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Improving Mega-site Management Performance through Incentives: Lessons Learned from the Shanghai Expo Construction

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Abstract

As the biggest Expo site in history, the construction of the Shanghai Expo site faced a lot of challenges. For example, involvement of lots of investors, mega construction scale, concurrent construction mode, involvement of more than 40,000 migrant workers, and the extremely tight completion deadlines, among others. Consequently they imposed great obstacles on accomplishing the safety, quality and environmental goals. Through a case study of the Shanghai Expo Construction, this paper reports the design and implementation of multi-criteria incentives in mega-projects to accomplish the safety, quality and environmental goals. Both quantitative and qualitative findings were triangulated to demonstrate the outcome of the incentives. Six Critical Success Factors (CSFs) for the incentives, rule design, process orientation, top management support, training and promotion, communication in process, as well as

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process learning and improvement, are identified and validated through case data and content analysis. It is believed that findings of this paper can enhance the understanding of multi-criteria incentive schemes in general and provide insights in implementing these incentive schemes in future mega-projects, particularly in the People's Republic of China (PRC).

Introduction

As the first registered world exposition in a developing country, the Shanghai Expo owned 136 pavilions and more than 160 supporting facility buildings with a total floor area of 2.3 million m^2. The Shanghai Expo built the biggest Expo site in history; therefore its construction was a complex mega-project with multiple subprojects (Ding 2010). The client, Shanghai Expo Construction Headquarters (SECH), was beset with a lot of challenges, such as huge numbers of investors, a mega construction scale, fast construction mode, over 40,000 migrant workers being involved, and an extremely compressed completion deadline. The SECH faced enormous pressure to the mega-site management works relating to the overall safety, quality and environmental goals. The ways of achieving these goals were not only concerns to the Chinese public but also to international stakeholders for their inherent political sensitivity (Flyvbjerg et al. 2003). In order to attain the prescribed safety, quality, and environmental goals, the Safety and Quality Management Division (SQMD) was established by the client to manage and coordinate ten Project/Program Management Teams (PMTs) and two developers (Hu and Le 2009).

Construction site management usually involves multi-activities in construction site and their corresponding independent management systems relating to safety, quality, and environmental goals with characteristics of dynamic uncertainty and process orientation (Laufer 1985; Koehn and Datta 2003). According to national construction laws and rules, as well as local (Shanghai) regulations (SCNPC 1998; MOC 1991 and 2006; SGOSCESQ 2008), construction site management performance in the PRC focuses

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on four main aspects: (1) construction safety; (2) construction quality; (3) environmental protection; and (4) occupational health and safety (OHS), and the safety of living conditions of migrant workers. Within these four aspects, migrant workers are a special concern to the State Council (2006) during the economic transition. Their OHS and safety of living conditions has been recognized as a main focus for site management performance by the Ministry of Construction in 2006, especially in the major mega-projects invested by the government. In response to this concern, some Chinese scholars advocated that construction safety can be improved by paying more attention to improvement of the living conditions and related issues of migrant workers (Liu et al. 2006). In the construction of Shanghai Expo Site, the OHS of more than 40,000 on-site migrant workers, combined with the safety issues of their living conditions was one key challenge for the client to resolve.

With these challenges, SQMD not only employed strict standards and frequent process inspection to manage PMTs and the main construction contractors, but also combined them with the incentives based on the assessment output of process performance and final results, which greatly contributed to the overall mega-project goals of safety, quality and environment. As one of the largest construction projects in the PRC since 1949, the Shanghai Expo not only has contained its construction cost within the approved budget but was also completed 11 days ahead of schedule. Also it has further attained great achievements in the following areas:

1. No fatalities were reported during the construction arising from construction accidents, unclean food or epidemic illness. This was achieved despite, on average, 40,000 migrant workers being on site every month and 60,000 people in the construction peak month. This demonstrates success in taking care of the OHS and safety of all the migrant workers on site. In October 2009, the Shanghai Expo Site smoothly passed the site assessment by the Safety Work Committee of the State Council with positive assessment result; more than half of the 36 sub-projects with the total floor area of the Shanghai Expo

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were awarded as model projects by the Shanghai Municipality for their excellent performance in construction site management.

2. All the sub-projects (about 200 pavilions and supported facility buildings) smoothly satisfied government's handover inspections in one go; and their engineering quality achieved 100% acceptance.
3. No environmental pollution incident occurred during the construction period; and no serious complaint from nearby community residents.

Recently incentive schemes based on the philosophy of "pay for performance" (also named as performance incentives), have received growing research interests (Arditi and Yasamis 1998; Bower et al. 2002; Gangwar and Goodrum 2005; Lock 2003; Warne 1994, Walker and Hampson 2003; Bubshait 2003). They usually involve one specific theme of construction site management, e.g. (1) safety performance (Choi et al. 2009; Gangwar and Goodrum 2005; Teo et al. 2005;Hinze 2002 and 2003); (2) quality performance (Tang et al. 2008; Warne 1994); and (3) environmental performance (Tang et al. 2008). However, only limited studies on multi-criteria site management incentives of the mega-projects are available (Tang et al. 2008). In addition, they seldom fully explained the philosophy on how to design such a complicated incentive scheme to deal with multiple goals and successfully implement it in mega-projects.

Thus, this paper attempts to uncover the ingredients of success underlying the design and implementation of the incentives of the Shanghai Expo Construction. The specific objectives of this paper are to: (1) identify the principles for designing a multi-criteria performance incentive scheme; (2) examine the Critical Success Factors (CSFs) for implementing the incentive scheme in mega-projects comprising multiple sub-projects; (3) assess the success of incentive scheme in the Shanghai Expo construction.

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Research Methodology

This study arose from the first and third authors' more-than-two-year consultancy experience of mega-site site management for the Shanghai Expo Construction. Explanatory Case Studies and Critical Success Factor Theory were both employed to explore the success of incentive scheme from the Shanghai Expo case (Yin 2003a). Compared with the dominant research method in construction safety research, such as extensive questionnaire surveys for statistical analysis, Individual Case Study method can provide deeper insights into the logic of contract incentives in complex mega-projects (Yin 2003b; Flyvbjerg 2006).

Firstly, the evidences for case study were collected through work documentation, records of meetings, and interviews. Based on these evidences, principles for designing a successful multi-criteria incentive scheme were formulated. Secondly an extensive literature review on construction contract incentives was conducted by reviewing main reputable journals of construction management, such as ASCE journals, *Construction Management and Construction, International Journal of Project Management,* etc., over the past three decades. Based on the CSFs identified through literature review, structured interviews were conducted for validation. Thirdly, content analysis combined with the quantitative approach was employed to assess process performance based on the information acquired in the work documentation and reports. Fourthly, a Key Performance Indicators (KPIs) questionnaire was developed to assess the mega-site management performance between the case and other mega-projects in Shanghai to get a thorough understanding of how successful incentives were in the case. Finally, the conclusions and recommendations were provided based on the case study.

Rule Design of Incentives

Design of Incentive Contract Clauses and Performance Standards

Incentives play an important role in construction contracts; and their role is to motivate the contractor to

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adopt the client's project objectives (Bower et al. 2002). In the Shanghai Expo case, economic incentives for mega-site management were designed into the general construction contracts for nearly all main general contractors, including all the building project general contractors, and part of the municipal project general contractors. The corresponding performance assessment standards not only considered the related goal results, but also considered the process performance. They each included two parts: (1) accomplishing related project goals required: no fatalities, nor major quality defects, nor environmental pollution incident; (2) attaining required process performance: secure required performance in the monthly site check (MSC) during the entire building duration, and passing the Site Interim Assessment (SIA) organised by the SQMD. If the general construction contractor could meet all the conditions mentioned above, it would receive the commendation certificate and the bonus which is about 0.1% -0.3% of the contract price, over and above the original competitive bid price. This policy was implemented in November 2007, the 16th month of the 44-month construction duration, and finished when the construction ended, which lasted for 29 months.

Process Performance Assessment System

The Process Performance Assessment Standards were designed into nine assessment tables (ATs) for the convenience for process performance assessment work. They concerned all four performance factors: (1) construction safety; (2) construction quality; (3) environmental protection; and (4) migrant worker management. Every factor was allocated with proper weightings according to local site management regulations (SGOSCESQ 2008). The relationship among assessment factors, tables and weightings are shown in Table 1. Construction safety ranked first with the biggest weighting of 55% in all four factors; construction quality ranked with the weighting of 24%, migrant workers management and environmental protection ranked third and fourth individually with the respective weightings of 11% and 10%.

(Please insert Table 1 here)

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The Shanghai Expo Site involved pavilions, supported service facility buildings, parks, ferries, municipal roads, and necessary various municipal facilities. Therefore, detailed assessment items of AT1, AT3, and AT9 of nine assessment tables were designed into two sets to apply for assessing two main project categories, building projects, and municipal projects; the other 6 assessment tables were the same. All the assessment items were designed based on the national and local related regulations and standards (SGOSCESQ 2008; MOC 1991; 1999 and 2005).

Implementation Process

(Please insert Fig. 1 here)

The process performance assessment system was a semi-structured system comprising two parts, the Monthly Site Check (MSC) and Site Interim Assessment (SIA). The MSC applied to every project in construction from its start to finish, which was recorded individually for assessing its site management performance. The SIA only applied to the project that had already submitted the application properly, which was the main index to judge whether the project met the requirement of the incentive agreement item. Only the project which passed SIA and attained the performance in all the MSCs without any occurrence of accidents could receive a hard copy certificate with the commendation of "Construction Site Management Model Project" in the year of passing the SIA and the final bonus after the project completion. This aimed to encourage general contractors to attain efficiency in the entire construction process and avoid shortsighted cheating in the process performance assessment. The sequence of implementation was as follows:

1. Sign general construction contract. The incentive item was included in all the general construction contracts, which constituted the basis for process performance assessment.
2. Conduct MSCs. MSC was a brief assessment on the same assessment context, which was executed by two or three staff of SQMD, monthly. For the projects passing the SIA, they also should accept MSCs

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in the later time before its completion.

3. Submit application document for SIA. Before SIA, the project general contractor should submit paper application document to SQMD. Besides, the general contractor should submit the application document in the time limit: (1) For building projects, at least 70% of the main structural engineering should be complete, and less than 30% completion of the fitting-out engineering; (2) For non-building projects, completion of 50% of the total construction quantity (such as roads or landscaping) should be completed. In the application document, the general contractor report added project construction safety and quality plan and their implementations as supplementary documents. It should be noted that not all the SIA applications meeting the time limit would be accepted unless it had a satisfactory performance in the MSCs before SIA application.

4. Conduct SIA. Relevant to MSC, SIA was implemented by a random assessment group organized by SQMD, which was made up of 18 assessment experts, 7 from the SQMD and 11 randomly selected from other eight functional management divisions of the client. Each of the assessment standards included 9 assessment items, and every assessment item was assessed by two experts separately, and the assessment score was the mean value of two scores. SIA was usually arranged in the month following the SQMD acceptance of the application. Based on scores of nine ATs given by the assessment group, the calculation of the SIA score of a single project assessed can be expressed as Eq. (1).

$$\text{SIA Score} = \sum_{i=1}^{n=9} \left[\frac{S_{AT\,i(1)} + S_{AT\,i(2)}}{2}\right] \qquad (1)$$

Where $S_{AT\,i\,(1)}$ = assessed score of No. *i* assessment table by one expert; $S_{AT\,i\,(2)}$ = assessed score of No. *i* assessment table by the other expert; n = the quantity of assessment tables.

5. Analyze data and release the result. Since the maximum score of SIA was 100, the score achieving 90

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was regarded as a pass, which was a score adopted in the site assessment organized by the government. If the contractor attained the necessary performance in all the MSCs, the Yearly Process Performance Score (YPPS) of the single sub-projects equaled to the SIA score. YPPS lower than 90 would be regarded as a 'fail' project in the process performance assessment. The MSC aimed to assure the validity of SIA and to attain full-process performance. Besides, if any accident or incident of safety, quality, environment and migrant workers occurred, the contractor would be regarded as having failed in meeting the requirements of the incentive.

Identification and Validation of CSFs for Incentives

Chua et al. (1999) pointed out that searching Critical Success Factors (CSFs) for a given type of project can be implemented both by a literature review and based on expert opinions. These methods could also be adopted to search for CSFs for implementing successful performance incentives. Through an extensive literature review on peer-reviewed journals, five CSFs were identified in previous studies: (1) proper rule design; (2) process orientation; (3) top management support; (4) training and promotion; (5) process communication. Table 2 shows the categories of these CSFs by previous studies.

(Please insert Table 2 here)

Based on CSFs identified from literature review, sixteen interview questions in total were developed to explore why the incentives were effective and to provide the details of implementing the effective incentives in mega-projects. The interview questions also addressed: (1) perceived extent of success in meeting safety, quality and environmental goals; (2) other perceived CSFs.

Two rounds of face-to-face interviews were conducted to analyze the major benefits and CSFs for the incentives. The interviewees included two client's representative from the SQMD, and ten representatives from eight main general contractors. They represented a cross section of the senior management and site

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management staff. They all had indirect involvement in the incentive process and were able to provide an overall picture in this case. All the interviews were conducted between January and April 2010.

The interview results indicates all interviewees advocated the five CSFs for incentives, adding process learning and improvement as an indispensable CSF for adopting incentives in this case. The interview details on perceived extent of Success in meeting site management goals and CSFs for incentives were formulated as follows:

Perceived Extent of Success in Meeting Safety, Quality and Environmental Goals

All interviewees agreed that although dynamic process performance may not be attained all the time, the overall results relating to safety, quality, and environment were satisfactory with consideration of the mega scale and complex nature of the case, which were the results of common and continuous efforts by the client and all the genneral contractors involved. The major successes could be supported by the following evidences: (1) No fatalities arising from construction were reported during the construction duration. (2) All the sub-projects passed the government's acceptance in one time smoothly; and their engineering quality achieved 100% of meeting the operational requirements. (3) No environmental pollution incident occurred during the construction period. Besides, the majority of general contractors agreed that, based on their construction experience, the Shanghai Expo Construction had better performance on safety, quality and environmental goals than the majority of other government-invested mega-projects in construction in Shanghai and nearby provinces in the PRC.

Rule Design of Incentives

Rule design is how the incentives are structured and it has great impact on the effectiveness of the incentives (Liska and Snell 1992; Jaraiedi et al. 1995; and Hinze 2002). According to the interview feedback, the client inputs a lot of efforts to design a proper incentive system. The client first selected a very experienced government officer as SQMD's head to take duty of designing and implementing the incentives, who possessed more than forty years professional experience and nearly twenty years

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experience in the government for inspecting the safety and quality of government-invested major projects. Therefore, based on multi-round internal discussions and full negotiation with major contractors, the process performance assessment system was developed to strengthen process control of the incentives. In the design process, they also had full consideration of a team orientation, for all the economic (monetary) bonus was set based on explicit team performance. Besides, the client added that although it was difficult to consider all details of incentives at the initial planning phase for such a mega-project, the incentives performance criteria were clearly defined.

Process Orientation

Process orientation correlates implementation process of site management incentives, since site management related to safety, quality and environmental goals is characterized by process orientation (Hinze 2002; Koehn and Datta 2003). In the interview dialogues, Contractor interviewees stated that although they had completed some contracts with similar safety and quality incentives, they seldom dealt with such a strict process assessment standards and system to monitor their process performance. They agreed that the rule design of the incentives should not only be assessed by the final result, but also focus on the process performance of doing the work. Besides, all interviewees agreed that common commitment in the process facilitated the incentives, and the process performance assessment in the construction period. A closer collaborative working relationship between the client and genernal contractors was developed, thereby strengthening mutual trust. The healthy competition in general contractors with a positive attitude was also established by communication and feedback in MSCs and SIAs.

Top Management Support

Top management support plays a critical role in an effective incentive scheme related to safety. (Teo et al. 2005; and Heberle 1998). The interview dialogues indicated that the client fully understood the difficulties of introducing incentive schemes in such a mega-project. However, there was no more alternative in order

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to attain high performance. There was a concern by the client's top management on the issue that not all the contractors held positive attitudes for the incentives, and so they made much effort to promote the incentives smoothly. The client established a system of regular meetings with the top management of main general contractors involved and they also often joined the activities organized by contractors. Correspondingly some general contractors involved in multiple major construction projects established on-site offices to manage and coordinate all the construction projects in the Expo site. The combined supports from the top management of the client and contractors promoted the incentives to work smoothly.

Training and Promotion

Training and promotion can be regarded as a necessary condition to implement a new safety or quality policy with regarding to all the construction workers and management staff of general contractor (Heberle 1998; and Warne 1994). In the interview dialogues, the client stated that besides the full negotiation of incentive clauses before signing the general construction contract with every contractor, SQMD also adapted some measures to promote the incentives and train stakeholders. These major measures included: (1) having promotion meetings with every site management team of general contractors after they entered the sites; (2) opening group communication meetings on related topics every two or three months; (3) holding an award ceremony at the end of the year; (4) holding annual site visit activities of site management model projects; and (5) publishing monthly site management newsletters and disseminating them. The majority of contractor interviewees agreed that the client made much effort in the training and promotion to facilitate the implementation of the incentives, which should be identified as the CSFs for the incentives.

Process Communication

Process communication is an indispensable task for project success; it also facilitates recognition and feedback between the client and contractors in safety or quality incentives (Geller 1999; Hinze 2000; and

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Warne 1994). In the interview dialogues, all interviewees from eight contractors agreed that communication between the client and general contractor was closer, and more efficient when compared with the projects they had worked on. Evidences such as having a clear communication channels at site level, and more frequent face-to-face communication and open discussion with the client were cited by contractor interviewees. The client stated that they could get more understanding of potential problems by process performance assessment in construction site management. Thus general contractors also could get more knowledge of client requirements and get timely feedback and suggestions from the client. All contractor interviewees confirmed that a friendly cooperative work relationship with the focus on common objectives was promoted through process performance assessment.

In addition, the client stated that they made much effort to improve the communication methods with general contractors. These included: (1) work contact letters; (2) one-on-one site meetings; (3) group meetings; (4) telephone; (5) fax; (6) group information/ notice messages; and (7) monthly site management newsletter. Finally, contractor interviewees also stated that communication was more often and accessible, resulting in speedier communication. These promoted the establishment of mutual trust and improvement of work efficiency.

Process Learning and Improvement

Process learning and improvement is developed on the common logic of continuous improvement in total quality management. All interviewees agreed that this CSF was practised in the multi-project environment during the construction duration for more than two years. The client stated there were some repetitive building projects involved in the case, so they tried to share success experience with other projects in order to improve the overall performance. Two main learning and improvement activities were identified as follows: (1) holding regular group discussion meetings for every three months on topics of site management issues with all general contractors involved, and (2) holding annual site visit activities of

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site management model projects selected from the case with an invitation to all the main contractors and government departments in Shanghai.

Process Performance Analysis

Analysis on the Yearly Scale Pass Rate (YSPR)

In order to validate these CSFs, quantitative analysis was employed to assess the SIA scores of pass projects produced between 2008 and 2009, which was the main phase of the whole implementation period. Since this policy covered about 2/3 of the whole construction period, only 70% municipal projects and all building projects could meet application requirements of SIA. In 2008, 35 projects applied the SIA; 33 passed it. In 2009, 32 projects applied the SIA; and 28 passed it.

Here the Yearly Scale Pass Rate (YSPR) was employed to calculate the ratio of the total floor area of pass building projects in all the building projects potential for the SIA. This was developed to assess the ratio change of pass building projects in the whole building projects. In 2008, all the building projects were available for the SIA, with a YSPR of 0.71. By the end of 2008, 1/3 of the overall floor area of building projects completed beyond 30% fitting-out engineering and hence not able to apply for the SIA, therefore only 2/3 potential building projects were available for SIA application in 2009, yielding a YSPR of 0.78. The 2009 YSPR was higher than the 2008, which means that the incentives had been better recognized by more contractors in 2009. This improvement was attributable to the client's effort in promotion, training, and, communication during the construction, which further affirmed the validity of related CSFs. The assessment scores of pass building projects in 2008 and 2009 will be analyzed in the following part.

Analysis on the Yearly Process Performance Score (YPPS)

In order to validate the CSF of process learning and improvement, a weighted mean method was

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employed to calculate the total YPPS of all pass building projects respectively in 2008 and 2009. The weight of individual projects was the ratio of its floor area in the total floor area of all the pass building projects. It is expressed as Eq. (2).

$$\text{Totoal YPPS} = \sum_{i=1}^{n} \text{YPPS}_i \frac{Scale_i}{Total\ Scale} \quad (2)$$

Where YPPS_i = YPPS of No. *i* pass building project; Scale_i = construction floor area of No. *i* pass building project; Total Scale = the total construction floor area of all the pass building projects in 2008 or 2009; n = the amount of all the pass building projects in 2008 or 2009.

Since the type compositions of passed municipal projects in 2008 and 2009 were different, they cannot be analyzed by this method. Therefore, only the YPPS of building projects were presented here. The total YPPS of 21 pass building projects in 2008 was 93.12; the total YPPS of 18 pass building projects in 2009 was 93.75, which was slightly higher than the score in 2008. It shows that continuous improvement was attained by the implementation of the incentives, validating the CSF of process learning and process improvement.

The YPPSs of passed building projects in 2008 and 2009 are shown as in Fig. 2.

(Please insert Fig. 2 here)

In 2008 and 2009, eight building projects passed the SIA consecutively, with a total floor area of 39%. This further proved the success of implementing the incentives in the case.

Overall Performance Assessment by the KPI Questionnaire

The total floor-area scale of pass building projects takes 80 % of all building project; the total construction scale of pass municipal projects takes more than 50% of all municipal projects in Shanghai Expo site. Therefore, based on a rough estimation, all pass projects takes about 70% of the whole construction scale of Shanghai Expo case. In order to analyze the overall impact on mega-site management through the

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incentives, a KPIs performance questionnaire was designed to compare mega-site management performance between the case and other mega-projects invested by the government in Shanghai in the past decade, such as Hongqiao Comprehensive Transportation Hub (the biggest transportation change hub with an investment of about 5 billion USD), No. 12 metro line (about 3 billion USD investment), Pudong Airport Phase II (about 4 billion USD investment),and Yangshan Port (about 7 billion USD investment).

The KPIs used in the questionnaire mainly include: (1) construction safety; (2) construction quality; (3) migrant worker management; and (4) environmental management. A four-point assessment scale was used to calculate the mean scores for four KPIs, where 1 = acceptable, 2 = good, 3= very good, and 4=outstanding. Based on the mean scores of four KPIs and their percentage in the process performance assessment system, the overall mega-site safety, quality and environmental performance KPIs of Expo and Shanghai City were calculated accordingly.

Since the success of the questionnaire survey depends primarily on the careful selection of the respondents, only experts with mega-project experience and in-depth knowledge of the Shanghai Expo were invited to participate in this questionnaire survey. Four government officers were selected and invited to take part in the KPIs questionnaire survey. The standards for selecting these experts involved included: They (1) undertook the duty of supervising construction safety and quality in the Expo site; (2) made site inspection at least once a month; (3) were involved in other mega-projects in Shanghai in the past decade; and (4) had at least ten years professional experience (two have more than 30 years experience).

Table 4 and Fig.3 show the KPIs results of Shanghai Expo and other Shanghai mega-projects. It can be found that the performance of Shanghai Expo is better than the average performance of other Shanghai mega-projects in all four KPIs. Migrant worker management in Shanghai Expo outperformed its

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counterparts with the largest margins, followed by construction safety. Construction quality and environmental protection both ranked third. They provided evidence that the incentives had a positive impact on the overall construction safety, quality, and environmental performance in Shanghai Expo.

(Please insert Table 4 and Fig.3 here)

All the respondents of KPIs questionnaire agreed that Shanghai Expo Construction is an excellent model mega-site with outstanding performance in consideration of its mega scale and complicated type composition. In the interview dialogues, all interviewees agreed with this opinion. Besides, the overall KPI of the case not only attain a higher score than other mega-projects invested by the government in Shanghai, but also all four sub KPIs had better performance.

Besides, all KPI questionnaire respondents concurred that the incentives may be the only proper reason for high mega-site performance and results in implementing the incentives in the Shanghai Expo case. They also added that the incentives should be employed with necessary caution in mega construction projects, and the identified CSFs should receive more attention in implementing the incentives.

Conclusions and Recommendations

Based on (1) the excellent mega-project results; (2) the excellent process performance; (3) the positive comments revealed by the interviews; (4) the excellent results of KPIs questionnaire; and (5) the positive comment by the questionnaire respondents, Shanghai Expo Construction is an outstanding example of mega-site management. The success was attributable to the introduction and implementation of the incentives in building projects and majority municipal projects.

From the study of the Shanghai Expo Construction case, the following conclusions and recommendations can be drawn:

1. The incentives are validated as an effective means to improve the safety, quality, and environmental

performance in mega-projects based on the case study reported in this paper.

2. The framework for designing an effective multi-criteria performance incentive is formulated through a case study, including incentive contract clauses, assessment standard, process monitoring system, and implementation process. It may be transferable to other projects worldwide.
3. The process performance assessment is identified as a new process monitoring technique matching with incentive contracts, which may realize the harmonious balance between process performance and final result, thereby providing necessary process monitoring for mega-projects.
4. The identified CSFs for the incentive scheme have been fully validated by the structured interviews, content quantitative analysis, and the KPI questionnaire survey. This may provide better guidance for practitioners to execute an effective performance incentive scheme in future mega-projects.

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Figure Caption List

Fig. 1 Excellent engineering construction assessment process

Fig. 2. YPPSs of pass building projects in 2008 and 2009

Fig. 3. Performance comparison matrix between Shanghai Expo and other Shanghai mega-projects

Figure 1 for revise

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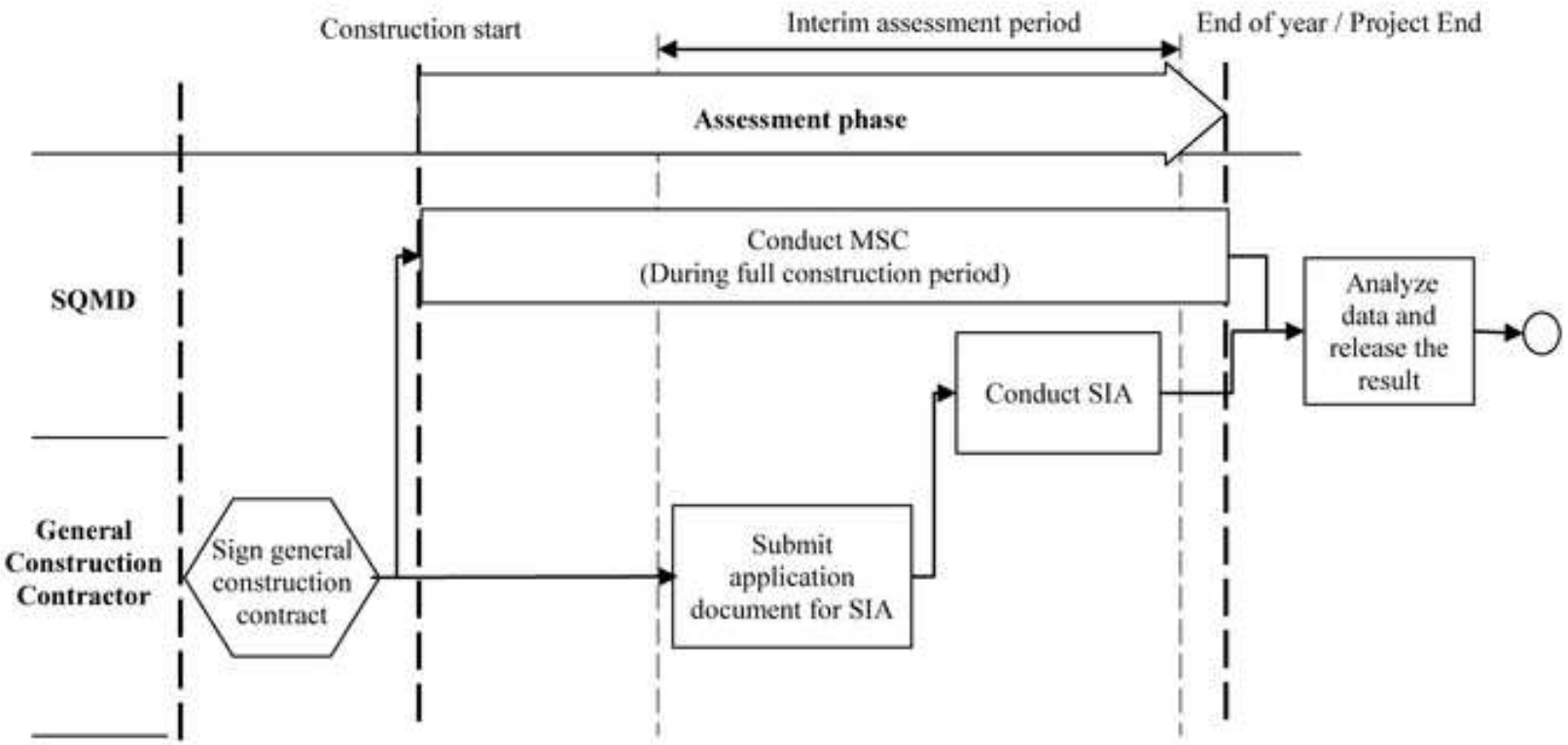

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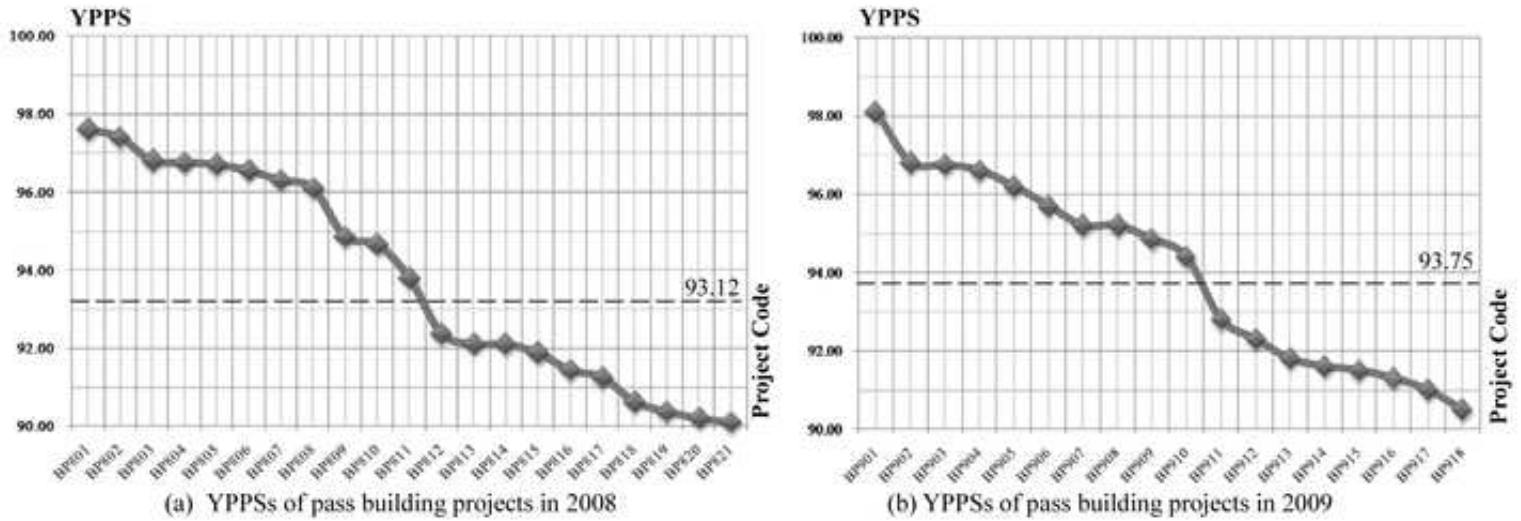

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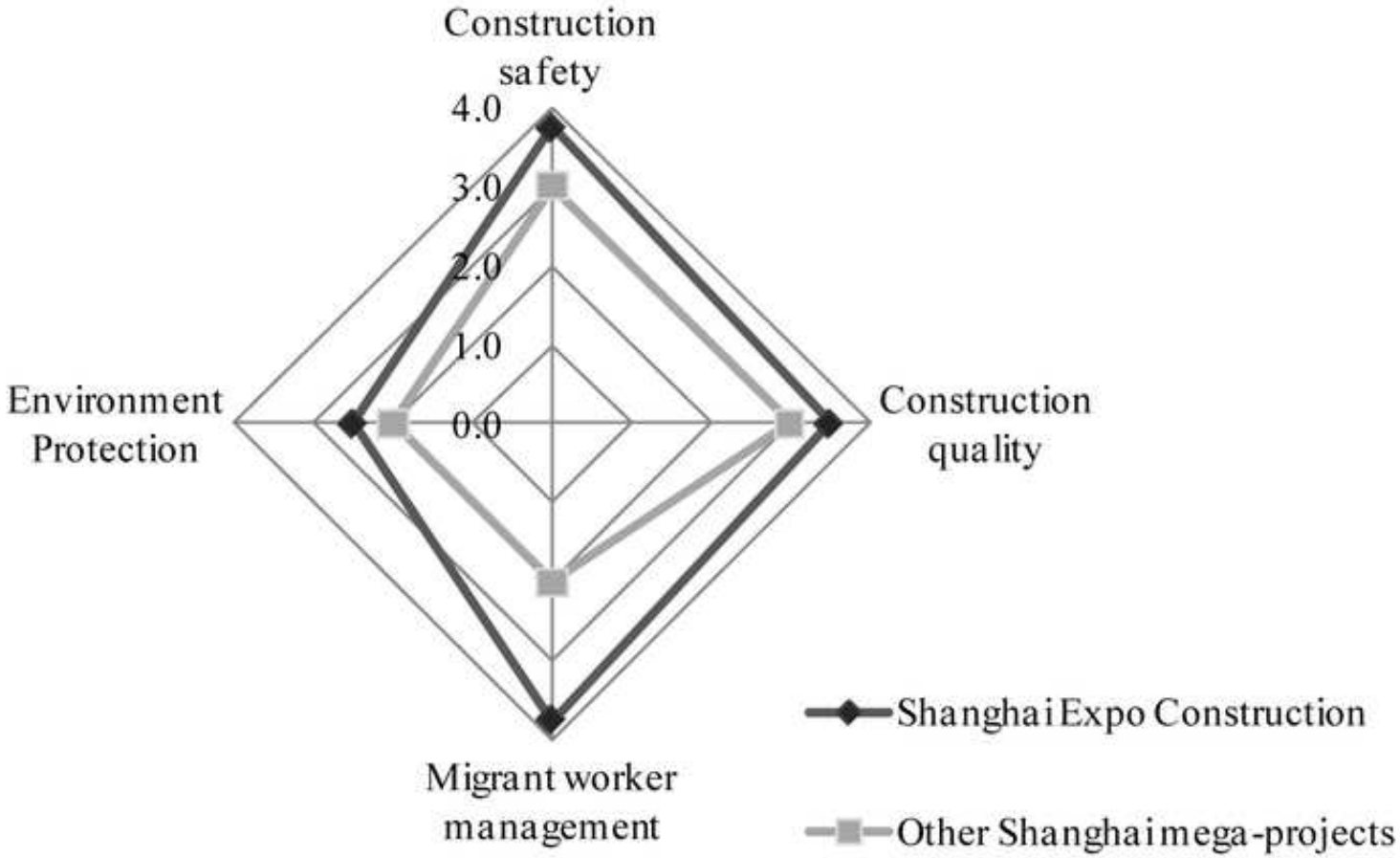

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Table 1. The relationship among assessment factors, tables and percentage weightings

Assessment Aspect (AA)	Assessment table (AT)	Score percentage of AT	Score weightings of AA
Construction safety	AT 1. Construction safety guard protection and facilities	15%	55%
	AT 2. Construction machines and temporary electricity use	15%	
	AT 5. Occupational health and epidemic prevention	3% (10%)	
	AT 6. Promotions and trainings for construction safety and quality	4% (10%)	
	AT 7. Site administration	8% (10%)	
	AT 8. Safety management documentation	10%	
Construction quality	AT 3. Construction quality	10%	24%
	AT 6. Promotions and trainings for construction safety and quality	4% (10%)	
	AT 9. Quality management documentation	10%	
Migrant workers management	AT 5. Occupational health and epidemic prevention	7% (10%)	11%
	AT 6. Promotions and trainings for construction safety and quality	2% (10%)	
	AT 7. Site Administration	2% (10%)	
Environmental protection	AT 4. Pollution prevention	10%	10%
	Total Amount	100%	100%

Note: Percentages in the parenthesis signify the overall score percentage of specific AT in overall assessment score.

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Table 2. Categories of CSFs for the effective incentives

CSFs / Previous Studies	Proper rule design	Process orientation	Top management support	Training and promotion	Process communication
Liska and Snell (1992)	√		√		
Warne (1994)		√	√	√	√
Jaraiedi et al. (1995)	√				
Hofman and Stetzer (1996)	√				
Heberle (1998)	√		√	√	√
Geller (1999)		√			√
Hinze (2000 and 2002)	√	√	√		√
Teo et al. (2005)			√		√
Tang et al. (2008)		√			
Total	**5**	**4**	**5**	**2**	**5**

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Table 3. Application and passed projects in 2008 and 2009

Year	Application project amount	Application project type		Pass project amount	Pass project type	
		Building project amount	Municipal project amount		Building project amount	Municipal project amount
2008	35	21	14	33	21	12
2009	32	20	12	28	18	10
Total	67	40	26	61	38	22

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Table 4. KPIs of Shanghai Expo and other Shanghai mega-projects

Project	Shanghai Expo					Other Shanghai mega –projects				
KPI	Constr. safety	Constr. quality	Migrant worker manage.	Environ. Protect.	Overall KPI	Constr. safety	Constr. quality	Migrant worker manage.	Environ. Protect.	Overall KPI
Percent -age	55%	24%	11%	10%	100%	55%	24%	11%	10%	100%
1#	4.0	3.0	4.0	3.0	3.7	3.0	3.0	2.0	2.0	2.8
2#	3.0	4.0	4.0	2.0	3.3	3.0	3.0	2.0	2.0	2.8
3#	4.0	4.0	4.0	3.0	3.9	3.0	3.0	2.0	2.0	2.8
4#	4.0	3.0	3.0	2.0	3.5	3.0	3.0	2.0	2.0	2.8
Total	3.8	3.5	3.8	2.5	3.6	3.0	3.0	2.0	2.0	2.8

Note: Constr. =Construction; Environ. =Environment; Manage. =Management; Protect. =Protection.