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Evaluating quality management of road construction projects: a Delphi study Debby Willar Civil Engineering Department, Manado State Polytechnic, Manado, Indonesia Bambang Trigunarsyah School of Property, Construction and Project Management, College of Design and Social Context, RMIT University, Melbourne, Australia Anak Agung Diah Parami Dewi Department of Civil Engineering, Udayana University, Bali, Indonesia, and Febriane Makalew Manado State Polytechnic, Manado, Indonesia
Abstract Purpose – There are various methods to assess the failure of a road construction project that does not meet quality and performance standards.

This study aims to evaluate the factors affecting the quality management of road construction projects in Indonesia by identifying the critical challenges in implementing quality management processes and examining the countermeasures to address these problems. Design/methodology/approach – In this research, the quality management processes in Indonesian road construction projects are evaluated using a mixed quantitative and qualitative approach.

Quantitative data obtained from two rounds of Delphi questionnaire surveys as the primary data source, and focus group interviews as the qualitative data are used to achieve the aims of this study. Findings – It is found that from as early as in the preconstruction stage of a project, the availability of quality standards and documentation is problematic when implementing quality management processes.

The critical factor of the quality control activities of a project and the quality management roles and responsibilities of the stakeholders during road construction is the project team. This constraint deals with the interaction of the competency, commitment, and mutual cooperation among the main stakeholders to ensure that

quality management processes are implemented.

This implementation is a part of controlling the road pavement materials, supervising the project activities according to a specified standard, and reporting the project performance. The findings of this study add parameters relating to quality management and quality processes in a road construction project area. Originality/value – This study is the first to evaluate the quality management processes in the construction of Indonesian road projects.

The investigation identifies and evaluates the causes of the persistence of poor road quality. All revealed constraints are substantial factors that hinder the implementation of quality management processes when delivering quality road products. This study addresses the key influencing factors and scenarios related to quality management during road construction projects in Indonesia and other developing countries as practical examples and provides case-based insights for construction practitioners and civil engineering academics in developed countries.

Keywords Quality management, Quality control, Quality measurement, Road projects, Indonesia Paper type Research paper 1. Introduction Transportation infrastructure, particularly road projects, is essential for economic growth and social development, and in developing countries, it is important for poverty alleviation (Amoatey and Ankrah, 2017 ; El-Hamrawy et al. , 2017).

Roads act as a circulatory system to Management of road construction projects This research was supported by the Directorate of Research and Community Service and Ministry of Education, Culture, Research and Technology. The current issue and full text archive of this journal is available on Emerald Insight at:

<https://www.emerald.com/insight/1754-2731.htm> Received 20 April 2022 Revised 14 August 2022 Accepted 19 September 2022 The TQM Journal © Emerald Publishing Limited 1754-2731 DOI 10.1108/TQM-04-2022-0132 promote commerce and communication, providing rural and urban communities access to health, education, employment, and other social services (Amoatey and Ankrah, 2017). Therefore, road construction projects must meet certain specifications to ensure a built road can function during its lifespan.

This is particularly important for highway construction products, which must be delivered in accordance with the technical specifications and quality standards to assess the performance of road projects (Akal et al. , 2016). The Ministry of Public Works and Housing of the Indonesian Government has reported that for fiscal year 2022, a budget of 21.8 trillion Rupiahs (1.52 billion USD) is allocated to construct 354

km of new national roads and improve the quality of national roads[1].

Governments of developing countries such as Indonesia must be aware that the speed of development of road infrastructure should be aligned with its quality. Thus, improving the quality of Indonesian road infrastructure is critical (Dewi, 2013). Global Competitiveness Report 2019 ranks the quality of Indonesian road infrastructure at 60, behind those of Singapore (1), Malaysia (19), and Brunei (32) road infrastructures (Schwab, 2019).

If the quality of a highway project does not meet the required level, the need for maintenance and repair works increases, which causes delays in traffic and transport flow, leading to increased losses and slower economic growth (Thurmer, 2001). The efficiency of road transport systems in developing countries (such as Ghana) is frequently restricted by operational and maintenance costs because of their poor road conditions (Moatey, 2007). Roads are important national assets that must be preserved (Moatey and Ankras, 2017; El-Hamrawy et al.,

2017). Concerning issues of quality in road construction projects, Choudhari and Tindwani (2017) determined that performance measures such as the quality, time, and cost of road projects are influenced by numerous factors.

Some example factors are the overall quality during road construction and the effectiveness of its measurement method (Nyakala et al., 2018). Quality in a construction process implies meeting the needs of the customers and providing personnel who perform many organizational tasks with a common language for improvement (Arditi and Gunaydin, 1997).

Principally, the definition of quality for construction projects differs from that for manufacturing and services industries, because the products of the former are not repetitive, instead are distinct with specific requirements (Asim et al., 2013). Therefore, quality of service is important in every construction project as a key factor for measuring the competitiveness and the project efficiency to ensure customer satisfaction (Nyakala et al., 2018). Quality must be effectively and efficiently managed during construction projects.

Similar to the definition of quality, quality management in the construction industry differs from that in the manufacturing and other service industries (Willar et al., 2015). This is because the quality of construction products requires holistic management approaches and functions to meet the defined project requirements of the clients, which is supported by the organizational responsibilities, procedures, processes, and resources

for implementing quality management (Lam et al.,

1994 ; Rumane, 2011). Research on road construction project quality has shown that meeting quality and performance targets is still challenging (El-Hamrawy et al. , 2017 ; Oechler et al., 2018 ; Akinradewo et al. , 2020b ; Sirin et al. , 2021). Studies assessing the quality management of road construction projects are lacking.

Therefore, investigating Indonesian road projects as study objects enables the evaluation of the factors affecting the quality management of road construction from the perspectives of three stakeholders: government, contractors, and supervising consultants. Such studies are conducted by identifying the critical obstacles in implementing quality management processes and examining the countermeasures to address them.

Quality management processes in Indonesian road construction projects can be evaluated based on the following research questions: RQ1. How are quality management processes currently implemented in road construction projects? TQM RQ2. What are the critical challenges encountered by the above-mentioned three parties of road construction projects in implementing quality management processes? R Q 3 .

How can quality management processes be effectively and successfully implemented in road construction projects? Considering the above research questions, the specific objectives of this study are as follows: (1) evaluating the factors affecting quality management processes in road construction projects, (2) identifying the critical challenges in implementing quality management processes in road construction projects, and (3) examining the countermeasures to address these problems in implementing quality management processes in road construction projects.

This study makes an important contribution to the knowledge on quality management in road construction projects and highlights substantial factors that hinder the implementation of quality management processes. It also examines the countermeasures to address the obstacles which are encountered by the stakeholders of road projects and hinder the production of quality road products. The remainder of this paper is organized as follows.

Section 2 reviews and discusses previous related studies on quality management processes in construction projects. The research methods selected to answer the research questions are presented in Section 3, including the conducted Delphi surveys and focus group interviews. Section 4 describes the factors affecting quality

management in road projects, presents significant remarks on quality management issues, and discusses the findings of the conducted analysis. Finally, the conclusions are presented in Section 5, including the research contributions and implications. 2.

Quality management processes in construction projects Construction quality problems are found worldwide (Ruman e, 2011; Hussai n et al ., 2019; Tariq and G ar de zi, 2023). To add res th e s h or tcomi ng s i n t he I n d o n e s i a n c o n s t r u c t i o n i n d u s t r y , t h e Indonesian government has ordered that all business entities in construction must implement a q u a l i t y m a n a g e m e n t s y s t e m (QMS) a c c o r d i n g t o I S O 9001.

I S O 9001 i s a q u a l i t y m a n a g e m e n t standard that is highly recommended for adoption by construction companies to help them im pl e m e n t q u a l i t y p r o c e s s e s (S w e i s a n d J a r a d a t , 2021). F o r a c o n s t r u c t i o n c o m p a n y u t i l i z i n g t h i s q u a l i t y m a n a g e m e n t s t a n d a r d , n o t o n l y a r e t h e i n t e r n a l m a n a g e m e n t p r o c e s s e s i m p a c t e d b u t a l s o , a c c o r d i n g t o S h e i k h e t a l . (2019), the on-site project environment.

U n d e r t h i s s t a n d a r d , t h e q u a l i t y o f c o n s t r u c t i o n i s s i g n i f i c a n t l y d e p e n d e n t o n t h e q u a l i t y o f t h e p r o c e s s , a s o p p o s e d t o o n t h e q u a l i t y o f t h e p r o d u c t . S p e c i f i c a l l y , q u a l i t y p r o c e s s e s i n c o n s t r u c t i o n p r o j e c t a c t i v i t i e s s h o u l d b e i n c l u d e d a n d g e n e r a t e d b y a q u a l i t y m a n a g e m e n t s t a n d a r d , s u c h a s I S O 9001.

T h i s s e c t i o n r e v i e w s a n d d i s c u s s e s t h e i m p l e m e n t a t i o n o f q u a l i t y p r o c e s s e s i n r o a d c o n s t r u c t i o n p r o j e c t s b y c o n s i d e r i n g t h e m a i n p r i n c i p l e s o f q u a l i t y m a n a g e m e n t s t a n d a r d s a s a b a s i s f o r q u a l i t y m a n a g e m e n t . T h e s e v e n q u a l i t y m a n a g e m e n t p r i n c i p l e s o f c u s t o m e r f o c u s , l e a d e r s h i p , p e o p l e e n g a g e m e n t , p r o c e s s a p p r o a c h , i m p r o v e m e n t , e v i d e n c e - b a s e d d e c i s i o n - m a k i n g , a n d r e l a t i o n s h i p m a n a g e m e n t a r e c o v e r e d [2].

A l t h o u g h t h e r e h a v e b e e n c o n s i d e r a b l e r e s e a r c h e f f o r t s o n q u a l i t y m a n a g e m e n t i n c o n s t r u c t i o n , t h e r e i s l e s s e r c r i t i c a l i n f o r m a t i o n r e l a t e d t o r o a d c o n s t r u c t i o n p r o j e c t s , s p e c i f i c a l l y i n t h e I n d o n e s i a n s c e n a r i o . R o a d c o n s t r u c t i o n p r o j e c t s t h a t d o n o t m e e t q u a l i t y a n d p e r f o r m a n c e s t a n d a r d s c a n b e v i e w e d f r o m v a r i o u s p e r s p e c t i v e s .

C u r r e n t r e s e a r c h i n d i c a t e s t h a t t h e f a c t o r s t h a t m o s t f r e q u e n t l y i n f l u e n c e q u a l i t y p r o c e s s e s i n r o a d c o n s t r u c t i o n p r o j e c t s a r e n o n t e c h n i c a l . T h e s e i n c l u d e a l a c k o f a c o m p e t e n t a n d e x p e r i e n c e d p r o j e c t t e a m (E l - H a m r a w y e t a l . , 2017; S h e i k h M a n a g e m e n t o f r o a d c o n s t r u c t i o n p r o j e c t s e t a l . , 2019), m a n a g e m e n t s k i l l s (K a r i m i a n e t a l . , 2019; S a n t o s o a n d G a l l a g h e , 2020) , t r a n s p a r e n c y i n c o n t r o l (B r a d y e t a l . , 2018; F a m i y e h e t a l . ,

2017), quality awareness and support (Dilawo and Salimi, 2019), effective quality management team (Hussain et al., 2019) and involvement and communication by project stakeholders (Al Nahyan et al., 2019). Road construction project implementation should meet the quality and safety standards set for road infrastructure to benefit road users.

However, there are numerous obstacles in achieving this, in particular, the capacity, quality control management, and policy of the service providers. However, quality during a road construction project can still meet the needs of the project customers, because employers and infrastructure project sponsors consistently aim for products that have a greater value with lower costs (Mousakhan et al., 2017).

All these challenges highlight the need to manage nontechnical factors during road project construction based on quality management standards and related factors. In the following, previous related studies on quality management processes in road construction projects are reviewed, including (1) factors affecting quality management processes in road construction and (2) the current scenario of road construction projects in Indonesia. 2.1

Factors affecting quality management processes in road construction 2.1.1 Quality standard documentation. Quality management begins with quality documentation (Willar, 2012). The documentation of the projects is very essential because poor project documentation leads to incomplete designs, design errors, bad specifications, as well as poor constructability (Malinda, 2017).

The quality standards and procedures required to be undertaken in a road construction project must be made available to allow the project team, construction workers, and other stakeholders to discharge their responsibilities correctly and with conformity. In the absence of quality documentation, a construction company cannot be recognized as possessing a quality system.

For successful implementation of a QMS, companies must possess quality requirements without any challenges (Willar, 2017), which shows their intent for providing the community with reliable infrastructure (Abdirad and Nazari, 2015). In addition to quality documentation procedures, there is a need to set stringent construction and environmental safety standards and procedures at a project site, because unsatisfactory safety levels and the impact of road construction on the natural environment have become major issues (Walimuni et al.,

2017; Ismail, 2019). In the construction industry, quality, environmental, and

occupational health and safety systems (Chountalas and Tepaskoualos, 2019) are commonly integrated into a single system called the quality system.

However, problems frequently occur in the adequacy of the compliance with the standards of quality and safety documents and procedures. For example, poor quality of design documentation is deemed inadequate in terms of accuracy and certainty, which is known to significantly contribute to delays, rework, and cost overruns in South African construction projects (Akampurira and Windapo, 2019).

Contractors desiring to undertake a government project in Indonesia must also provide the complete package of quality documentation (quality policy, standard operating procedures, work instructions, quality records, and quality plans). The objective is to prove their commitment to adhering to quality processes in their construction project activities together with the construction safety standard documentation.

Their contract quality plan must establish all quality and safety targets and the methods by which those targets and the project specifications will be met. The complete quality documentation and standards must also be made available during the preconstruction phase. However, the existence of quality documentation in company head offices, which is a requirement for ISO 9001 certification, has not proved the commitment of companies to ensure that their construction products meet customer satisfaction (Willar, 2012).

ISO 9001 certification allows any organization to gear towards achieving the quality goal [3]. Many strategies exist regarding customer satisfaction TQM measurement, however, overlooking the fundamentals of how to measure customer satisfaction can be detrimental to a business. 2.1.2 Quality control and measurement of quality processes. According to Sheikh et al.

(2019), quality processes are the core of achieving quality in construction projects. When construction organisations adopt complete quality management, managers and leaders should examine at a macro level what does and does not work in such a difficult environment (Dilawo and Salimi, 2019).

This is because the overall quality of the construction phase primarily depends on the process quality, instead of the product quality (Sheikh et al. , 2019). Quality processes require vigilant supervision and regular inspection by a representative of the owner, to minimize the probability of mistakes and the need for rework during construction (Dilawo and Salimi, 2019).

Approaches for streamlining process quality in construction projects involve quality control and measurement. Quality control in construction projects can be defined as a procedure that monitors specific project outcomes to determine their conformity to specifications; thus, methods to disregard the causes of poor results should be identified (Cooke and Williams, 2004).

Quality control efforts are considered essential in ensuring the quality programs of a contractor, such as efforts of a contractor to comply with tolerances based on the size of the aggregate used in a highway base process (Oechler et al., 2018). Therefore, regular inspection and vigilant supervision by a representative of the owner are crucial for achieving high quality and minimizing the probability of errors and rework during construction (Sheikh et al., 2019).

During road construction, quality processes depend on the effectiveness of quality control and measurement; therefore, it is important to measure quality. Difficulties remain in improving the quality of construction projects because of a lack of quality measurement methods (El-Hamrawy et al., 2017). Construction project stakeholders and project team understand the concept of quality control; however, they are unfamiliar with the methods of measuring quality other than reporting the results of quality checks. Consequently, quality control processes are neither comprehensive nor transparent.

Measuring and predicting the level of quality of construction projects are crucial in construction management and vital for improving quality project performance. This is expected to help project stakeholders periodically follow up and assess project performance, to take the necessary action with regard to any deviation from the project target quality (Amer, 2002; El-Hamrawy et al., 2017).

Consequently, any rework owing to workmanship issues is minimized, and a project can be delivered on time and within budget (El-Hamrawy et al., 2017). According to El-Hamrawy et al. (2016), highway agencies typically employ quality measures in pavement construction. The volume of heavy vehicles, low asphalt content, pavement design disregarding regional conditions, and labour and equipment capabilities of contractors are the most crucial factors affecting pavement performance measurement (El-Hamrawy et al., 2017; Sirin et al., 2021). 2.1.3 Roles and responsibilities of stakeholders.

The key construction service providers in project execution are contractors and supervising and management consultants, all of whom must be competent in undertaking construction project tasks. The project owner, who represents the road

users, is another key player in a road infrastructure project. All key players should have a project team comprising members who excel in their respective roles and responsibilities to meet the quality targets of the project.

However, the most important factors influencing the quality performance of a project include the availability of experienced staff in the teams of the owner and contractors during the project execution (El-Hamrawy et al., 2017). Other factors which contribute to poor quality of work include the engagement of contractors with unqualified supervisory staff and lack of appropriate project monitoring and evaluation by executing agencies (Coleman et al., 2020).

Hence, nominating a qualified contractor has been shown to be the most critical factor in quality management processes of construction projects (Sheikh et al., 2019), to effectively empower the quality management roles and responsibilities of the stakeholders during road construction. Management of road construction projects Teamwork during construction is important for achieving high-quality results.

Thus, development of an appropriate structure to describe the teamwork among construction project participants is needed for improved cooperation and coordination to produce high-quality work (Sheikh et al., 2019; Dilawo and Salimi, 2019). This effective teamwork must be supported by careful selection of a contractor after a prequalification analysis (Dilawo and Salimi, 2019).

Contractor criteria for the prequalification stage should include the following: previous work on similar projects, adequate financial status, relevant technical experience of the staff, contractor-owned equipment, reputation of the contractor, and workload (Sheikh et al., 2019). This is because the quality processes are not only to be stated in the quality policy of the contractor but also be proven; however, the role of a contractor during project execution must be supported by other key players and their members.

In addition, the responsibility to provide project teams that are both experienced and competent lies with both the contractors and project owner (El-Hamrawy et al., 2017). Therefore, it is important to select competent and professional contractors after examination of their financial status, the technical skills of their human resources, their ownership of heavy equipment, their reputation, and their commitment to quality processes during construction, as shown by their quality documentation. Construction project stakeholders should be involved from the beginning to the end of the project cycle. Al Nahyan et al.

(2019) recommended that all stakeholders should interconnect from the early stages of the project, and revealed that their ability to do so is a function of their legitimacy, power, and urgency to ensure the effectiveness of the management processes. There is evidence that to achieve a high-performing project team, integrated performance must be fostered by the project team over the life cycle of its project (Ibrahim et al. , 2016).

The success of a project is built on a high level of trust and cooperation between the project team, expressed by human factors such as physical proximity, commitment, knowledge exchange, and trust (Bond-Barnard et al. , 2018). Different stakeholders influence communication, coordination, decision-making, and knowledge-sharing at different stages of the construction project; therefore, it is very important to determine the levels of the legitimacy, power, and urgency of the stakeholders across different project stages (Al Nahyan et al., 2019).

Indeed, the management of all involved companies should actively participate in promoting high process quality in QMSs and measures and also ensure their commitment to quality modules and quality enhancement protocols (Dilawo and Salimi, 2019). Critical factors affecting the performance of construction projects in developing countries such as lack of management and technical skills, human capacity, and understanding and knowledge of the local context as well as changes in government policies and political interference are still found (Santoso and Gallage, 2020).

However, the management of companies must continually show a commitment to improving the quality enhancement protocols and quality modules, to promote high process quality during construction works (Sheikh et al. , 2019). 2.1.4 Constraints on quality processes of road projects. There is ongoing research on the constraints of quality management processes in construction projects.

Quality in construction has no upper limit owing to the steadily increasing quality standards, particularly when pertaining to the standards and specifications of road construction projects and other related effective managerial project factors. Weak managerial factors include difficulty in mobilizing interactions between production and quality departments and failure to undertake quality control in each project activity. Concurrently, difficulty in controlling subcontractors is frequently a weakness of a contractor.

Several factors can weaken the implementation of quality management, including managerial, or organizational, communication, financial, cultural, educational, and auditing factors (Ahmed et al. , 2017). Social constraints influencing complete quality management implementation in road construction projects

include corruption and difficult business environments, which are not easy to manage (Dilawo and Salimi, 2019).

In addition, according to Volden and Andersen (2018) , extensive delegation of governance tasks to subordinate agencies, including strategic TQM **tasks such as project selection and portfolio management**, suggest the presence of risk stemming from the narrow and internally focused nature of public project governance. These factors can lead to a lack of control and abuse of authority, eventually undermining many parties, including the community as project users.

Effective interconnection and communication are required between the groups of people responsible for implementing a QMS successfully in a construction project. **Irfan et al. (2019) showed that in the construction industry, stakeholder conflicts affect all project constraints, i.e. any change in the effect of stakeholder conflicts directly influences the project constraints of cost, time, and resources.**

Naveed and Khan (2020) found that ineffective communication, unclear details, contractual changes, information delays, unpleasant relationships between stakeholders, and project complexity are elements which affect the information complexity in a construction project, which reduces **the quality performance of the project** owing to increased rework and decreased implementation of complete quality management.

Moreover, a lack of effective communication and **transparency in construction planning and control** can result in failure to integrate the **measurement of quality processes** within project teams, resulting in implementation of measures based on individual subjective interests. Brady et al. (2018) introduced a lean construction management model as a visual tool to systematically control and predict **problems in a timely** manner, to ensure measures can be taken **to resolve them or** adapt the processes to the current scenario.

This leads to improvement in the **transparency in construction planning and control** (Brady et al. , 2018). It is also generally understood that time delays can affect project quality. Ahmad et al. (2020) found that the five most common causes of delays in a public **road construction project are** as follows: payment processing by the owner, slow decision-making by the owner, changes in the order specification by the owner, mismatch between the location of an infrastructure service compared to that approved in the tender and provided in the drawings by the contractor, and problems in financing the project by the contractor.

Moreover, Amoatey and Ankrah (2017) showed that 70% road projects experience

delays and 52% experience cost overruns, and that their causes may be client-, contractor-, or donor-related. Among them, client-related problems are associated with the finance and payment for a completed work by the owner, changes in the design by the owner during construction, and **delays in handing over** project sites to the contractor.

In contrast, contractor-related problems are associated with a lack of contractor experience, whereas donor-related problems are related to inflexible allocation of the project budget. Famiyeh et al. (2017) found that **the key factors causing construction time overrun** are **financial problems, unrealistic contract durations imposed by** the client, a **poorly defined project scope, client-initiated variations,** and underestimation of the project cost by the consultants.

The **other key factors identified by them were poor project inspection/supervision by the consultants, poor site management, inappropriate construction methods used** by the contractor, and delays by government agencies in issuing permits. Karimian et al. (2019) defined eight categories of constraints on road construction projects: financial, workforce-related, technological/process, statutory/**regulatory compliance, p****roject characteristics, project management/ project team** characteristics, unforeseen circumstances, and other/external factors.

All constraints of weak managerial factors, ineffective communication and coordination, and construction time overrun may hinder **the quality performance of a** construction project. These constraints, which affect quality processes of road projects, as reviewed in this study, are proven to be consistent with the constraints **in road construction projects in** Indonesia, as expressed by the informants in the preliminary interviews conducted in this study. 2.1.5 **Success factors in construction** projects.

The contractor is the main key player **in a road construction** project, and project performance, to a great extent, depends on the performance definition set by the contractor (Santoso and Gallage, 2020). Si nes ilass ie et al. (2019) regard ed project success factor as a tool to improve the effectiveness of a project, which in the case of a **Manag****ement of road construc tion projects** government project implies that the project scope is clearly defined, the owner/contractor partnership is effective, and competent stakeholders are involved.

They **also found that project success can be measured by the following factors: competence of the project manager, competence of the owner, management support and updates, scope clarity, effective partnering, and monitoring. Success of public construction projects** is measured by the performance in terms of cost, schedule, quality,

and no-dispute parameters.

Community involvement is critical for achieving a high-quality product. Ali et al. (2018) revealed that greater promotion and awareness of the benefits of a project among those living nearby lead to more support from local residents. Stakeholders of highway engineering projects are recommended to use green construction management, to improve the quality of their projects.

However, implementing this recommendation in highway construction projects requires adjustments in the budget and schedule depending on the level of innovation involved. The use of green construction techniques requires complex implementation strategies, which increases the time and schedule in processes incorporated in the design and realization process (Wu et al., 2019). 2.2

Current scenario of road construction projects in Indonesia Currently, the Indonesian road infrastructure is inadequate to sufficiently service the entire country (Dewi, 2013). Therefore, the Indonesian government launched the National Strategic Projects in Infrastructure initiative, aimed at improving national interconnectivity by developing transportation infrastructure networks (Agustiawan, 2020).

Consequently, in the last two years, the Indonesian Ministry of Public Works and Housing has distributed road infrastructure projects among small- and medium-sized construction service providers to act as a type of training and an opportunity for work, in which such companies either compete with larger companies or become their subcontractors.

Larger contractors are well-equipped with method and technology, human resources, and quality systems, whereas small- and medium-sized contractors are still developing QMSs that account for cost and gaining internal understanding of the benefits of QMSs. The successful implementation of national road construction is reflected not only in the performance of a particular number of actors in the construction sector but also in the overall number of construction actors involved.

This is a challenge in Indonesia, where construction service providers have nonuniform capacities and politics and nepotism combined create difficulties. Civil construction projects in Indonesia are frequently criticized by the stakeholders because of low-quality results (Mubin and Latief, 2019), such as poor road conditions, which are generally far from satisfactory (Dewi, 2013). Therefore, expectedly, a government program was launched to improve the quality of road projects.

The use of small- and medium- qualification contractors as subcontractors is inevitable, leading to significant challenges that arise in the management of interorganizational relationships (Agustiawan, 2020). According to Nyakala et al. (2018) , small-to-medium construction companies lack strategic planning, with project delivery frequently presenting poor quality owing to the inadequate development of quality control programs.

Considering the conditions and characteristics of the Indonesian construction industry, it is necessary to evaluate specific problems of the QMS practices of road construction projects, for contractors to benefit from their developed QMSs, which, in turn, will increase the quality of road projects. A quality system for a construction environment cannot simply be adopted from another region; instead local conditions should be considered in its development (Dilawo and Salimi, 2019 ; Sheikh et al. , 2019).

Quality and safety in road construction projects continue to be concerns for the Indonesian government, as the quality, performance, and competitiveness of national contractors necessitate both improvement in orderly implementation of construction activities and reduction in the number of construction failures and accidents. Several cases of construction failure and work accidents have occurred during the construction of national road infrastructure, including the TQM Light Rail Transit project in Jakarta in January 2018 , Bekasi–Cawang–Kampung Melayu toll road in Jakarta in February 2018, and Manado–Bitung toll road in April 2018.

These incidents reflected a low level of safety management by service providers, weak implementation of the construction control system, particularly from service users, and lack of effective quality assurance systems frequently seen in construction operations. The requirements for quality planned documentation imposed by the government on contractors nominated for government projects are insufficient.

A significant level of commitment from project owners and construction service providers is also required, in which a level of shared responsibility is assumed to achieve the required standard of quality in road construction projects. 3. Research methods This research conducted two rounds of Delphi studies and two focus group interviews aimed at practitioners of construction projects.

The aim was to collect empirical data regarding (1) factors affecting quality management processes, including the identification of critical obstacles in implementing quality management processes for road construction projects, and (2) countermeasures to address these obstacles. Questions pertaining to the evaluation of the methods by which quality management processes are currently implemented in road construction

projects, including questions regarding the identification of factors that contribute to successful quality management processes in road infrastructure projects, were raised.

These questions were based on the conducted preliminary interviews, previous studies, and government procedures for undertaking road construction projects. Based on the research techniques of data collection, mixed quantitative and qualitative methods were utilized; data collection by more than one method and from multiple sources can reduce data collection bias (Sekaran and Bougie, 2009).

Furthermore, compared with the use of a single method, mixed methods add value to the results of studies (Hurmerinta- Peltomaki and Nummela, 2006), since mixed method research allows the respective strengths and weaknesses of each approach to complement each other (Regnault et al. , 2018). Thus, the overall purpose and central premise of mixed methods studies are that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems and complex phenomena than either approach alone (Creswell and Plano Clark, 2017).

Quantitative data were obtained from two rounds of Delphi questionnaire surveys, and focus group interviews were conducted to obtain qualitative data. Specifically, the Delphi studies were the main data collection technique, which were followed by the focus group interviews to validate the results of the Delphi studies and achieve the research aims.

Before the Delphi questionnaires and focus group interviews were conducted, preliminary interviews were conducted to ensure the significance of the topic and establish a working communication base for further data collection. The preliminary interviews confirmed the relevance and validity of the topic in relation to the knowledge and experience of the respondents in implementing quality management in road construction projects. Other related quality system processes that were not the main concerns of this study were excluded from the questionnaire.

Subsequently, the results of the preliminary interviews were categorized and integrated with those of previous studies and government rules as a reference point for the design of the Delphi questionnaires and the focus group interviews. 3.1 Selection of respondents The target respondents of the preliminary interviews, Delphi studies, and focus group interviews were government officers, supervising consultants, and contractors in road construction projects.

In particular, the respondents of the preliminary interviews and focus group interviews were involved in the construction of Manado Outer Ring Road (MOR) III Management

of road construction projects Stage 1, located in North Sulawesi province, Indonesia, with a project value of 60 billion Rupiahs (4.18 million USD). A total of eight respondents representing three parties were involved in the preliminary interviews, to ensure the significance of the topic studied and validate the quality management factors identified in this study.

Comments and feedback were obtained from these sources to finalize the Delphi questionnaire, which served as the main data source for the study. The first phase of the preliminary interviews involved five participants who were officers from the National Roads Implementation Agency (NRIA) (referred as R1 –R5). The selection of the five participants was based on their roles as policymakers and owners of road construction projects.

The second part of the interviews involved two construction professionals from consulting management companies (referred as R6 and R7) with more than 20 years of experience in supervising road construction projects. The third part of the interviews involved a general superintendent (GS) from a leading construction company that took part as the main contractor in the MOR III project (R8).

Prior to conducting the preliminary interviews, informal contact was made with the selected participants, followed by an electronic delivery of a covering letter and an interview question sheet. Each interview lasted for approximately 2 h. In each case, the authors spent the first 5 min introducing the topic and aim of the preliminary interview.

The participants were asked to express their opinions and inputs on quality management implementation in road construction projects, including major problems in achieving quality management of road projects and the possible causes of the problems. They were also invited to discuss any other issues about quality processes in road construction that they felt were important.

Tables 1–3 summarize the profiles of the participants of the preliminary interviews, Delphi studies, and focus group interviews, respectively. The main features of the Delphi technique include the engagement of experts, anonymity of the experts, repetitive rounds of polling for expert opinions, controlled responses, statistical group responses, and constancy in the responses of the experts on a specific issue (Yik et al. , 2012).

This research conducted two rounds of Delphi questionnaires to obtain the opinions of a panel of experts on quality management processes and other related factors in road construction projects. In the Delphi technique, the number of experts depends on the scope or nature of the problem under study, number of available experts, and available

resources of time and money (Hallowell and Calhoun, 2011). The selection method of members or panelists has a very strong effect on the validity of a study.

According to Xia and Chan (2012) , Delphi panelists should have sufficient working experience or knowledge and work in relevant organizations. In these Delphi surveys, the expert panels represented the three parties of construction project stakeholders with roles and responsibilities as contractors, No. Position Role/Expertise Organizations R1 Head of road project working unit (KSK) Representing project owner National Roads Implementation Agency (NRIA) R2 Commitment officer (PPK) Ensuring project can be accepted R3 Commitment officer (PPK) Ensuring project can be accepted R4 Head of engineering unit Ensuring technical aspects of project meet specifications R5 Project assistant Assistant of Head of engineering unit R6 Quality engineer Ensuring quality aspect of project Supervising consultants R7 Quantity engineer Ensuring achievement of project progress R8 General superintendent (GS) Ensuring project meets constraints of time, quality, and cost Contractor Table 1. Profiles of preliminary interview participants TQM supervising consultants, and road construction project owners, respectively.

A total of 44 experts were used in round 1, of whom 43 were also involved in round 2. The total number of respondents in every round satisfied the requirements of a Delphi study, which requires a range of 15–30 (Clayton, 1997) or 3 –93 (Ameyaw et al. , 2016) experts.

In the literature, no specific rule is available on the ideal number of rounds for a Delphi procedure; however, most Delphi studies involving construction, engineering, and management have reach a consensus by round 2 or, at the latest, round 3 (Ameyaw et al. , 2016 ; Aghimien et al., 2020).

This study employed two rounds of Delphi questionnaire surveys to obtain a panel of expert opinions on quality management processes of road Organizations Experts who participated in the Delphi studies Expert criteria Round 1 Round 2 National Roads Implementation Agency (NRIA) Head of road project working unit (KSK) 11 Commitment officer (PPK) 2 2 Head of engineering unit 1 1 Site coordinator 2 2 Quantity controller 1 1 Supervising consultants Supervising engineer 6 6 Site inspector 2 2 Surveyor 1 1 Quality engineer 3 3 Quantity engineer 1 1 Laboratory technician 2 2 Contractors General superintendent (GS) 8 7 Site supervisor 2 2 Surveyor 1 1 Quality controller 6 6 Quantity controller 3 3 Construction safety expert 2 2 Total 44 43 Organizations Expert criteria Remarks Projects Group 1: National Roads Implementation Agency (NRIA) Head of road project working unit (KSK) 1 All interviewees are undertaking Manado outer ringroad (MOR) III phase 1 – Project budget 60 billion Rupiahs (4.18 million USD) Commitment officer (PPK) 1 Head of engineering unit 1 Project assistant 2 Group 2:

NRIA Head of engineering unit 1 Supervising consultants Quality engineer 2 Quantity engineer 3 Construction safety expert 1 Contractors General superintendent (GS) 1 Site supervisor 2 Quality controller 1 Table 2.

Profiles of Delphi study participants Table 3. Profiles of focus group interview participants Management of road construction projects construction projects. Round 1 was scheduled in April 2020 and Round 2 in May 2020, and panel validation for the Delphi survey was conducted in round 2. Focus groups typically comprise 7–10 members; however, they may contain as few as 4 or as many as 12 participants (Marshall and Rossman, 2011).

In this study, the first focus group comprised 5 government officers from the NRIA, and the second group contained 11 persons from the NRIA, supervising consultants, and contractors. None of the participants were involved in the Delphi studies; they were selected based on their knowledge and experience of the topic under investigation. 3.2 Results of Delphi questionnaires The Delphi method has been employed for various purposes.

In the field of construction management, the Delphi method helps achieve a reliable consensus of opinion among a selected panel of experts (Sourani and Sohail, 2015). In the past two decades, the Delphi technique has been used as the main research method by a growing number of construction engineering and management researchers (Ameyaw et al., 2016). The Delphi method can be applied to solicit opinions from experts and can be controlled.

Specifically, experts tend to be better informed and equipped to answer questions (de Groot et al., 1996; Klein, 2017). Because a degree of judgmental analysis is required to evaluate quality management processes of road construction projects, the Delphi method is a systematic process that is suitable for this study to obtain expert opinions and provide controlled feedback.

In addition, in view of several factors such as resource constraints, limited access to sites, practical confounding factors, and ethical limitations, the Delphi method can be modified (Alomari et al., 2018) to balance research limitations and study purposes (Bhandari and Hallowell, 2021). Using the Delphi method, control can be realized in the data collection and analysis step by anonymously, multiple rounds, and controlled feedback (Eckert et al., 2011; Hallowell and Gambatese, 2009).

These controls can overcome the biases that threaten the validity and reliability of the results (Bhandari and Hallowell, 2021). In round 1, a questionnaire was developed based

on the preliminary interviews, a literature review, and government procedures for undertaking road construction projects. The experts were asked to provide individual knowledge and opinions regarding the rating of quality management processes of road construction projects for each item in the questionnaire.

The rating was a six-point Likert scale defined as follows: "1" is "very pleasant," "2" is "pleasant," "3" is "somewhat pleasant," "4" is "somewhat unpleasant," "5" is "unpleasant," and "6" is "very unpleasant." This six-point Likert scale was adopted in the Delphi survey owing to the consideration of a potential cultural bias in the responses to the questionnaire if a midpoint was included.

Asian countries tend to select a midpoint in an odd-number-based rating scale in a questionnaire (Hofstede and Bond, 1988; Hofstede, 1991; Si and Cullen, 1998; Coffey, 2010). In round 2, the questionnaire was developed based on the results of round 1 of the Delphi survey. The participants were asked to reconsider and re-evaluate their answers by answering "yes" or "no" to the questions.

An agreement measurement approach of "yes" or "no" in the research area of construction was also employed by Dewi (2013). A review of a wide range of Delphi studies revealed that there are different methods for measuring consensus (Sourani and Sohail, 2015). Delphi study is a flexible approach to result in consensus.

The Delphi allows the researcher to develop the questions in the five or six Likert scale or other types of questions throughout questionnaires (Hasson et al., 2000) depending on the researcher's objective and the time provided. The "yes or no" is not restricted to conducted in Delphi round two, it can be used in rounds one, two, or three.

Several studies use a "yes" or "no" scale or two options "agree" and "disagree" to obtain consensus (Cottam et al., 2004; Silva and Montilha, 2021). After round 1 of the Delphi survey, the collected data were analysed using mean values to determine the rating of the quality management process factors. In round 2, frequency was calculated to assess the consensus among the experts.

Generally, consensus is regarded as TQM achieved if at least 67% experts hold the same view (Alexandrov et al., 1996), while according to Vernon (2013), Delphi consensus typically ranges between 55% and 100%, with 70% considered to be the standard. In this study, the frequency of agreement ranged from 68.90 to 100%. Tables 4–8 report the results of the Delphi questionnaire rounds 1 and 2.

They account for the factors of quality standard documentation (Table 4), factors of

quality measurement standard (Table 5), factors of construction safety standard (Table 6), factors of quality control activities (Table 7), and factors of roles and responsibilities (Table 8). All factors are considered to be influential in quality management processes of road construction projects. No.

Quality standard documentation Delphi questionnaires R1 Mean R2 % R2 Rating 1 Availability of detailed **standard operating procedures (SOP)** to meet quality of project work 5.56 100.00 High 2 Existence of project work instructions mutually agreed upon by project owner and contractor 5.49 100.00 High 3 Availability of regular checklists to ensure project works meet SOP 5.47 95.60 High 4 Availability of regular checklists to ensure project works meet specifications 5.37 95.60 High 5 Availability of daily and weekly project requests 5.26 97.80 High 6 Existence of measurement standard of project owner to ensure quality and safety of construction works 5.21 93.30 High 7 Existence of measurement standard to ensure project product meets specifications 5.16 95.60 High No.

Construction safety standard Delphi questionnaires R1 Mean R2 % R2 Rating 1 All items of construction works are undertaken based on construction safety procedures 5.30 97.80 High 2 All items of construction works comply with environmental safety 5.30 97.80 High 3 Contractors conscientiously provide safety tools for ensuring construction safety 3.68 68.90 High No.

Quality measurement standard Delphi questionnaires R1 Mean R2 % R2 Rating 1 Regular and strict MC-0 is applied in every project work to measure quality of work 5.19 95.60 High 2 Existence of quality measurement standard in every phase **of road construction project** lifecycle 4.25 73.30 High 3 Quality policy of project owner and contractor measures quality of road infrastructure 3.91 80.00 High 4 Existence of record to report quality defects of road construction works 3.68 86.70 High 5 Program **of road infrastructure development** clearly defines quality of road infrastructure 3.66 80.00 High Table 4.

Quality documentation influencing quality processes Table 6. Safety standards influencing quality processes Table 5. Quality measurements influencing quality processes Manag **ement of road construction projects** No. Quality control activities Delphi questionnaires R1 Mean R2 % R2 Rating 1 Quality controller ensures that work of contractor meets determined standards 5.65 97.80 High 2 Quality controller ensures that project materials meet specifications 5.53 100.00 High 3 Quality controller ensures that quality of subgrades, aggregates, hot mixes, and structural works is met, verifying they are all acceptable 5.53 100.00 High 4 Supervising consultant controls project work of contractor against project specifications 5.49 100.00 High 5 Contractor quality plan

documentation is available in every construction project 5.44 100.00 High 6 General Superintendent (GS) controls all project works against quality, cost, time, and scope 5.42 95.60 High 7 GS assists PPK in controlling quality of project works based on SOP in every phase of project work 5.35 97.80 High 8 Quality controller supervises laboratory technicians (team of contractor) while conducting material tests of samples 5.35 100.00 High 9 Quality controller understands technical aspects of how to treat samples for material tests 5.33 88.90 High 10 Methods to control all items of construction work processes meet specifications are available 5.26 97.80 High 11 GS conducts technical evaluation of project work performance 5.26 97.80 High 12 KSK monitors and controls consultants who supervise project work of contractor 5.21 95.60 High 13 If unsatisfactory works are found, quality controller (team of project owner) and quality engineer (team of consultant) report to PPK as soon as possible 5.12 88.90 High 14 Project owners and service providers strictly control quality of road construction processes 4.34 77.80 High 15 Supervising consultant consistently reports to PPK based on evaluation procedures of quality and safety during project execution 4.02 73.30 High No.

Roles and responsibility of there main project stakeholders Delphi questionnaires R1 Mean R2 % R2 Rating 1 Awareness of project owners and contractors as road users in public interest is considered satisfactory 4.41 86.70 High 2 Project owners and contractors fully understand aims and benefits of road construction projects 4.34 80.00 High 3 Project owners and contractors interact and communicate when making critical decisions on road construction project works 4.20 82.20 High 4 Competency levels of quality controller and quantity controller in project teams are considered satisfactory 4.14 80.00 High 5 Project owners and contractors understand construction quality and safety when undertaking design and control in road project execution 4.11 77.80 High 6 Project owners and contractors collaborate well to prevent accidents during project execution 4.09 75.60 High 7 Government is not strict about imposing implementation of quality management system and construction safety system 3.75 75.60 High 8 All main project stakeholders are reluctant to learn from quality and safety errors in construction 3.70 71.10 High 9 Project owners, contractors, and consultants are committed to implementing quality management system 3.68 73.30 High 10 Contractor and project owner (PPK) support construction safety system implementation 3.55 82.20 High Table 7.

Quality control influencing quality processes Table 8. Roles and responsibilities influencing quality processes TQM The factors were grouped based on the results of the preliminary interviews and supported by the literature review results.

Tables 4– 8 map the quality management processes during road construction project

execution and arrange them in the order of **the extent to which** the factors influence the effectiveness of the quality processes and other factors related to project quality. Moreover, using both Delphi questionnaire results, the factors in every factor group are ranked according to the mean value of Delphi round 1, and the percentage of the factors and the rating of the agreement are based on Delphi round 2. 3.3

Results of focus group interviews The second approach adopted to collect new data and assist in validating data from the Delphi studies conducted two sets of focus group interviews. In this study, the focus group interviews aimed to obtain data regarding (1) critical issues related to obstacles in **the implementation of quality management processes of road construction projects** and (2) preventive and corrective countermeasure factors to minimize obstacles to ensure effective **quality management processes** of road construction projects.

The focus group interview method is socially oriented and a relevant approach to examine tentative conclusions, as well as is useful for applied **research** and program evaluations (Marsh and Rossman, 2011). Focus group interviews have the potential to produce rich data on a study topic (Fellows and Liu, 2015).

They were considered to be the most appropriate method to obtain the intended data. The focus group interviews were tape-recorded and subsequently transcribed into text document files. The transcribed data were edited, coded, and arranged in order in categories defined by the key and related questions developed during the discussion.

The "classical analysis approach" (Krugger and Casey, 2009) was used to categorize the results and analysis of (1) critical issues and obstacles in implementing quality **processes** in road **construction projects** and (2) preventive **and corrective actions** to improve quality **processes in road construction projects**.

During the **analysis**, several factors were considered before making decisions based on the comments of **the focus group interview** participants. These included how frequently particular comments were made; comments themselves with details and repeated comments; extensiveness of comments; and attitude, intonation, emotion, and enthusiasm shown by the participants.

This allowed a systematic and thorough analysis of the perceptions of the participants and evaluation of the **quality processes in road construction projects**. Table 9 summarizes the indirect phrasing of typical comments and the significant remarks related to the key and related questions. 4. Research findings and discussions In the **data collection** of Delphi rounds 1 (R1) and 2 (R2), experts rated 40 **factors of quality**

management processes.

The factors are arranged in groups of factors as follows: quality standard documentation, quality standard measurement, construction safety standards, quality control activities, and roles and responsibilities of the stakeholders. Table 4 shows that the indicators rated by the mean values range from 5.56 to 5.16, with a relatively high level of agreement (>93.30%).

These results suggest that most experts find the availability of quality standard documentation to be unpleasant, with the availability of detailed standard operating procedures to meet the quality of project work most unsatisfactory. Table 5 lists the responses of the experts regarding the extent to which the factors of quality measurement standards influence quality processes.

There is a high level of agreement for all indicators at >73.30%. The experts award an unpleasant rating to the factor of application of regular and strict MC-0 to every construction work. The other factors (the road infrastructure development quality program, quality measurement standards, and quality record of road construction work defects) are rated as somewhat unpleasant.

Management of road construction projects Table 6 shows that two factors of safety standards influencing quality processes are rated as very unpleasant, with mean values of 5.30. The frequency of agreement responses for re-evaluation of the construction safety standard rating is 97.80%, indicating that the experts agree that construction safety standards are highly unpleasant.

Concurrently, the indicator of contractors conscientiously providing safety tools in implementing construction safety is not rated high by the experts, with an agreement frequency of 68.90%, slightly above the required 67%. Key issues of quality processes Significant remarks A. Documentation A.1 A critical reason for project delay is that quality documentation of contractor is incomplete A.2

Shop drawing must already be available in preconstruction meeting A.3 All documents must be completed before project starts A.4 All quality control documentation should be based on defined specifications and contract documents A.5 Project should not run without complete shop drawing document A.6

Project works are sometimes initiated without consent signatures of three key construction players B. Road construction execution B.1 Quality processes of road construction start from preconstruction meeting B.2 Checklist document is unavailable

on project site B.3 Contractor should complete construction request form before starting project work, including detailed procedures of activities of project B.4

Request form of contractor should include all types of road construction equipment and particular competent worker B.5 Construction request form should contain quality and quantity standards, safety standards, material specifications, worker qualification, and work methods, and be controlled by supervising consultant. Three construction key players should validate requested document B.6

Sometimes project work starts without complete construction request form B.7 Local contractors, at most, do not provide construction request form B.8 Completeness of construction request form implies high security, in terms of quality. Only problem is that according to people, typically, numerous items are available to write when this should be standard operating procedure C.

Roles and responsibilities C.1 Commitment officer (PPK) should ensure contractor has possession of all required and complete quality documentation in preconstruction meeting C.2 Project owner sometimes order supervising consultant, to supervise without complete quality control documentation C.3

For benefiting community, consultant should be independent of supervision of government projects D. Material testing D.1 Without knowledge of consultant, contractor collects sample materials from other places for laboratory tests. It is suggested that consultants use laboratory test results, along with contractor and PPK D.2

We recommend that quality standard of pavement material must be checked from base camp D.3 Quality and quantity officers must be transparent in inspecting material at project sites E. Communication E.1 In preconstruction meetings, project quality team is rarely present; present staff are mostly quality managers E.2

In preconstruction meetings, no experts are present to explain technical matters. Supervising consultants are eager to know technological processes and other issues related to road product achievement E.3 We recommend that experts be available during preconstruction meeting F. Qualified project team F.4

We recommend that all members of every project team must be competent Table 9. Results of focus group interviews TQM Based on Table 7, most quality control factors of road construction projects receive a rating of unpleasant, with mean values ranging between 5.12 and 5.65, with at least 88.90% experts in agreement.

The high level of unpleasant rating of quality control activities suggests a realization by the three main project stakeholders that a refocus on quality processes in road construction projects is urgently required. A somewhat unpleasant rating is awarded to two factors dealing with issues of the reporting procedure (mean 5 4.02) and quality control of the service users and providers (mean 5 4.34).

Table 8 lists the opinions of the experts regarding the factors of the influence of the roles and responsibilities of the main project stakeholders on the quality processes. The indicators are rated a somewhat unpleasant with mean values ranging between 3.55 and 4.41, with a frequency of agreement > 71.10%. The experts agree (86.79%) that awareness of project owners and contractors is in public interest, as road users award the highest consideration for factors involving the influence of the roles and responsibilities of the main project stakeholders on the quality processes.

Based on Table 9, all experts confirm the importance of quality management processes in road construction projects. The experts agree that the completeness of project documents significantly impacts quality processes and leads to delayed start of a project, insufficiently defined safety standards and quality specifications, and inclusion of approved documents.

This similar finding has been also highlighted in South Africa (Akampurira and Windapo, 2019) and Iran's construction projects (Abdirad and Nazari, 2015). The experts also agree on the need for consistent checking of the documentation quality during preconstruction meetings (PCMs). In the PCM, the commitment officer (PPK) (the representative of the owner) should ensure the provision of all complete quality assurance documents by the contractor.

Some experts support the view that the construction project request form is an initial indicator of the quality of the road project processes. It should outline in detail the specifications and quality standards of the project. This will lead to a description of the required quantity standards, safety standards and equipment, construction methods, material standards, and worker qualification, with all required standards being approved by all three key players.

However, the experts acknowledge a dependence on the ability of subcontractors to complete the form and the willingness of the project team to deal with written documentation. The experts highlight that laboratory material test results are nonapplicable at project sites. The issues of material testing influencing the quality of road construction pavement are raised by the experts because consultants are, for the

most part, not involved in sampling the materials for laboratory tests.

The experts support the requirement that all three key project stakeholders the commitment officer (PPK) who is in charge on behalf of the owner, GS and his/her project team, and supervising consultant, should take responsibility for verifying the performance of the contractor and report to the project owner. Without neglecting the roles of each key player, all three parties should communicate with each other and check the completeness of the documents before the work begins. This factor sometimes requires the project team of the contractor to explain or clarify technical matters to the consultants and the project owner.

Most technical matters are typically explained by the GS. The major findings of this qualitative study revealed significant constraints affecting quality management processes in road construction projects in Indonesia, and the need for these to be discussed to propose solutions to achieve quality in an unfavourable environment.

Involvement of people, quality assurance/quality control training, project planning and control techniques, according to Nyakala et al. (2018) , are the importance of the quality efficiency of successful road construction, and thus, the need for project stakeholders to allocate various success factors in construction project quality.

From the quantitative data collection and analysis, quality standard documentation emerged as a core factor impeding the implementation of quality management processes in road construction projects in Indonesia. Several significant factors are included in this core factor such as the need for detailed standard operating procedures to Management of road construction projects ensure the quality of project work, application of quality measurement standards throughout the project lifecycle, and establishment of construction safety procedures as guidance for all construction works.

Several participants also mentioned that a general absence of application of regular and strict early mutual checks (MC-0) to every construction work prevents the implementation of quality measurement in road projects. The focus group interview panelists clarified that this lack of regular quality road project measurement is caused by incomplete checklist documents and construction request forms, which impede the execution of project works according to specifications and cause the project to start without complete documents.

The importance of construction companies developing quality documentation packages should be reflected by strictly checking and evaluating the completeness of these documents from the procurement to the PCM phase by the project owner and the

supervising consultants. Ensuring complete quality documentation before a project starts is an essential part of the project planning phase. Akinradewo et al.

(2020b) found that inappropriate project planning, inadequate initial site investigation, and frequent use of shortcuts act as barriers to improving road project performance. Accordingly, they suggested a need to clearly define the project scope and ensure that sufficient design documentation and information are available before a project begins (Akinradewo et al., 2020a).

The quantitative Delphi survey and qualitative focus group interview participants viewed quality management processes as vital elements in enhancing quality control, quality measurement, construction safety, and environmental safety. They considered the roles and responsibilities of project stakeholders for meeting quality targets in road construction projects as subject to constraint soft time, budget, and scope.

Successful and effective management of quality processes, as essential components in road construction projects, can improve the quality performance of construction companies. There remains an urgent need for the construction sector to sustain its long-term business and focus on organizational learning and people management as approaches to enhance its quality culture (Lau et al., 2016).

Numerous studies have shown that a quality culture helps and encourages construction organizations to successfully implement quality management processes in Indonesian construction works (Willar et al., 2016; Agustiawan et al., 2019; Mu bin a nd L ati ef , 2019). It is impossible to import a quality culture in construction from another region; quality and safety cultures follow the characteristics and conditions of the local region (Dila wo an d Sali mi, 2019; Sheikh et al., 2019).

A large number of respondents agreed that awareness of road quality on the part of the project owner and the contractor will impact the community through economic and social benefits. It may also encourage these key construction players to apply effective quality processes despite the difficult environment surrounding road construction projects.

Awareness of quality can be built within an organization with a strong quality culture. Most participants viewed the roles and responsibilities of stakeholders as strong factors influencing the implementation of quality management processes in road construction projects.

The perspective that the contractor is responsible for providing the pavement material

and the consultant for ensuring the quality of the material is significant, as this is related to critical issues of effective **quality processes in road** projects. The constraint factors found **in this study were** related to the quality control of materials in either the base camp or laboratory tests.

Most focus group interviewees recommended cooperation between the contractor and the consultant project team in the issues of quantity and quality when handling samples of pavement materials during an inspection at laboratory and project sites as well as for ensuring appropriate and qualified material usage. **Guaranteeing the use of** suitable materials for road **construction** pavements requires appropriate pavement management of the material logistics plan, **includin g** procurement, processing, and distribution, to improve the pavement performance, increase the pavement life, and reduce the procurement and maintenance costs (Choudhari and Tindwani, 2017 ; Sirin et al. , 2021 ; Alvanchi et al. , 2021).

Thus, the need to ensure **the quality of pavement performance** is not TQM limited to coordination and mutual trust in handling the material quality. It **has a wider scope** that covers the logistics of the raw materials, assessment of the quality of the materials supplied for road projects, and transportation planning from the base camp to the project site.

Material logistics management should be designed and approved by the three main construction stakeholders (owner, contractor, and supervising consultant) to ensure that the quality processes of the road project materials are met. Other interviewees found that **the presence of** competent staff in the project team, including those employed by the owner, contractor, and consultants, **is an important factor** influencing **quality management processes in road construction projects.**

The need to empower professionals to manage and construct road **construction** projects is related to the constraint of communication, commitment, and willingness to learn from **quality** and safety errors. **Both quantitative and qualitative** data revealed the need for PCMs for discussion and positive involvement of project team experts in technical matters and methods **to improve the quality of road** products. Good project preparation from PCMs might lead to better quality control and quality measurement of project work performance.

Current studies have revealed the role of visual construction management tools, such as lean construction management promoted by Brady et al. (2018) and visual management systems in construction developed by Tezel and Aiz (2017). **According to these studies, visuals offer systematic approaches to improve the control of con**stru

ction processes, which results in focused control or prevention, instead of correction.

It also increases participation and collaboration among the project teams to make project control more transparent and manageable. Thus, quality management processes in road construction are influenced by the availability of various resources and the willingness of project teams to focus on quality, as opposed to only on time and targets regarding project completion. 5.

Conclusions Owing to the dynamic characteristics of construction projects, the desired result of simultaneous stakeholder satisfaction and construction performance cannot be achieved without a management system that is integrated, precise, and safe. Most critical causes of the barriers in implementing quality management in construction have been discussed in the literature.

However, this study found that the constraints in typical Indonesian construction, the likes of which are also seen in other developing countries, influence quality management processes during road construction. This relates to empirically proven factors in quality process improvement. The availability of quality standards and documentation was acknowledged by the panelists of the Delphi surveys and focus group interviews conducted in this study as a problem when implementing quality control as early as in the preconstruction stage.

The results emphasized the need for detailed standard operating procedures, a project checklist, a construction request form, and quality measurement standards approved by the three key construction players (owner, contractor, and supervising consultants) for road construction project execution. This study emphasized that all items of construction works must be undertaken based on construction safety and environmental standards.

These standards cannot be separated from quality standards to support quality management processes in road projects. This study revealed the critical factors of quality control and the roles and responsibilities of the stakeholders in relation to influencing quality management processes during road construction. The largest obstacles are project team members.

These constraints deal with competency, commitment, and mutual cooperation among the three main stakeholders of road construction projects who interact to ensure that quality processes are implemented when controlling road pavement materials, supervising project works according to a specified standard, and reporting project

performance.

The constraints revealed in these findings are substantial factors that hinder the implementation of quality management processes for producing high-quality road infrastructure products. Management of road construction projects The study is important to enrich the literature on road construction project quality management and provides new insight into the reasons for road quality remaining poor; hence, the study is essential as it attempts to seek the causes of the poor and deteriorated road infrastructure.

Future research on the quality management processes of road projects is recommended, primarily to ensure that the representation of the views of project stakeholders covers several areas in Indonesia. In practice, the current findings provide insights into the development of more visual quality control management tools as a part of the policy to focus on quality control and measurement activities. This is in addition to confirming the availability of all required quality documentation packages.

Besides improving the quality of road construction products, the findings could be used to update the contents of government modules as a part of the QMS coaching programs used by practitioners and implemented by construction service providers involved to improve the quality of the road infrastructure. Owing to the lack of research in the area of quality management in road construction projects, the reported results contribute to the literature.

Specifically, past studies on quality processes in road construction, coupled with the findings of this research, relate our knowledge of factors affecting quality management for road construction projects in Indonesia, including the critical obstacles in implementing quality management processes. The research findings will help improve the understanding and awareness of road construction project stakeholders regarding the causes of the ineffectiveness of the quality management processes during road construction project execution.

In the context of the implication to policies, the research findings will provide a future reference for facilitating communication among construction service providers, supervising consulting companies, and the NRIA to redefine and determine a list of requirements for road project tender administration to be announced to the public.
Notes 1. <https://pu.go>

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