Project Performance Evaluation of Multi-prime Contracts in Comparison with General Contractor Contracts

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Abstract
This research focuses on multi-prime (MP) contracts, as an alternative contracting method to general contractor (GC) contracts, to reduce the construction costs of the Korean government. Two pilot projects were executed under MP contracts with direct owner management (without professional construction management services). The project performance (i.e., construction costs, schedule, defects and participant satisfaction) under the MP contracts was then compared with a GC contract. The results show that construction costs reduced somewhat but not as much as expected (8% reduction). Direct construction costs were also reduced using the lowest bid system, but indirect construction costs, such as common laborer costs, increased. Fast track construction was not applied to the pilot projects, and therefore their schedule and defects are not distinguished from those under a GC contract. However, project participant satisfaction is very high and participants stated they would use MP contracts again for future projects. These pilot projects show that the owner's management ability is very important in MP contracts and directly affects project performance. Therefore, professional construction management services for owners in MP contracts are strongly recommended for successful projects.

Keywords: multi-prime contract; general contractor contract; project performance; direct owner management; professional construction management

1. Introduction
In September 2008, the Korean government announced a scheme to build 1.5 million affordable residential homes for Korean citizens, with the aim to improve their overall welfare. To achieve these objectives, both the permit process and project organization would be simplified, and a low-bid award system would be used. Thus, multi-prime (MP) contracts would be adopted as a means of simplifying the project organization and a low-bid award system used because total construction costs could be reduced via MP contracts.

Because this marked the first time that MP contracts were to be used in Korea, it was unclear what the expected savings in construction costs would be in comparison to general contractor (GC) contracts. Therefore, the Korean government decided to execute two pilot projects before MP contracts are actively applied. Based on the results of the two pilot projects, the government could make its final decision regarding the active application of MP contracts.

The purpose of this study is to compare the project performance evaluations of the two pilot projects and to provide recommendations for the future application of MP contracts. The project performance evaluations are made based on construction costs, schedule, defects, and participant satisfaction.

2. Research Process and Methodology
The study process is shown in Fig.1. First, the two pilot projects for MP contracts were described, as were the project descriptions, characteristics, and organization. The projects were monitored during the construction and maintenance period. Project performance was evaluated by looking at total construction costs, schedule, and defects after the projects were completed. Project participant satisfaction, especially for prime contractors, was measured by questionnaires. Finally, recommendations for the future application of MP contracts were made based on the results.
3. Literature Review

Under current policy, known as the Wicks Law, most US state and local public construction projects require multiple packages for MP contracts as shown in Fig.2.: one package concerns general contractors and other major packages for electrical, heating ventilation and air conditioning (HVAC), and plumbing contractors (Rojas 2008).

MP contracts are defined as follows (Gordon 1994): "More than one contractor holding contracts directly with the owner to perform specific parts of the same project. The contractors can be general contractors overseeing various trades, or subcontractors performing one trade. The owner is responsible for overall project management and coordination, replacing a general contractor of a construction manager."

Based on that definition, there have been significant debates as to whether the use of MP contracts or GC contracts is the most appropriate in construction projects. Generally, general contractors prefer to apply GC contracts, whereas specialty contractors prefer MP contracts. General contractors argue that MP contracts result in higher bidding costs, increased administrative expenses, more change orders, higher claims, and poor quality (Holland 2002). In contrast, specialty contractors argue that GC contracts result in higher costs and lower quality (Kuprenas and Rosson 2000). Thus, previous research has attempted to determine the quantitative cost differences between MP and GC contracts. The results are shown in Table 1. (Becker 1993; Becker 1995; Carnoustie Group 1999; Rojas 2008).

As shown in Table 1., GC contracts result in 2.75%–9.54% higher costs than MP contracts. However, the results depend on capable management by the public owner. If public owners have no such ability, then they should hire a construction manager for MP contracts (Monti 1997). Unless carefully pre-planned and executed, construction delivery using MP contracts can result in project budget and schedule overruns because of issues over contractors' responsibilities and various disagreements (e.g., scope of work) (Kuprenas and Rosson 2000).

4. Pilot Project Description

The two pilot projects, which involved the building of apartments, were executed under MP contracts. The owner of these projects was the Korea Land and Housing Corporation (LH). Pilot project A was located in Anyang and pilot project B in Jeonju. Each project is described in Table 2.

Table 1. Cost Differences between MP Contracts and GC Contracts

| Description                      | Result                      |
|----------------------------------|-----------------------------|
| New Jersey study, 1960s          | GC bids 9.54% higher       |
| New Jersey study, 1970s          | GC bids 8.67% higher       |
| Electrical contracting foundation, 1993 | GC bids 3.0% higher       |
| North Carolina study, 1994       | No significant difference  |
| New Jersey study, 1999          | GC cost overrun 2.75% higher |
| National study, 2008             | GC direct costs 5.0% higher |

Table 2. Pilot Project Description

| Description | Pilot project A | Pilot project B |
|-------------|----------------|-----------------|
| Owner       | LH             | LH              |
| Location    | Anyang, Kyunggi | Jeonju, Jeonrabuk |
| Type        | 970 apartment units | 690 apartment units |
| Building area | 39,004 m² | 25,182 m² |
| Construction cost | 1.82 mil. Won/m² | 2.09 mil. Won/m² |
| Construction period | June 2010 to October 2012 | August 2012 to November 2014 |
The project organization of the pilot projects is shown in Table 3. The same number of engineers as under a GC contract were assigned to the pilot projects. The number of common laborers is slightly higher than for a GC contract to account for any ambiguity concerning the scope of work between MP contractors.

Table 3. Project Organization

| Organization     | Pilot project A | Pilot project B |
|------------------|-----------------|-----------------|
| Project manager  | 1               | 1               |
| Cost engineer    | 3               | 4               |
| Construction     | 6               | 7               |
| Mechanical       | 1               | 1               |
| Engineer         |                 |                 |
| Electrical       | 1               | 1               |
| Civil engineer   | 1               | 1               |
| Safety engineer  | 2               | 2               |
| Quality control  | 2               | 2               |
| A/E              | 1               |                 |
| Accounting       | 2               | 2               |
| Foreman          | 1               | 1               |
| Common laborer   | 4               | 6               |
| Total            | 25              | 28              |

The MP contract packages used in pilot projects A and B are shown in Table 4. Each pilot project has 21 MP contracts.

Table 4. MP Contract Packages used in Projects A and B

| Contract packages                      | Pilot project A | Pilot project B |
|----------------------------------------|-----------------|-----------------|
| Temporary buildings                    | 0               | 0               |
| Temporary facilities                   | 0               | 0               |
| Temporary utilities                    | 0               | 0               |
| Safety facilities                      | 0               | 0               |
| Pile works                             | 0               | 0               |
| Reinforcement concrete works           | 0               | 0               |
| Masonry, Plastering, Waterproofing, Tiling | 0         | 0               |
| Interior finishing                     | 0               | 0               |
| Doors, windows, and metal works        | 0               | 0               |
| Roofing                                | 0               | 0               |
| Stone work                             | 0               | 0               |
| Painting                               | 0               | 0               |
| Earth works                            | 0               | 0               |
| Water supply and drainage              | 0               | 0               |
| Paving                                 | 0               | 0               |
| Mechanical works                       | 0               | 0               |
| Gas                                     | 0               | 0               |
| Electrical                             | 0               | 0               |
| Information and communication          | 0               | 0               |
| Landscaping                            | 0               | 0               |
| Landscape facility works               | 0               | 0               |

As shown in Table 4., the MP contract packages are applied especially for pilot projects A and B. They are based upon different types of specialty contractors. This is different from the MP contract packages of the US contracting method, the Wicks Law, which consists of a general contractor, electrical specialty contractor, HVAC specialty contractor, and plumbing specialty contractor, as explained in the literature review.

To compare the project performance of pilot projects A and B (which are executed under MP contracts) with a GC contract, a breakdown of the GC contract is shown in Table 5. Each pilot project has one GC contract and three prime contractor (PC) contracts. The GC contract was not applied and is used only for comparison purposes.

Table 5. GC Contract Packages used for Relative Comparison

| Contract packages                      | Pilot project A | Pilot project B |
|----------------------------------------|-----------------|-----------------|
| GC (Building, Civil, Mechanical Works) | 0               | 0               |
| PC 1 (Electrical work)                 | 0               | 0               |
| PC 2 (Information and communication)   | 0               | 0               |
| PC 3 (Landscaping)                     | 0               | 0               |

The GC contract package shown in Table 5. is commonly used in public projects in Korea. This differs from the GC contract packages of the US contracting method, the Wicks Law. Therefore, this difference could impact on project performance.

5. Project Performance Evaluation

Pilot projects A and B were monitored during construction. Project performance data were collected during construction and after move-in, and classified as construction cost, schedule, and defects.

First, project performance regarding construction costs is shown in Tables 6., 7., and 8. A total construction cost comparison (GC vs. MP) for pilot project A is shown in Table 6. The final construction cost (including additional costs) of the MP contracts (B) for pilot project A is 55,031 million Korean won (KRW). This is 77.4% of the estimated total construction cost, which is 71,059 million KRW. The bid construction cost of the GC contract (A) is a hypothetical value calculated using a standard index based on an estimated total construction cost. This standard index is a statistical average value, 75% of the estimated total construction cost, and is only applied when using a low-bid award system with a GC contract in Korea. As a result, the construction bid under the GC contract is 55,905 million KRW. This is 77.4% of the estimated total construction cost. Therefore, this difference could impact on project performance.

Table 6. Construction Cost Comparison (GC vs. MP) for Pilot Project A

| Contract packages                      | Pilot project A | Pilot project B |
|----------------------------------------|-----------------|-----------------|
| GC (Building, Civil, Mechanical Works) | 71,059          | 55,031          |
| PC 1 (Electrical work)                 | 0               | 0               |
| PC 2 (Information and communication)   | 0               | 0               |
| PC 3 (Landscaping)                     | 0               | 0               |
| Total                                  | 71,059          | 55,031          |

As a result, the construction bid under the GC contract is 55,905 million KRW. Therefore, under MP contracts, 902 million KRW was saved (A−B) in comparison to GC (A) costs, representing a saving of 1.6%. Table 6. shows construction cost savings (A−B), excluding additional costs, of 1,928 million KRW more than those of construction costs, including additional costs. This represents a reduction of 3.5%, and is lower than the GC (A). However, additional costs under the MP contracts were incurred because of time extensions and office overheads. These additional costs reduced the savings (A−B) by 1,026 million KRW. A comparison of the total construction costs for pilot project B is shown in Table 7. The final construction cost (including additional costs) under MP contracts
For pilot project B is 44,299 million KRW. This is 84.0% of the estimated total construction cost, which is 52,719 million KRW. The construction bid under the GC contract (A) is a hypothetical value that was calculated using a standard index based on estimated total construction costs. The construction bid for the GC contract is 40,441 million KRW. Under the MP contracts, the savings (A−B) are −3,858 million KRW, which represents a saving of −9.5%; thus, the cost under the MP contracts is higher than under the GC contract (A). As shown in Table 7, the construction cost savings (A−B) (excluding additional costs) are −2,151 million KRW, which are higher than those that include additional costs. This represents a saving of −5.3%, and is higher than GC costs (A). Additional costs under the MP contracts were incurred for time extensions and home office overheads. The savings (A−B) of construction costs (excluding additional costs) is therefore reduced by 1,707 million KRW. The cost distribution percentages of pilot projects A and B are shown in Table 8. The cost distribution percentages of site overhead costs under the MP contracts in pilot projects A and B are 11.0% and 10.3%, and 6.5% and 6.1% for additional costs, respectively. These figures show that project management ability could have a considerable impact on total construction costs.

Regarding project performance, the schedule was delayed by 114 days and 151 days in pilot projects A and B, respectively. Accordingly, the time extension cost of pilot project A is 1,690 million KRW and that of pilot project B is 2,242 million KRW. These delays were caused by the bankruptcy of prime contractors. As mentioned before, fast track construction was not applied to these pilot projects.

Finally, the various defects (i.e., project performance) are shown in Table 9. Regarding total defects per apartment unit including move-in (D), D +30 and D +60 defects are 5.38 and 5.92 in pilot projects A and B, respectively. These are 8%–15% less than for GC contracts.

6. Project Participant Satisfaction

Before the implementation of the pilot projects, a survey questionnaire was used to measure professionals’ expectations of project performance. These results would be used to decide whether pilot projects under MP contracts would be executed. The professionals were classified as follows: owner, GC, Subcontractor (Sub), construction management (CM), and researcher and developer (R&D) (Table 10.). The survey results are shown in Table 11. All participants expected a better performance result for construction costs under MP contracts than under GC contracts. However, except for Sub and CM, they all expected poorer performances for time, quality, and safety under MP contracts. Fair evaluation results are expected from R&D, and they predicted that costs under MP contracts would be lower than under a GC contract, but that the other features of project performances would be worse under MP contracts.

After the pilot projects were completed, participants’ performance satisfaction of the pilot project was also measured using a questionnaire survey with a 5-point scale. The survey information is shown in Table 12. A total of 19 project engineers participated in pilot project A and 13 in pilot project B. The survey results are shown in Table 13. Performance satisfaction for cost and time under MP contracts in pilot project A

| Table 6. Total Construction Cost Comparison between GC and MP Contracts for Pilot Project A (million KRW) |
| Description     | Estimated Cost | GC (A) Bid cost | GC (A) Final cost | MP (B) Bid cost | MP (B) Final cost | Savings (A−B) | Savings% (A−B)/A |
|-----------------|----------------|-----------------|-------------------|-----------------|-------------------|----------------|------------------|
| Construction Cost |                |                 |                   |                 |                   |                |                  |
| Direct cost     | 69,602         | 51,909          | 45,385            | 6,524           | 11.7%             |
| Site overheads  | 1,457          | 1,457           | 6,053             | −4,596          | −8.2%             |
| Sub total       | 71,059         | 53,366          | 51,438            | 1,928           | 3.5%              |
| Additional Cost |                |                 |                   |                 |                   |                |                  |
| Escalation      | 0              | 2,539           | 1,866             | 673             | 1.2%              |
| Time extension  | 0              | 0               | 1,690             | −1,690          | −3.0%             |
| Home office overheads | 0  | 0             | 136              | −136            | −0.3%             |
| Disposal of scrap iron | 0  | 0             | −127             | 127             | 0.2%              |
| Sub total       | 0              | 2,539           | 3,565             | −1,026          | −1.9%             |
| Total cost      | 71,059         | 55,905          | 55,003            | 902             | 1.6%              |

| Table 7. Total Construction Cost Comparison between GC and MP Contracts for Pilot Project B (million KRW) |
| Description     | Estimated Cost | GC (A) Bid cost | GC (A) Final cost | MP (B) Bid cost | MP (B) Final cost | Savings (A−B) | Savings% (A−B)/A |
|-----------------|----------------|-----------------|-------------------|-----------------|-------------------|----------------|------------------|
| Construction Cost |                |                 |                   |                 |                   |                |                  |
| Direct cost     | 52,196         | 38,929          | 37,015            | 1,914           | 4.7%              |
| Site overheads  | 524            | 524             | 4,589             | −4,065          | −10.0%            |
| Sub total       | 52,719         | 39,453          | 41,604            | −2,151          | −5.3%             |
| Additional Cost |                |                 |                   |                 |                   |                |                  |
| Escalation      | 0              | 988             | 368               | 620             | 1.5%              |
| Time extension  | 0              | 0               | 2,242             | −2,242          | −5.5%             |
| Home office overheads | 0  | 0             | 111              | −111            | −0.3%             |
| Disposal of scrap iron | 0  | 0             | −26              | 26              | 0.1%              |
| Sub total       | 0              | 988             | 2,695             | −1,707          | −4.2%             |
| Total cost      | 52,719         | 40,441          | 44,299            | −3,858          | −9.5%             |
### Table 8. Total Construction Cost Comparison between Pilot Projects A and B (million KRW)

| Description          | Pilot project A | Pilot project B |
|----------------------|-----------------|-----------------|
|                      | Est. cost       | GC | MP | Est. cost | GC | MP |
| Construction Cost    |                 |    |    |           |    |    |
| Direct cost          | 69,602          | 51,909 | 45,385 | 52,196 | 38,929 | 37,015 |
|                      | (98%)           | (92.9%) | (82.5%) | (99%) | (96.3%) | (83.6%) |
| Site overheads       | 1,457           | 1,457 | 6,053 | 524 | 524 | 4,589 |
|                      | (2%)            | (2.6%) | (11.0%) | (1%) | (1.3%) | (10.3%) |
| Sub total            | 71,059          | 53,366 | 51,438 | 52,719 | 39,453 | 41,604 |
|                      | (100%)          | (95.5%) | (93.5%) | (100%) | (97.6%) | (93.9%) |
| Additional Cost      |                 |    |    |           |    |    |
| Escalation           | 0               | 2,539 | 1,866 | 0 | 988 | 368 |
|                      | (0%)            | (4.5%) | (3.4%) | (0%) | (2.4%) | (0.8%) |
| Time extension       | 0               | 0 | 1,690 | 0 | 0 | 2,242 |
|                      | (0%)            | (0%) | (3.1%) | (0%) | (0%) | (5.1%) |
| Home office overheads| 0               | 0 | 136 | 0 | 0 | 111 |
|                      | (0%)            | (0%) | (0.2%) | (0%) | (0%) | (0.3%) |
| Disposal of scrap iron| 0             | 0 | 127 | 0 | 0 | -26 |
|                      | (0%)            | (0%) | (-0.2%) | (0%) | (0%) | (-0.1%) |
| Sub total            | 0               | 2,539 | 3,565 | 0 | 988 | 2,695 |
|                      | (0%)            | (4.5%) | (6.5%) | (0%) | (2.4%) | (6.1%) |
| Total cost           | 71,059          | 55,905 | 55,003 | 52,719 | 40,441 | 44,299 |
|                      | (100%)          | (100%) | (100%) | (100%) | (100%) | (100%) |

### Table 9. Comparison of Defects between GC and MP Contracts

| Description          | Move-in (D) | Defects | No. of apartment units |
|----------------------|-------------|---------|------------------------|
|                      | D +30       | D +60   |                        |
|                      | Total       | Defects/Units | (A)/(B) |
| MP (A)               |             |         |                        |
| Pilot A              | 970         | 3,218   | 516                    | 1,482 | 5,216 | 3.38 | 84.3% |
| Pilot B              | 690         | 1,844   | 934                    | 1,306 | 4,084 | 5.92 | 92.8% |
| GC (B)               |             |         |                        |
| Project C            | 704         | 2,345   | 769                    | 1,381 | 4,495 | 6.38 | 100% |

### Table 10. Questionnaire Survey Information by Professionals

| Classification | Participants |
|----------------|--------------|
| Owner | GC | Sub | CM | R&D | Total |
| Owner | 47 | 48 | 364 | 29 | 20 | 508 |

### Table 11. Questionnaire Survey Results of Expected Project Performance of MP by Professionals (5-point scale)

| Description | Cost | Time | Quality | Safety |
|-------------|------|------|---------|--------|
| Owner       | GC   | Sub  | CM      | R&D    |
| Expected project performance | 3.09 | 2.40 | 2.43 | 2.47 |
|               | 3.15 | 2.48 | 2.38 | 2.31 |
|               | 4.03 | 3.81 | 3.99 | 3.85 |
|               | 4.10 | 3.17 | 3.10 | 2.90 |
|               | 3.35 | 2.65 | 2.89 | 2.80 |

### Table 12. Questionnaire Survey Information by Pilot Project Participants

| Description | No. of participating engineers | Date       | Method    |
|-------------|---------------------------------|------------|-----------|
| Received survey | Completed and returned | May 9, 2013 | 5-point scale |
| Pilot project A | 20 | 19 | |
| Pilot project B | 13 | 13 | January 5, 2015 | 5-point scale |

### Table 13. Questionnaire Survey Results of Performance Satisfaction by Pilot Project Participants (5-point scale)

| Description | Mean | SD | Mean | SD |
|-------------|------|----|------|----|
| Performance satisfaction | Pilot project A | Pilot project B |
| Cost        | 2.47 | 0.90 | 3.08 | 1.19 |
| Time        | 2.79 | 0.79 | 3.23 | 0.73 |
| Quality     | 3.68 | 0.67 | 3.77 | 0.73 |
| Safety      | 3.53 | 0.90 | 3.85 | 0.69 |
are lower than under the GC contract, while that for quality and safety are higher under MP contracts. All performance satisfaction items (cost, time, quality, and safety) under MP contracts in pilot project B are higher than those under the GC contract. Pilot project B began shortly after the completion of pilot project A. Thus, it is likely a learning curve effect has resulted in pilot project B being awarded higher overall participant satisfaction. Most of the participants are subcontractors. As shown for direct construction costs in Table 7., the direct costs of the MP contracts are less than the direct costs of the GC contract. Thus, participants' satisfaction for cost under MP contracts in pilot project B is higher than under the GC contract. Even though a time extension was obtained for the MP contracts in pilot project B (because of the bankruptcy of a structural subcontractor in Table 7.), the participants' satisfaction for time under MP contracts in pilot project B is higher than under the GC contract. Furthermore, project participants would also recommend the use of MP contracts in future projects.

7. Lessons Learned from the Pilot Projects

Based on the results above, a number of lessons can be learned from the pilot projects. A project's success greatly depends on the owner's ability to manage the project. Under the GC contract, the owner only managed the GC, while the GC managed all the subcontractors. Under this system, the owner minimizes the number of staff and applies the GC's management know-how to the project. Under MP contracts, the owner directly manages all MP contractors. To manage the project effectively, he needs to ensure he has enough staff and appropriate project management know-how to the project. Under MP contracts, the owner directly manages all MP contractors. To manage the project effectively, he needs to ensure he has enough staff and appropriate project management know-how as provided by GC under the GC contract. Thus, even though direct costs can be saved using the low-bid award system for MP contracts, indirect costs can also increase and additional costs will be incurred if the owner does not possess the skills to manage the project. If the number of MP contract packages is increased, total direct costs can be reduced by low-cost bidding. However, the owner must have very high project management skills, otherwise indirect costs and additional costs could increase. Therefore, the following four recommendations are made for future applications. First, if possible, the number of bid packages for MP contracts should be minimized. Second, project management training for the owner is essential before the project starts. Third, an appropriate number of staff should be assigned to the project. Finally, professional CM services are recommended for owners who do not have the appropriate project management experience/skills or staff numbers.

8. Conclusion

MP contracts are an advanced project delivery method and an effective system to improve transparency in the construction industry. However, the project performance of the two pilot projects is lower than expected. Furthermore, under MP contracts, reduced construction costs are less than expected and the defects and schedule do not differ significantly from that under a GC contract. Thus, it is not easy to achieve expected project performance under MP contracts in the short term.

The owner's project management skills are very important under MP contract applications. When an owner wishes to use MP contracts for his project, he must self-evaluate his own ability to successfully manage the project. If qualified for MP contracts, he should have project management training, minimize the number of bid packages, and assign an adequate number of staff to the project, prior to it starting. However, if he is not qualified, then professional CM services should be utilized.

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