

# The execution of infrastructure project life-cycle

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**Abstract.** The significant increase in Indonesian construction sector activity nowadays is also influenced by government financing for infrastructure projects. Therefore, the government needs to ensure that the infrastructure projects are consistently constructed along the project life-cycle. Phases of the infrastructure project life-cycle implemented in the Ministry of Public Works and Housing consist of 1) planning, 2) selection of service providers, 3) construction processes, and 4) construction product hand-over. Data collection using three rounds of Delphi Study was undertaken to empirically test the level of implementation of the project life-cycle indicators, which are used as standards to construct infrastructure projects. The respondents of the studies came from sectors who were executing infrastructure projects in the areas of *Cipta Karya*, *Bina Marga*, *Sumber Daya Air*, and *Penyediaan Perumahan*. The results of the studies concluded that the sectors have understood and implemented most of the indicators, however, different levels of implementation have existed along with the barriers of the implementation. From the studies, profiles of the execution of infrastructure project life-cycle were provided as references for the government to evaluate the performance of the sectors, as well as to take corrective actions to improve their performance.

## 1 Introduction

The Ministry of Public Works and Housing of Indonesia had been allocated 106.9 trillion IDR, making it the largest recipient of government funding in 2018. The allocation of the funds mostly covers increasing connectivity, housing and settlements, and clean water infrastructure. Along with the increased development of the national infrastructure projects, Indonesia's construction industry is facing tight competition in both domestic and global construction markets; concerning that the infrastructure project is an open construction market. Therefore, the quality of infrastructure project execution hence the project results are of concern to the government and other stakeholders in addressing this issue, particularly in providing qualified and sustainable infrastructure products.

The Indonesian government has serious questions relating to the poor construction processes that have an impact on the failure of several infrastructure products. There have been several cases of recent infrastructure construction failures, such as Situ Gintung Dam, which collapsed in March 2009, the collapsed Kutai Kertanegara Bridge in November 2011, Makassar Hasanuddin Airport Hangar that collapsed in March 2015, and the collapsed bridge at BSD Toll in December 2016. Various aspects might cause the failure of such infrastructure projects such as unaccountable

procurement of materials and services, the construction processes that had not met the specification of the project work as agreed in the construction contract. Poor construction end-product performance reflects the low performance of service providers, as well as the weakness of monitoring system during construction implementation which is managed by service users in particular, and the weakness of construction quality control system in general.

In the execution of infrastructure projects, every phase of construction or known as a phase of project life-cycle is equally important in determining the quality of project implementation. Since every phase of construction is critical, it requires control and evaluation before moving to the next phase. The phases of project life-cycle that become a concept in the Ministry of Public Works and Housing to execute the construction of infrastructure project consists of (1) project development needs, (2) selection of service providers, (3) construction processes, and (4) project hand-over. It is the government desire also to ensure that the construction of an infrastructure project fulfills the work being contracted (as stipulated in the contract quality plan/*Rencana Mutu Kontrak*-RMK).

This study, therefore, examines the level of implementation of the indicators of infrastructure project execution developed by the Ministry of Public Works and Housing. The findings contribute to the

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understanding of infrastructure project life-cycle execution-as-practice on four sectors, namely *Cipta Karya*, *Bina Marga*, *Sumber Daya Air*, and *Penyediaan Perumahan*, and to the evaluation of the sectors' performance through profiles of the execution of Indonesian infrastructure project life-cycle. Furthermore, the study provides insights about the increase of the sectors' performance by reviewing the corrective actions of barriers that may hinder the success of infrastructure project execution.

## 2 Phases of infrastructure project execution

In the infrastructure projects life-cycle many activities are involved that direct projects to meet constraints of on time, within budget, quality standard, and achieved scope. In particular, the Ministry of Public Works and Housing in ensuring that the execution of infrastructure projects meet the constraints together with a target of zero-accident has divided infrastructure project execution into four main phases:

- 1) Planning, with core activities: needs identification, programming, and technical planning;
- 2) Selection of service providers, with core activities: a review of procurement plan, procurement implementation, and procurement administration;
- 3) Construction processes, with core activities: pre-construction preparation, construction works, and control and monitoring progress of construction works;
- 4) Construction product hand-over, with core activities: identification and preparation of product hand-over, acceptance of a product, project work transfer process, and documentation and administration of product hand-over.

The phase of project life-cycle can be defined differently. However, the nature of construction project can be recognized from its slow movement at the beginning of project starts, then it increases during the construction processes, and it is more gradual approaching the end of project duration. In general, the project life-cycle consists of initiating process group, planning process group, executing process group, monitoring and controlling process group, and closing process group [1]. Hence, it can be stated that the phases of project life-cycle may differ, depending on project scope and pattern of project execution.

Although the life-cycle of infrastructure project has been well recognized to maximize the performance in every phase, it will be an inevitable requirement due to shortages of project resources and quality control system throughout the project life-cycle. The success of the infrastructure project should be evaluated from the

planning phase to construction product hand-over phase. In other words, the success of infrastructure projects depends on the active involvement of various parties, namely: construction service providers, service users/ the government and its partners; this has been regulated, however, the roles and responsibilities of those parties need to be clarified. According to Abou-Senna et al. [2] stakeholder involvement is critical as they are great assets throughout the length of the project development; thus they need to be appropriately managed and respectfully addressed and regarded, as they can be a source to push the progress of the project.

### 2.1 Planning

The planning phase of infrastructure project aims to prepare and provide information on the implementation of the required work, including drawings and specifications, and the completion of all tender documents. At this phase, the roles of project owner cover having ideas under the project plan, providing funding and project area, making final decisions regarding project development, and having absolute authority in determining and appointing construction management and project planners/ planning consultants.

In reviewing the roles of the project owner and the planning consultant, the government as the owner of the infrastructure project provides ideas to the planning consultant, who is obliged to translate the owner's ideas technically. Ideally, every planning phase generated by the consultant shall be reported and approved by the owner. However, constraints that often occur in such cooperation is that the consultant is less able to translate the intention and desire of the project owner. The assumptions made by the consultant in completing the planning documents are often different from the situation on the ground, resulting in additional work that exceeds the allowable standards [3]. An example of successful freeway project in Melbourne, Australia, in fact, was driven by a construction planning process which was integrated with OHS, EM, QM systems [4]; this case is such a recent circumstance to be developed in the phase of construction project development needs in Indonesia.

Developing project development needs is an essential task in the area of construction and project management [5], while the ability to undertake project depends on the planning documentation [6]. The latter authors further explain that construction planning requires expertise and competent planner, especially on two aspects, i.e., understand what will be built and have a plan on how to build while maximizing project resources [6]. This then leads to the election of the contractor as the executor of the planning documentation. Formal documentation is required as sources of information to be delivered to project stakeholders in the next phase.

### 2.2 Selection of service providers

At the phase of service providers selection, project owner through selection committee is fully charged to prepare procurement documentation and processes. The

project owner submits tender documents prepared by the planning consultant to the committee. The process of determining the service providers is conducted electronically, which is based on the government regulations.

Along with the implementation of the regulations on the selection of service providers in executing government's goods and services, there is lack of consistencies in this phase. The selection results are inconsistent with the required qualification and competency of the winners as outlined in the tender documentation for standards of work required; this allows the evaluation of the proposed tendering to be only qualified administratively. Whereas, the award of a contract to a competent contractors should ensure effective delivery of construction project to cost, time and quality standard [7]. There are also found contractors who could not implement the planning documentation due to misconduct in a preliminary investigation of project location [8]. Therefore, project owner should validate not only the pre-award contractual project winner but also the project planning document that can be appropriately executed.

### 2.3 Construction implementation

The phase of construction implementation aims to produce construction product that meets the specification required by project owner which has been designed by the planning consultant, within project timeframe, cost constraint, and quality standard, as agreed upon in the contract. The primary project stakeholders who have involved in this phase are project owners, contractors, and supervising consultants. As Oyegoke et al. [9] say that a construction project involves many stakeholders, long project durations, and complex contractual relationships.

In reviewing the roles, tasks, authorities, and responsibilities of the stakeholders during the infrastructure project implementation, it is inevitable for them to build strong relationships and effective communication. For example, contractors are required to have approvals of completed work from technical director and supervising consultants. Problems might occur whenever the contractors cannot execute the project works since they are different with the planning documentation. In this case, the supervising consultants are unable to decide the best solution for they do not undertake the project planning, and the planning consultant is not required to be on project site at this implementation phase. Concerning a type of construction contract, this case adopts a design-bid-build approach, where project design and construction are contracted separately. Research on road infrastructure projects in Indonesia carried out by Trigunarsyah and Parami Dewi [10] has promoted the implementation of design-build procurement which can result in better performance of Indonesian infrastructure projects. According to these authors, although a design-bid-build approach is deemed fairer to contractors, it may not be able to create value for the infrastructure owner since the lengthy

procurement periods often result in less desirable outcomes, such as excessive costs, poor quality and time delays [10]; these barriers might affect the performance of the infrastructure project during the construction phase.

The uniqueness of every construction project might result in an evaluation of construction performance starting from the project task level [11]. This insight also applies in constructing an infrastructure project, where intensive monitoring work progress seemingly is much implemented in the phase of project construction. Nevertheless, the activities of monitoring project performance including quality control shall be conducted throughout the phases of project life-cycle. PMBOK [1] suggests the interaction between the phases of project life-cycle with monitoring and controlling process exists from project start to finish. Admittedly, the performance of infrastructure project during the construction phase is much determined by the performance of contractors, without neglecting the performance of other project stakeholders. Contractors should be holding regular meetings with the operations and maintenance groups to ensure that their original intentions for the project are reasonably executed [2].

### 2.4 Hand-over of project results

The phase of the hand-over of project results aims to ensure that the final project results confirm with the contractual agreement, and to evaluate the performance of all construction project stakeholders in regards with their needs. Although every party has been aware of its needs and thus supports the project success, however, there are still issues relating to the final phase of infrastructure project life-cycle.

Frequent problems in the final phase of infrastructure project life-cycle, such as project activities have been amended exceeding the job requirements; this is due to inaccurate project planning and control. Concerning the scope and roles of the Indonesian infrastructure project, the government as project owner and regulator should actively play a role in every sub-phase of hand-over of project results, covering: re-reviewing project needs, conducting mutual check 100, conducting commissioning test, conducting partial until final stage of project hand-over, and checking construction failure. Barima and Rowlinson [12] give insight in the use of the virtual model in construction project value delivery, an innovative and modern ICT concept, which can enhance the delivery of construction end products via the use of efficient processes for effective results delivery. Eventually, meeting stakeholders' satisfaction through successful completion of overall project performance (time, quality and cost) is a key attribute in developing project performance criteria for construction projects [13]; this achievement remains a challenge for infrastructure projects in Indonesia.

### 3 Research methods

The understanding of which research methodologies and methods are appropriate is important in development for successful data collection in the construction industry [14]. Accordingly, this research intends to seek consensus on the level of implementation of the indicators of infrastructure project execution developed by the Ministry of Public Works and Housing. This study then employs three rounds of Delphi questionnaires surveys, to obtain a panel of expert opinions, who were the government officials and practitioners, on the research question (see Table 1). The groups of experts are working on *Cipta Karya* – sector regarding building construction, *Bina Marga* – sector regarding road and bridge construction, *Sumber Daya Air* – sector regarding water facilities construction, and *Penyediaan Perumahan* – sector regarding house and settlement construction, in Bali Province, North Sulawesi Province, and Centre Capital of Jakarta Province.

Selecting an appropriate panel of experts for data collection by using a Delphi study is crucial [15]. Respondents targeted to provide the intended data in this research study were selected from purposive sampling techniques, i.e., obtaining a consensus of data from experts who involved in the execution of infrastructure projects from project start to end of the project. In addition, this technique is chosen with consideration of time-consuming and economic cost; however, it still produces the information as required. The respondents in Delphi survey can be 15 to 30 experts [16], even three to 80 respondents as needed [17]; as long as they are experts on the research studies.

Delphi round one aims to gather the experts' opinions on the research question, and Delphi round two and three aim to consider then to approve the results from round one. All data collected were analyzed using descriptive statistics mode to obtain the level of implementation of the indicators in the four phases of infrastructure project life-cycle. The first round was scheduled on 12 to 22 June 2017, while the second round was on 5 to 12 July 2017, and the third round was on 19 September 2017.

**Table 1.** Number of experts who participated in the Delphi survey.

Sectors	Expert Criteria	Round 1	Round 2	Round 3
<i>Cipta Karya, Bina Marga, Sumber Daya Air, Penyediaan Perumahan</i>	Head of Working Unit - <i>Satker</i>	7	5	4
	Procurement Unit - <i>ULP</i>	11	5	2
	Committing Officer - <i>PPK</i>	13	6	2
	Product Hand-over Committee - <i>PHO</i>	4	3	2
	Others	13	3	-
	<b>Total</b>	<b>48</b>	<b>22</b>	<b>10</b>

## 4 Results and discussion

**Table 2.** Indicators of project development needs.

Indicators	Delphi Round 1		Level	Delphi Round 2 %Yes
	Mode	% Mode		
It is adjusted to the strategic plan	4.00	44.20	High	100
It is adjusted to the master plan	5.00	39.50	High	100
Project output is tailored to the community needs	4.00	41.90	High	100
It is analyzed based on stakeholder involvement	4.00	41.90	High	86.4
Developing internal coordination	5.00	32.60	High	86.4
Developing general procurement plan	5.00	74.40	High	95.5
Reviewing the general procurement plan	4.00	48.80	High	95.5
Developing term of reference	5.00	69.80	High	95.5
Developing feasibility study	5.00	39.50	High	95.5
Developing preliminary investigation	5.00	39.50	High	100
It is based on project risk analysis	4.00	41.90	High	86.4
Developing project execution system	4.00	34.90	High	90.9
Conforming to the regulations	5.00	51.20	High	95.5
Developing OH&S budgetting plan	5.00	37.20	High	77.3
Developing DED	5.00	72.10	High	95.5
Developing quality plan	5.00	65.10	High	100
Developing master schedule	5.00	74.40	High	100
Developing procurement plan	5.00	62.80	High	95.5
Reviewing the procurement plan	4.00	37.20	High	77.3
Developing selection of service providers plan	5.00	65.10	High	90.9

Delphi study Round 1 and Round 2 deal with the questions related to the level of implementation of the indicators of infrastructure project execution developed by the Ministry of Public Works and Housing. Tables 2 to 6 reveal the experts' opinions on the Delphi questionnaire surveys.

In the data collection of Delphi Round 1, there are 20 indicators of project planning/ project development needs that were rated by the experts. The measurement was based on unbalanced itemized rating scales [18], which are 5=always implemented completely, 4=always implemented but not completely, 3=often implemented, 2=rarely implemented, 1=never implemented. It can be seen from Table 2 that the indicators have been scored relatively high, 7 of the indicators were rated 4.00, and 13 indicators were rated 5.00. Of the 20 indicators, there are 12 indicators with the frequency of mode < 50%; this indicates that less than 50% of the respondents agreed with the level of implementation of the indicators of project development needs.

In Delphi Round 2 the experts were asked to review the results of Delphi Round 1 and to consider the level of implementation by answering "yes" or "no" to respond to the questions. If they felt that it was not at the right level, they were asked to revise the rating. The data analysis for the questionnaire Delphi Round 2 used the frequency of the respondents' similar answer. Consensus on the level of implementation of the indicators can be achieved if it reaches at least 67% of the time [19]. In the re-evaluation of the level of implementation of the indicators, the agreement response frequency was > 67%, indicating that the experts agreed with the high level of implementation of the indicators.

**Table 3.** Indicators of services providers' selection.

Indicators	Delphi Round 1		Level	Delphi Round 2 %Yes
	Mode	% Mode		
Conducting auction announcement	5.00	95.50	High	95.5
Registration procurement documents	5.00	86.40	High	100
Explaining construction OH&S requirements	5.00	65.90	High	86.4
Opening procurement documents	5.00	95.50	High	100
Evaluating OH&S tender plan	5.00	59.10	High	86.4
Evaluating tender administration	5.00	97.70	High	100
Evaluating qualifications	5.00	93.20	High	100
Publishing auction results	5.00	95.50	High	95.5
Publishing suppliers	5.00	97.70	High	95.5
Documenting procurement process	5.00	70.50	High	90.9

**Table 3.** Indicators of services providers' selection  
(continued).

Indicators	Delphi Round 1		Level	Delphi Round 2 %Yes
	Mode	% Mode		
Announcing the winner	5.00	95.50	High	100
Conducting pre award meeting	5.00	72.70	High	90.9
Preparing contract document	5.00	86.40	High	95.5

Table 3 lists the experts' responses with regard to the level of implementation of the indicators of services providers' selection. All indicators were rated highly (a mode score of 5.00). The experts have high levels of agreement with the level of implementation, considering all the agreement response frequency was > 67%.

**Table 4.** Indicators of construction implementation.

Indicators	Delphi Round 1		Level	Delphi Round 2 %Yes
	Mode	% Mode		
Conducting handover of work location	5.00	79.10	High	86.4
Publishing letter of project start	5.00	93.00	High	100
Preparing mobilization documentation	5.00	58.10	High	54.5*
Conducting pre-construction meeting	5.00	88.40	High	100
Conducting mutual check 0	5.00	93.00	High	95.5
Conducting cost management	5.00	62.80	High	81.8
Conducting time management	5.00	69.80	High	81.8
Conducting contract management	5.00	67.40	High	95.5
Conducting sub-contractor management	4.00	30.20	High	31.8*
Conducting contract control	5.00	72.10	High	100
Conducting OH&S implementation	5.00	53.50	High	86.4
Conducting quality management	5.00	55.80	High	72.7

Note: \* Consensus was reached at Delphi Round 3.

Table 4 shows that all of the indicators of construction implementation were also rated high, with a mode score of 4.00 and 5.00. However, in Delphi Round 2, two indicators were rated high with agreement frequencies of lower than 67%. Those indicators are preparing mobilization documentation (54.5%), and conducting sub-contractor management (31.8%). A follow-up Delphi Round 3 was conducted to disseminate the results of this study, including to gain the final consensus of the two indicators. In this final round, the experts have achieved their agreement on the level of implementation of the two indicators, which are "medium level" for preparing mobilization documentation, and "low level" for conducting sub-contractor management (see Table 6).

**Table 5.** Indicators of project hand-over.

Indicators	Delphi Round 1		Level	Delphi Round 2 %Yes
	Mode	% Mode		
Developing committee of project handover	5.00	88.40	High	100
Re-reviewing project needs	5.00	46.50	High	63.6*
Conducting mutual check 100	5.00	74.40	High	100
Conducting commissioning test	4.00	37.20	High	59.1*
Conducting partial handover	1.00	34.90	Low	54.5*
Conducting the first stage of project handover	5.00	86.00	High	100
Defining project maintenance periode	5.00	86.00	High	86.4
Conducting final stage of project handover	5.00	69.80	High	100
Checking document completeness	5.00	58.10	High	77.3
Checking construction failure	4.00	65.10	High	68.2
Checking planning needs	5.00	41.90	High	68.2
Checking OH&S requirements	4.00	39.50	High	63.6*

Note: \* Consensus was reached at Delphi Round 3.

Table 5 presents the results for Delphi Round 1 and 2 with the level of implementation of the indicators of project hand-over as determined by the experts. It was considered that the experts in Delphi Round 2 had reached agreement frequencies of higher than 67% on most of the indicators. However, several indicators have not met the agreement standard; namely, re-reviewing project needs (63.6%), conducting commissioning test (59.1%), conducting partial handover (54.5%), and checking OH&S requirements (63.6%). Since there were still four indicators that did not reach consensus, Delphi Round 3 needed to be conducted.

**Table 6.** Indicators of infrastructure project execution for Delphi Round 3.

Indicators	Rating	Delphi Round 2 Proposed Rating	Delphi Round 3 % Yes
Preparing mobilization documentation	High	Medium	100
Conducting sub-contractor management	High	Low	100
Re-reviewing project needs	High	Medium	100
Conducting commissioning test	High	Medium	100
Conducting partial handover	Low	Medium	100
Checking OH&S requirements	High	Medium	100

Table 6 presented the results for Delphi Round 3 with the rating of the indicators as determined by the ten experts after third round alteration. The final round of Delphi consists of only six indicators where again the experts were asked to give their final answers in order to get the final consensus. In this final round, all the experts agreed with the proposed rating provided by Delphi Round 2, where the agreement response frequency was 100%.

Based on the findings of the evaluation of the four sectors' performance in managing the infrastructure project execution, almost all indicators are well understood and implemented. It is still possible for the indicators to be implemented completely. However, several barriers hinder the implementation of such the indicators; as revealed from the open-ended questions that are apart from the Delphi questionnaires. Following is the discussion of the findings and the barriers, which reveal the profiles of the execution of Indonesian infrastructure project life-cycle.

As found in Tabel 2, four indicators of project development needs are very well understood and implemented by the four sectors, namely 'developing general procurement plan', 'developing terms of reference', 'developing detailed engineering design', and 'developing master schedules'. All these indicators signify that the four sectors which consider the details of procurement plan, engineering design, and project timeline are crucial being well developed during the planning phase. However, several barriers obstruct the implementation of the indicators of project development needs. Apart of the Delphi survey, the barriers were identified as lack of proportionate project budgeting, lack of a detailed master plan that is directed and appropriate to the needs of the community, land acquisition problem, and there are still many requirements from local governments in licensing rights to the proposed project. It is then argued by Shen and

Walker [4], who suggest the integration of quality management (QM) systems and design and construction procurement in facilitating a more rational way that influences better planning. The implementation of QM systems in the Ministry of Public Works and Housing through regulation *Permen PU* No. 04/PRT/M/2009 about Quality Management System should be consistently implemented right from the project planning, not just covering the development of contract quality plan/ *Rencana Mutu Kontrak*-RMK.

The experts had the high level of agreements for all indicators of services providers' selection (see Table 3). These agreements indicate that the selection of service providers should be undertaken following the regulation and procedure. The absence of following the procedures may lead to the legal problem. Although all the indicators are considered important to be implemented, the barriers still remain. The findings on the barriers indicate that the availability of experts is often a dilemma, budget constraints to clarify or directly check the equipment during the process of selection service providers, the procedure of evaluating project bidders is more oriented towards the cost, not to the technical aspect. These barriers are still consistent with Parami Dewi's study [20] on promoting design-build project delivery system in Indonesian road infrastructure project.

Findings on the evaluation of the indicators of construction implementation reveal that the indicator of 'conducting sub-contractor management' is finally rated low by the Delphi experts (see Table 6). While the indicator of 'preparing mobilization documentation' needs to be more consistently implemented. The experts also consider several indicators as barriers in the phase of project implementation. Among others are weak supervision on the inaccuracy made by contractors, low awareness of OH&S by project managers and project workers, and occasionally hand-over of project location is such a matter of an administrative formality. According to Hoeber and Alsem [21], there is a clear separation between the project phases with formal information deliveries after each phase, and this might result in the loss of information and knowledge when they are delivered to the next phase. Therefore, when reaching phase of construction implementation, the project owner must ensure that information and knowledge from previous phases are well understood, and the main stakeholders can execute all standardizations and project specifications. Likewise, full project information and learning from this phase can be delivered to the next phase.

As identified in Table 5, there are four indicators of project hand-over that have the low percentage of Delphi experts agreements. They are, 're-reviewing project needs', 'conducting commissioning test', 'conducting partial handover', and 'checking OH&S requirements'. Even though the panel experts finally had medium levels of agreements for these four indicators, the experts had realized that several problems were arising in the final phase of the infrastructure project execution. For examples, defect or work failure need a long time to be carried out, quality system and quality control have not

been fully implemented, and final product sometimes does not comply with the specified requirements. It is therefore stated by Aje [7] that the phase of prequalification is crucial to objectively evaluate the contractor who has potentials to deliver construction projects with acceptable quality standard within the scheduled time. In other words, the success of project delivery is already started from the early procurement phase. This insight suggests that strong interconnectedness between phases of infrastructure project life-cycle must exist, and not fragmented as recognized by Adriaanse [22].

## 5 Conclusions

The infrastructure project life-cycle execution needs to be profiled in order to improve the implementation of the project indicators which are authorized by the Ministry of Public Works and Housing. As a project owner, the government needs to pay attention to the successful implementation of the infrastructure project execution as well as minimizing construction failures.

The research found that the four sectors. i.e., *Cipta Karya*, *Bina Marga*, *Sumber Daya Air*, and *Penyediaan Perumahan*, have had the intention to implement the indicators of infrastructure project life-cycle completely. The study revealed that the four sectors consider the details of procurement plan, engineering design, and project timeline are crucial for being well developed during the planning phase; these indicators achieved the high level of implementation. It was also noted that all indicators of services providers' selection have been scored relatively high and have high levels of agreement with the level of implementation, to avoid the legal problem. During construction implementation, the indicator of conducting sub-contractor management has been scored low, while the indicator of preparing mobilization documentation was rated medium. The Delphi questionnaires results also show four indicators in the phase of project hand-over have been finally achieved the medium level of implementation, namely re-reviewing project needs, conducting commissioning test, conducting partial handover, and checking OH&S requirements.

Despite most of the indicators of infrastructure project execution are well understood and implemented, several barriers to implementing the indicators still exist throughout the project life-cycle, which might hinder the high level of performance of the sectors. To overcome the barriers and to promote the consistency and high performance of the four phases of infrastructure project life-cycle, there is still a need to adjust and improve relevant regulations and processes in terms of detailed legislation and regulation on project planning and control, the service providers' capabilities, and the implementation of the quality system and OH&S. Last but not least, the roles and responsibilities of project stakeholders in every phase of the project infrastructure life-cycle should be re-visited to stimulate their positive involvement in implementing the quality of infrastructure project execution.

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