as the insured parties, can buy different insurance products to protect themselves against the risk of different contingent losses.

4.2 Suretyship

Surety bonds are mostly three-party guarantee agreement between the obligee, the principal and the surety company. A surety bond is a guarantee by the surety company to pay the obligee if the principal fails to meet some obligations. In case of the principal's default, the surety company is called in by the obligee. The principal pays as much of the loss as he is able to, and then the surety company pays the remaining. The surety company will try to reclaim its loss from any resources left to the principal (losses are recoverable) according to the indemnity agreement. In suretyship the principal retains the risk of failure. As a result, because of being still responsible, the principal will try to minimize the possibility of failure. To determine the premium, surety underwriters assess their risk by looking at the record and current status of only the individual who is seeking the bond and the bulk of the premium goes to administrative costs and profits (overheads). Construction bonds such as bid bond, performance bond, payment bond, and maintenance bond involve the surety company, the owner as the obligee, and the contractor as the principal. The bond guarantees to the owner that the contractor will perform the construction project in accordance with the provisions of the contract. If the contractor fails to perform the contract, the owner may call on the surety to step in and complete the project or correct project deficiencies. The extent of the surety's liability is determined by the penal sum of the bond which is the dollar value of the bond. In true suretyship, the premiums paid are "service fees" charged for the use of the surety company's financial backing and guarantee. In underwriting traditional insurance products the goal is "spread of risk." In suretyship, surety professionals view their underwriting as a form of credit so the emphasis is on prequalification and selection. On most construction projects the penal sum of the bond is the value of the contract price.

4.3 Reasons to choose suretyship

Based on the following reasons, suretyship can provide a better solution to the earlier discussed problem:

First of all, a solution to the problem needs the effort of all major parties (owner, contractor and, insurance or surety company) during the construction project. Emissions liability insurance is an indemnity agreement between contractor and insurance company. The owner does not play an active role in this mechanism. What the owner can do in this mechanism is to adjust the rate of penalty for over-emission in order to reduce GHG emissions. On the other hand, suretyship is a three-party guaranty agreement. Specifically, the surety company has this opportunity to establish a bilateral relationship with the contractor before the bidding process because of the general prequalification as a part of underwriting process. The surety company also has access to useful data about the contractor's capability in different aspects that contractors rarely release or truthfully report to the project owners despite conducting the most rigorous prequalification processes by owners. Consequently, the surety company may be able to first, evaluate the contractor's mitigation plan before the project and second, offer technical, financial, or managerial assistance to the contractor before and during the project (SIO 2009).

Second, the right mechanism has to allocate risk to the party so that the possibility of over-emission becomes minimized. Insurance is a loss funding mechanism designed to compensate the insured against unforeseen adversities. In emissions liability insurance (Song and Peña-Mora 2012), the contractor's loss, which is the penalty charged by the owner, will be compensated by the insurance company; the contractor transfers the risk of financial penalty due to over-emission to the insurance company. However, environmental damages are irreversible to the society and should be avoided as much as possible instead of being compensated in terms of money. In contrast with insurance, suretyship is a loss avoidance mechanism designed to prequalify individuals based on their credit strength and construction expertise. The surety company selects and guarantees green contractors that are reliable to meet the environmental requirements. Both in short term and long term suretyship provides preventive measures which are more favourable to the owner than compensatory ones. In suretyship mechanism, the contractor will do his best to prevent any environmental damages because of still keeping the risk of over-emission and its consequences. As will be discussed in the following section, suretyship can prevent from opportunistic bidding as well.

Our last reason which justifies using suretyship mechanism is related to the dilemma of the premium. Generally, there are two types of scientific uncertainty. Statistical uncertainty (risk) is a random event with a known probability but an unknown future outcome and true uncertainty (indeterminacy) is an event with an unknown probability because of a lack of knowledge at a deeper level or limited information (Costanza and Cornwell 1992). As an example for statistical uncertainty, the probability of having a car accident for a driver is calculable for an insurance company with very high certainty thanks to high number of accidents in past. On the other hand, no one knows to what extent somebody's health is in danger if his living place is exposed to toxic chemical although there may be concerns. This is an example of true uncertainty. Costanza and Cornwell (1992) believe that most important environmental problems are influenced by true uncertainty, not statistical uncertainty. Uncertainty over the level of emissions is also a kind of "true uncertainty" not "statistical uncertainty". At this point, there is no information about emissions performance of construction projects as a basis for determining insurance premium. Since surety underwriters can take a judgment based approach to determine premium for surety bonds, they can overcome this challenge. As a result, the practicality of the premium determination is another reason for choosing suretyship.

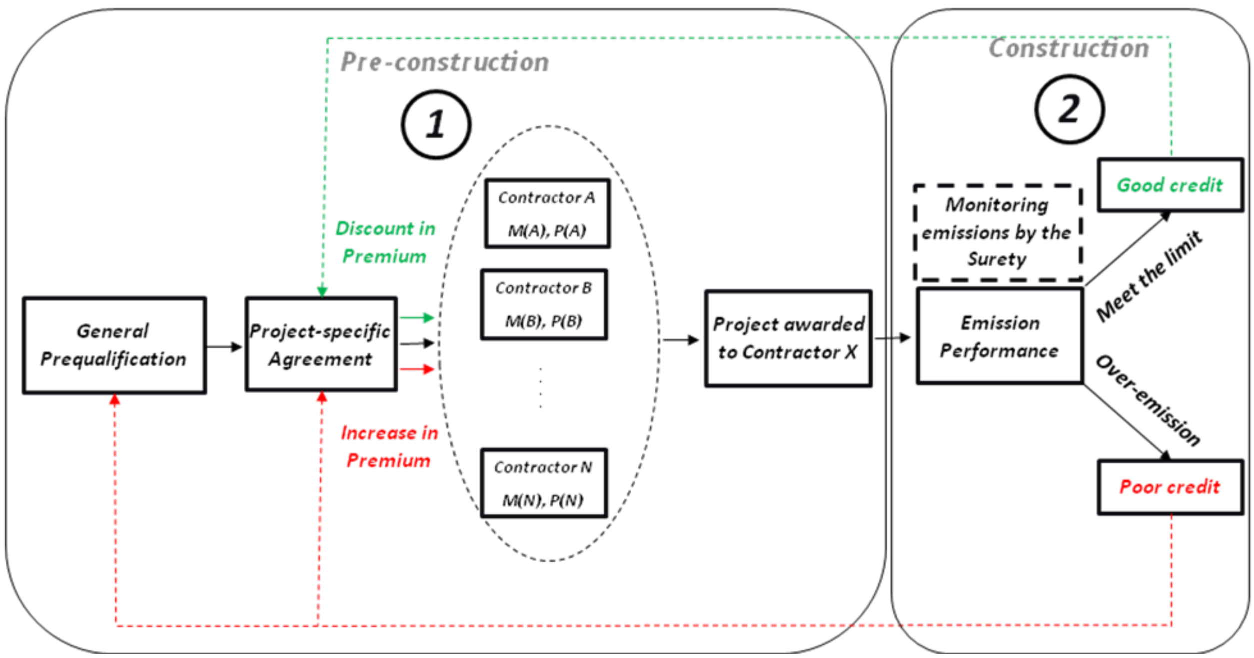

Figure 1. The proposed framework based on the concept of green performance bond

5 Green performance bond framework

In the proposed framework, public owners require the green performance bond for green projects. A green performance bond is a promise by the surety to pay the owner the environmental damage costs if the contractor fails to meet the promised level of emissions based on submitted mitigation plan. As Figure 2 shows the proposed framework has two main phases: pre-construction and construction. In the first phases, to qualify for bidding on a green work and expect support from the surety company, the contractor must first be evaluated (the general prequalification). Criteria for qualification are varied from a surety company to another but generally can be summarized into contractor specific evaluation criteria in terms of capacity, whether the contractor has the technical and managerial capabilities to perform the obligations, character, whether the contractor's past performances show him to be of good character and likely to perform the obligations, and capital, whether the contractor's financial state justify approval of the particular risk (Russell 2000; Awad and Fayek 2012). Then, for a specific project the contractor must demonstrate the project specific information as well as his plan for evaluating and mitigating the risks associated with the promised level of GHG emissions. For example, it has to be shown the proposed technology is a proven one. When the surety provider issues a green performance bond, the business financially backs the quality of work to be done by the contractor. If the contractor wins the bidding, the surety company and the owner monitor and track emissions during the construction phases. The surety will provide technical and managerial assistance to the contractor to optimize emission performance of construction processes. Finally, if the contractor meets the limit, the surety will probably reward him by a discount in premium of future green works. Otherwise, over-emissions can bring immediate consequence (severe financial penalty charged by the owner) and future consequence (increase in premium by the surety company). In this framework, the owner may use non-linear functions for determining the environmental damage costs as the penalty for over-emissions. The more the over-emissions are, the more severe the consequences the contractor may face.

Both owners and surety companies can prevent opportunistic bidding in the proposed framework. In green works, the damage costs may be considered as the penalty of over-emissions in the contract. If these damage costs are less than the weighted environment cost (factor C) multiplied by {1+contractor's discount rate power to the project duration}, opportunistic contractors (like contractor 2) have financial incentive to promise a mitigation plan beyond their capability. In this case, the contractor improves his chance of success. However, devising damage costs sufficiently higher than the corresponding eco-costs (factor C) in A+C contract can decrease possibility of contractors' opportunistic behaviour. The surety company can also help the owner by rejecting or charging higher premium to optimistic (impractical) mitigation plans (see Figure 2). Higher premium by the surety company decreases the contractor's competitiveness by offsetting the effect of this behaviour. Next paragraphs will discuss premium as a key component of the proposed framework.

Surety bond premiums in common construction projects have been usually determined by judgment-based approaches. For instance, premium of performance bond varies from one surety company to another but can range from 0.5% to 2% of the contract amount, depending on the penal sum (the bond's total worth), the contractor's previous works, equipment, staff, credit, and financial history, size, type, and duration of the project, and jurisdiction. In case of green performance bond, the submitted mitigation plan for the project is a major element in the process of determining the premium. From the surety company's perspective, the premium has three components (Russell 2000): 1- expenses, which is intended to cover all operating expenses such as salaries, commissions, rent, utilities, potage, communications, consultants, supplies, taxes, etc. 2- loss cost, which is associated with investigating and settling losses. 3- profit factor.

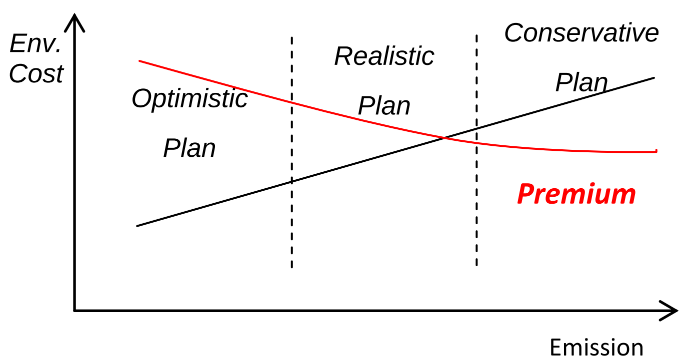

Figure 2. Degree of Practicability of Mitigation Plan and Premium

6 Illustrative example

Consider the example introduced in section 3. Assuming all contractors have passed the general prequalification process, they have to reach a project specific agreement for the green performance bond with a surety company. The surety company considers a contingency factor based on the proposed level of emissions but independent of contractors' mitigation plan; the lower the level, the riskier and the greater contingency factor. Then, the highest possible eco-cost can be determined as the difference between "weighted environment cost times contingency factor" and "the base total eco-cost (using no specific mitigation plan)". Consequently, the highest possible damage cost is calculated by multiplying the highest possible eco-cost by the damage cost. Since promoting sustainability is a major concern for the owner of this project, the coefficient for determining the damage costs is assumed to be 2. For determining the premium rate, the surety company looks at contractors' mitigation plan, past performance (if there is any record), equipments, etc. In our example, the surety will assign a higher rate to the riskier mitigation plans where contractor 2's the unreasonable mitigation plan (2a) is assigned the highest rate (say 5%). As shown in the last column of Table 2, adding premium without constant fee to contractors' bid, the contractor 2 has no chance to win since the surety cost ($60,766) offsets the competitive advantage (the gap in Table 1: -$19,169) he can get with opportunistic bidding.

Table 2. Determining premium of green performance bond (Theoretical)

Contractor	Submitted Mitigation plan	Total eco-cost ($)	Weighted environment cost (C) ($)	Contingency Factor	The highest possible eco-cost ($)	The highest possible damage cost ($)	Premium rate	Premium w/o constant fee ($)
1	DOC	974,418	974,418	1.15	156,339	312,679	1.5%	4,690
2	None	983,267	983,267	1.10	98,327	196,653	1.0%	1,967
3	SCR+DOC	908,539	908,539	1.25	320,545	641,090	1.1%	7,052
4	B20	936,070	936,070	1.20	243,850	487,700	1.0%	4,877
2a	Hybrid Equipment.	768,915	768,915	1.40	607,659	1,215,318	5.0%	60,766

7 Conclusion and future works

In highly competitive and risky construction industry, surety bonds serve as evidence of the contractor's competence and capability; surety bonds have performed well as the basis for a competitive, properly functioning bidding system (Russell 2000). This study introduces a two-phase framework based on green performance bond for managing GHG emissions in construction projects. This framework brings benefits for all parties; it helps owners hire competent and environmentally responsible contractors and promotes sustainability in construction. For competent, green contractors, it enhances competitiveness in the growing market of green projects. To surety companies, it presents a new business opportunity.

For future studies, an in-depth analysis of the proposed framework from all parties' perspective is still recommended. The rich literature around performance bond (Kangari and Bakheet 2001, Bayraktar and Hastak 2010, Awad and Fayek 2012) can help develop a decision support system for prequalification and pricing premium of the green performance bond. Another important question is which sureties are qualified to grant green performance bond since this product involves financial, technological and environmental risk assessment.

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