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Research Paper

An Evaluation of the Quality Management System for a 70-Meter, 2-Span Stressed Box Girder Bridge Construction Project Double Cell Be Mos River, Casnafar Dare, Municipality Dili of Timor Leste

Jony Rodregues Varela[1], Lalu Mulyadi[2*], Erni Yulianti[3]
[1,2,3] *(Post Graduate Program of Civil Engineering, National Institute of Technology, Malang, Indonesia)*
Corresponding Author: Lalu Mulyadi

ABSTRACT: *Bridge construction is a fundamental component of the modern transportation system and regional connectivity. These projects have significant impact to the development of today's community. The evaluation of the quality management for such projects has significant economic and social impacts. Bridge construction process usually take place on local road networks with an involvement of variety of complex issues that can be adressed effectively through application of quality management.*
The research method used in this study is a quantitative method, whereas data collection technique was carried out using a survey method by sending questionnaires directly to contractor members, planning consultants, and construction management consultants. The questionnaire was sent via personal chat and email in the form of Google Form. The result of the study revealed the factors that able to influence the Quality Management System in the Bridge Construction Project include: Quality control process steps (X1) with an influence value of 0.273, quality management tools (X2) with an influence value of 0.242, inspection and testing of executed work (X3) with an influence value of 0.303, prestressing material quality (X4) with an influence value of 0.321. the result of the analysis showed that the most dominant factors influencing the Quality Management System include Inspection and Testing of Executed Work (X3) with an influence value of 0.303.

KEYWORDS: *Quality Management, Bridge Construction, Construction Project.*

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I. INTRODUCTION

Dili as the capital and largest city in Timor Leste stretches in land area of 48.27 km2. Dili city is the main destination for tourists visiting Timor Leste, where many tourists from other countries as well as local residents arrive in Dili. The previous research says that Dili metropolitan area is one of the areas utilized as center of government, environmental and local exchange, education, welfare, transportation and banking activities. [1]

To support economic activities in the area, the Public Works Department of Timor Leste Ministry announced several tenders or construction auction activities in which one of the tender auctions was the construction of a 70 m2 span stressed box girder double cell road and bridge construction in the Dili Be'e mos river Casnafar location. The construction of road and bridge infrastructure held vital function for the accessibility and mobility in the area. [2]

One of the projects which currently underway in the Be'e mos river Casnavar Dare of Dili Municipality of Timor Leste is the Road and Bridge Construction project which directly connects Dili Municipality to the Aileu Municipality. By conducting an in-depth evaluation, expectation of the author is the use of prestressed concrete in the Timor Leste Bridge project will run smoothly and produce a safe, durable structure that able to meet the functional and aesthetic needs. Thus, a rigorous or very strict evaluation becomes the first step to ensure the sustainability of prestressed concrete technology for other bridge projects in the future time.

So far, the discussion related to evaluation of Quality Management System in the Construction project of 70 m 2 span stressed box girder double cell Be'e mos river Casnafar Dare Bridge, Dili Municipality of Timor Leste has not been carried out by many researchers, therefore the postulated study problem in this study is: (1)

What factors influence the quality management system of bridge construction? (2) What factors have the most dominant influence to the quality management system of bridge construction?

II. LITERATURE REVIEW

2.1. Quality Management

According to Lestari quality is one of the main goals that highly desired by the construction companies, both in service and construction services. One of the well-known quality management systems is the Total Quality Management (TQM). TQM or Integrated Quality Management is a method for giving continuous improvement to the work performance at every level of operations and processes in all functional areas of the organization, by utilizing all available human and capital resources. According to Witara (2018) in Rabihati et.al., in general, the Quality Management System is a series of continuous activities carried out by an organization to achieve goals such as meeting customer or market needs, preventing pollution, and avoiding accidents in accordance with the company policy. [3,4]

2.2. Definition of Quality Management System

Rabihati et.al., (2024) stated that Quality Management System (QMS) as one of the most effective tools for surviving and thriving in business competition. One of the most well-known and perhaps most widely used Quality Management System worldwide is the QMS published by the International Organization for Standardization (ISO). [4]

The ISO 9000:2015 (E) standard explains a quality management system involves so many activities conducted by an organization to establish objectives and determine the processes and resources needed to achieve the desired results. The quality of product and services from that organization will be determined by its ability to satisfy customers expectation and the resulting impacts whether intended or unintended on related parties. The quality of products and services includes the function and expected workperformance, as well as the value and benefits perceived by customers. [5]

2.3. Quality Control

Quality control is a process aimed to make every element involved in construction implementation able to act as a quality assessor. Quality control is an effort to supervise and intervene work implementation with aim for ensuring the end results are in accordance with predetermined or agreed provisions, by producing the most efficient product and meeting user needs. Whereas, a quality control system (Quality Management System) is the management of all activities within a company, which includes input, process, and output, to improve product quality. According to Darmawan et.al., quality control is an activity that give emphasis to prevent damage rather than only detecting it, and it involves the application of PDCA cycle of plan (planning), do (implementation), check (inspection), and act (action) which aims to identify and resolve problems that arise. In essence, PDCA cycle is a method used to carry out continuous improvement. [6,7,8]

2.4. The Establishment of Standart of Design Quality

According to Fernanda Zulviandika et al., implementing a quality management system in road and bridge paving is a crucial aspect that able to influence the success of a road and bridge construction project. The quality standards can be pursued by monitoring, supervising and evaluating work implementation process to ensure the final results comply with the established technical specifications. [9]

Tahrir et al., explain the implementation of ISO 9001:2015 Quality Management System is a quality assurance documents that certifies every construction work stage is carried out in accordance with good management principles. ISO 9001:2015 has seven main principles:

1. Customer focus
2. Leadership
3. Engagement and competence of individuals
4. Process approach
5. Improvement
6. Informed decision-making
7. Relationship management

These seven ISO principles are used as guidelines in the planning, implementation, and control of every supervision process in road and bridge construction projects. [10]

2.5. Steps in Quality Control

There are several steps in the Quality Control activities as stated in the following explanation:

1. Planning: Planning is the initial stage in the quality control process. Quality planning is the process of determining relevant quality standards, in accordance with the owner's needs and complying with applicable

standards for every aspect of the work. It also includes establishing standard specifications applied in the project and planning strategies to achieve the established standards. [11]

2. Implementation: Once quality standards are determined, the production or service delivery process is carried out following established guidelines. According to Wacono, quality control is implemented as an effort to optimize work, so that the process runs smoothly and the results achieved are in accordance with predetermined quality standards. [12]
3. Monitoring: Monitoring is a confirming process that a designed program is running according to plan, identifying any emerging obstacles, and assessing how policy implementers are addressing these issues. Monitoring is an ongoing activity to track the progress of program implementation and ensure its compliance with the plan. The purpose of monitoring is to provide routine oversight of program implementation, including input receipt, work scheduling, and expected results, among other aspects. [13,14]
4. Evaluation: Etymologically, "evaluation" derives from the English word "evaluation," from the root word "value," meaning worth or price. Evaluation refers to an action or process to determine the value of something. Meanwhile, according to L., Idrus, evaluation is a method or process used to measure the extent of success that has been achieved. [15,16]
5. Corrective Action: Monitoring and controlling ongoing projects are very important to support corrective action in the event of delays, as well as to deliver the project to the client on time. [17]

The main basis for process control and conformity as well as the workperformance measurement, according to Lydia (2010) in Mane & Patil are guidelines for ensuring quality in planning include:

1. Put all relevant parties involved, including consultants, subcontractors, and suppliers in project quality planning;
2. Establish and define the objectives of the quality system;
3. In planning stage, reduce the effort required to modify documents within the plan;
4. Establish a quality system development team to develop an effective plan;
5. Assuring the focus remains on customer needs throughout the quality planning process. [18]

2.6. Quality Management Tool

Quality management tools encompass a variety of approaches and strategies used to certify the products or services meet the specific quality standards during the operational or production process. One famous method is Seven Quality Tools which includes tools such as observational sheets, histrograms, Pareto charts, stratification, cause-and-effect diagrams, control charts, and scatterplots. These tools serve to identify quality problems, evaluate their root causes, design and implement structured solutions to improve the productivity and workperformance of an organization. [19,20,21]

2.7. Quality of Workperformance

Putra et al., said that quality workperformance is the achievement of work results aimed at meeting certain requirements. The quality workperformance refers to achieved work results that must ensure in comply with predetermined standards or provisions. Meanwhile, according to Ferdian et al., quality is defined as ability to fulfill the predetermined objectives or meet the expected needs. Quality workperformance is the level of achievements of a product's characteristics in meeting the predermined requirements, needs and expectations. [22,23]

2.8. Inspection and Testing of the Executed Work

2.8.1. Inspection

Inspection is a method for assessing work activities in the construction process to ensure the result product quality meets the specification standards to maintain the customer satisfaction fulfilled. There are many steps of inspection activities such as review, survey, inspection, measurement, detection, testing, data collection, analysis, reporting, recording, documentation, and verification. Inspection usually results in field findings when there are errors in the completed work, and requires repair or rework if the work does not meet the standards. Meanwhile, according to Muhammad et.al., inspection is an effective method for identifying problems and evaluating risks before losses, accidents, or occupational illnesses occur. [24,25]

2.8.2. Testing of the Executed Work

Work testing is a process with target to verify all construction work on a project site meets the quality standards, technical specifications and design requirements. This process involves evaluation methods such as:

a. Material testing: conducted through laboratory testing for material like concrete, steel or asphalt to ensure the quality, durability and strength of these materials is in accordance with the project specifications. [26]
b. Visual Inspection: doing on-site inspection, since routine inspection for rigid pavement construction projects play a crucial role. The inspection aims not only to detect potential damage but also to identify its causes and determine appropriate repair masures. [27]
c. Expert involvement: the expert involvement in physical inspections or testing on construction projects aims to ensure that work, materials and structures meet the established standards. These experts are responsible for conducting technical analysis, verifying quality and providing recommendations for risk control and improvements during the construction process. [28,29,30,31]
d. Test Result Documentation: the test result documentation in construction project is a structured recording process of evaluating the work quality, materials and structures that have been tested. This process includes technical data such as field measurement, visual inspections, and laboratory test results, which serve to certify the established quality standards are met and support project control and decision-making during construction konstruksi. [32,33,34]

2.9. The Importance of Quality Control to Construction Company

Every company in nature wishes to produce quality products, therefore, this is where the essential role of quality control is evident. Through quality control, a leader can give assurance that the product or service received by customers meet the desired standards, or whether quality improvements are needed. The quality of a company production is highly dependent on the workperformance of its quality control team. Therefore, companies employ specialized staff in this area. In their duties, quality control, evaluates the products or services produced by conducting tests to ensure the output quality. [35]

2.10. Prestressing Material Quality

Prestressed concrete defines as concrete material that has been given a specific internal stress which is distributed in such a way so it is able to withstand the stress generated by external loads according to the work design. [36]

Quality of the materials used in prestressed concrete has significant affect to the workperformance and durability of the structure. There are several important aspects to consider include:

1. Concrete Compressive Strength (f'c): The high compressive strength concrete in this project, K-500, is able to withstand greater compressive stress and reduce the possibility of cracking.
2. Modulus of Elasticity of Concrete: High modulus of elasticity allows concrete to return to its original shape after receiving a load, thereby reducing permanent deformation.
3. Reinforcing Steel Quality (Tendon): High-quality steel, such as prestressing steel with a yield stress of 1862 MPa or more, is required to provide effective prestressing force and compensate for prestress loss due to relaxation. [37]

In addition, factors such as quality control during the production process, proper construction technique and good maintenance also play essential role for confirming the quality of prestressed concrete materials and the overall workperformance of the structure are met the standard bar.

2.11. Solution to Improve the Application of Quality Management System

The solutions for improving the Quality Management System implementation and strengthen the application of a quality management system come in several steps of:

1. Integrating Quality Control with other management processes.
2. Maintaining high standards in reporting and analysis.
3. Carrying out continuous improvement.
4. Maximizing the implementation of quality management comprehensively.

According to Ramadhany and Supriono as stated in their research, the improvement of quality management system can be achieved through these approaches:

1. Top management division of an organization demonstrates a commitment and deep understanding of the implementation of the ISO 9001:2015 quality management system. When the organization fully mastering the new system that has been updated to ISO 9001: 2015, the organization needs to develop more detailed procedures.
2. All parties involved in the business activity of a company must be given a more complete understanding that the company is implementing the ISO 9001:2015-based management system and is taking firm steps to ensure its employees comply with these procedures. [38]

2.12. Hyphotesis

The research hypotheses are formulated based on the theoritical foundation and literature as follows:

1. H1: Quality workperformance influences the quality management tools variable.
2. H2: Quality workperformance influences the quality control steps variable.
3. H3: Quality workperformance influences the inspection and testing of work performed variable.
4. H4: Quality workperformance influences the prestressing material quality variable.

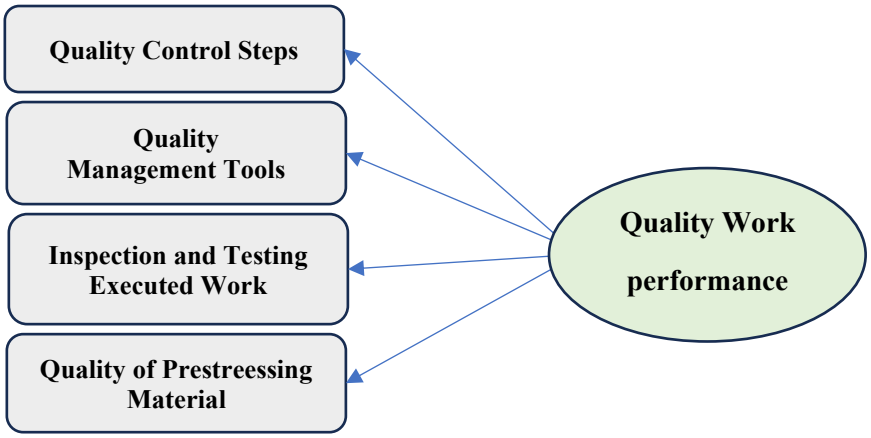

Figure 1. Research model

III. RESEARCH METHOD

3.1. Research Location

The research location was at 70 Meter 2 Span Stressed Box Girder Double Cell in Be Mos River Casnafar Dare Bridge, Dili Municipality of Timor Leste, as displayed in the following image (Figure 2).

Figure 2. Site location

3.2. Sample and Population

According to Sugiyono population is a generalization area of object or subjects that have certain characteristic qualities that determined by the researchers to be studied and to be taken the conclusion. While the sample of study is part of the number and characteristics of the population. The population in this study were contractor members, planning consultants, construction supervision/management consultants and others in Timor Leste in relation to the Evaluation of Quality Management System in Construction Project of 70 m2 span stressed box girder double cell Be'e mos river Casnafar Dare Bridge, Dili Municipality of Timor Leste for the work that has been completed or the work that still in construction progress. [39]

3.3. Technique of Sample Collection

The data sampling technique applied in this study was the probability sampling method. It is a technique that provides an equal opportunity for each element (member) of the population to be selected as a sample member. [39]

This study uses Proportionate Sampling technique with Proportionate Stratified Random Sampling, where in this study, the research selected this sampling method because the technique is used when the population has members/elements that are not homogenous and are stratified proportionally. In this technique, all individuals in the sampling frame are divided into 'strata' (group or category) then, for the depth of each category was taken from simple random sample or selected systematic sample. [39]

According to Sugiyono, this study uses a proportional random sampling technique where it took members from the population through random way without paying attention to the strata in the population, using the following formula [40]:

$$n = \frac{N}{N.d^2 + 1} \quad \text{..... (1)}$$

Where:
n = Amount of the selected sample
N = Number of population
d = Precision value (95 % or d = 5%)

The number of stratified sample member is determined by collecting sample using the proportionate random sampling through the following proportionate allocation formula:

$$ni = \frac{NI}{N}.n \quad \text{..... (2)}$$

Where:
ni = Number of sample members according to strata/stratum
n = Total number of sample members
Ni = Number of population members by strata/stratum
N = Total number of population members

3.4. Method of Data Collection

The data collection method is a crucial stage in the research process since the collected data becomes the main basis for analysis during the research. The data collection technique in this study was carried out using a survey method by sending questionnaires directly to contractor members, planning consultants, and construction supervision/management consultants, or by sending questionnaires via personal chat or email through Google form. A survey is a measurement process that aims to collect data using an instrument in the form of questionnaire as the main tool. While the primary data is type of information collected directly by researchers from the original source without going through a third party or any intermediary, obtained directly from the research object. [41,42]

3.5. Variable and Indicators

1. X1 variable (steps in quality control process)
2. X2 variable (tools of quality process)
3. X3 variable (inspection and testing of the executed work)
4. X4 variable (quality material prestreesing)
5. Y variable (quality workperformance)

Table 1. The research variable indicators

No	Code	Variables and Indicators
1	**X1**	**Steps in Quality Control Process**
	XA1	Correct way of collecting sample and conducting testing
	XA2	Study task and responsibility
	XA3	Quality control Lab is available on the site
	XA4	Coordination with project's purchasing division
	XA5	Quality movement skill construction
	XA6	Follow the established medication rule and deportation

No	Code	Variables and Indicators
	XA7	Work order in construction
	XA8	Inspect and have a meeting with staff in all work locations.
	XA9	Scheduled observation daily at work location
	XA10	Additional components and material availability for laboratory equipment
	XA11	Maintain the schedule
2	**X2**	**Tools of Quality Control**
	XB1	Pareto analysis (rule of 80-20)
	XB2	Ishikawa diagram
	XB3	Flow chart diagram
	XB4	Checklist
	XB5	Histogram
	XB6	Calculation sheets
	XB7	Statistical analysis
	XB8	Control chart
	XB9	Scatter diagram
	XB10	Organizational structure
3	**X3**	**Inspection and Testing of the Executed Work**
	XC1	Physical testing
	XC2	Testing report from the supplier
	XC3	Inspection of work on time
	XC4	Third party inspection
4	**X4**	**Quality Material Prestreesing**
	XD1	Strict inspection of material specifications
	XD2	Periodic material testing
	XD3	Third party inspection (inspectorate or certification agency)
	XD4	Training for technician or workers regarding material selection and installation
	XD5	Laboratory testing for material strength and durability
	XD6	Preparation of prestressing table
	XD7	Frequency of the material testing
	XD8	Method and material specification
	XD9	Mix formula design and work mix formula
	XD10	Procedures and sample collection method
5	**Y**	**Quality Workperformance**
	Y1	Management infalibility
	Y2	Individual neglects his/her duty
	Y3	Bad Leadership performance
	Y4	Less focus to customer
	Y5	Work load
	Y6	Lack of inadequate training
	Y7	Lack of skill in carrying task
	Y8	Teamwork in all activities
	Y9	Correct order of construction drawing
	Y10	Review meeting
	Y11	Acceptance fulfilled customer
	Y12	Acceptance fulfilled client
	Y13	Acceptance fulfilled the stakholders
	Y14	Human resources

IV. RESULT AND DISCUSSION

4.1. Hypothesis Analysis

4.1.1. Result of Linear Regression Analysis

In this study, the author used SPSS statistical program series to analyze the linear regression, SPSS is a computer software program used to process both parametric and nonparametric data as shown in the following table (Table 2):

Table 2. Linear regression test

Variable	B	Beta	Tcount	Sig t	Description
(Constant)	-6.380				
Steps in Quality Control Process (X1)	0.282	0.273	2.322	0.029	Significant
Tools of Quality Management (X2)	0.331	0.242	2.209	0.037	Significant
Inspection and Testing of the Executed Work (X3)	0.800	0.303	2.386	0.025	Significant
Quality Material Presteesing (X4)	0.604	0.321	2.288	0.031	Significant
F count	19.011				
Sig F	0.000				
R square	0.713				
Dependent Variables		Quality Workperformance			

According to table 2, the linear regression calculation using SPSS program yields the following results:

E = -6,380 + 0,282X1 + 0,331X2 + 0,800X3 + 0,604X4

4.1.2. Partial Hypothesis Test T (T Test)

Table 3. The result of T test

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-6.380	7.305		-.873	.391
	Steps in Quality Control Process	.282	.122	.273	2.322	.029
	Tools of Quality Management	.331	.150	.242	2.209	.037
	Inspection and Testing of the Executed Work	.800	.335	.303	2.386	.025
	Quality Material Presteesing	.604	.264	.321	2.288	.031

a. Dependent Variable: Quality Workperformance

1. The result of linear regression analysis revealed that a coefficient value of B (0,282) and a calculated t value (2,322) were found, indicated that the influence of Quality Control Process Steps on Quality workperformance has a positive value, meaning the better the steps in Quality Control Process, the better the Quality Workperformance will be and vice versa. While the significance value is 0.029 (sig.0.029 < 0.05) affirming that there is a significant influence, so the hypothesis statement of "Quality Control Process Steps have a positive and significant influence on the Quality Workperformance" **is accepted**.
2. The result of the linear regression analysis revealed a coefficient value of B (0.331) and a calculated t value (2.209) indicates the influence of Quality Management Tools on Quality Workperformance has a positive value, meaning that the better the Quality Management Tools, the better the Quality Workperformance and vice versa. With the significance value of 0.037 (sig.0.037 < 0.05) meaning there is a significant influence, so the hypothesis statement of "Quality Management Tools have a positive and significant influence on Quality Workperformance" **is accepted.**
3. The result of linear regression analysis revealed a coefficient value of B of 0.800 and a calculated t value of 2.386, indicates that influence of Inspection and Testing of Executed Work on Quality Workperformance has a positive value, meaning the better the Inspection and Testing of Executed Work, the better the Quality Workperformance will be and vice versa. With the significance value of 0.025 (sig.0.025 <0.05) meaning there is a significant influence, so the hypothesis statement of 'Inspection and Testing of Executed Work has a positive and significant effect on the Quality Workperformance" **is accepted**.
4. The result of linear regression analysis revealed a coefficient value of B (0.604) and a calculated t value of 2.288, indicates the influence of Quality Material Prestressing on Quality Workperformance has a positive value, meaning the better the Quality of Material Prestressing, the better the Quality Workperformance and vice versa. With the significance value of 0.031 (sig. 0.031 < 0.05) meaning there is a significant influence,

so the hypothesis statement of "Quality Material Prestressing has a positive and significant influence on Quality Workperformance" **is accepted.**

4.1.3. Simultaneous Hypothesis Testing (F Test)

Table 4. The result of F test

Anova[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	2223.623	4	555.906	19.011	.000[b]
	Residual	731.044	25	29.242		
	Total	2954.667	29			

a. Dependent Variable: Quality Workperformance

b. Predictors: (Constant), Quality Material Presteesing, Quality Management Tools, Steps of Quality Control Process, Inspection and Testing of the Executed Work

The result of F test obtained an F count value of 19.011 and a significance value of 0.000 (sig.0.000<0.05) meaning there is a significant influence simultaneously, so the hypothesis statement of "Quality Control Process Steps, Quality Management Tools, Inspection and Testing of Executed Work and Quality Material Prestressing, altogether have a positive and significant influence on Quality Workperformance" **is accepted.**

4.1.4. Determination Coefficient (R Square)

Table 5. The result of determination coefficient (R^2)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.868[a]	.753	.713	5.408

a. Predictors: (Constant), Quality Material Presteesing, Quality Management Tools, Steps of Quality Control Process, Inspection and Testing of Executed Work

b. Dependent Variabel: Quality Workperformance

According to the result of Determination Coefficient test, coefficient of determination (R2 square) sought a number of 0.713, meaning the independent variables together able to influence the dependent variable by 71.3 % while the remaining 28.7 % is influenced by other variables which are not included within the research model.

V. CONCLUSION

According to the result discussion about the Evaluation of Quality Management System in Bridge Construction Project of 70 m 2 span stressed box girder double cell Be'e mos river Casnafar Dare Bridge, Dili Municipality of Timor Leste, the author able to withdrawn conclusion of:

1. Factors with significant influence to the Quality Management System in Bridge Construction Project are include: the quality control process steps (X1) with an influence value of 0.273, the quality management tools (X2) with an influence value of 0.242, the inspection and testing of executed work (X3) with an influence value of 0.303, and the quality of prestressing material (X4) with an influence value of 0.321.
2. The result analysis revealed the most dominant factor influencing the Quality Management System is Inspection and Testing of Executed Work (X3) with an influence value of 0.303.

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