Proposed maintenance system of Gelora Sriwijaya Jakabaring Stadium (case study: lighting utilities)

Muhammad Syazari Yazuar¹, Senot Sangadji², Stefanus Adi Kristiawan²

¹Master Program in Infrastructure Maintenance and Rehabilitation Management, Civil Engineering Department, Faculty of Engineering, Sebelas Maret University, Surakarta, Indonesia
²Civil Engineering Department, Faculty of Engineering, Sebelas Maret University, Surakarta, Indonesia

m_syazari_y@yahoo.co.id; s.sangadji@ft.uns.ac.id; s.a.kristiawan@ft.uns.ac.id

Abstract. Maintenance of the stadium has been done for the 18th Asian Games 2018. However, the previous maintenances were not comprehensive and held in the run up to the big events only. It affects the performance of its components utilities. A new local company was established by the Government of South Sumatra Province, in order to make a good maintenance of the stadium. However, the planned maintenance has not been actualized by the company yet. Many obstacles encountered in stadium maintenance, including regulatory, complexity of utilities, and stakeholder’s influences. This paper aims to develop a maintenance system that is in accordance with existing conditions and applicable regulations. This study is devoted to electrical lighting systems because almost every week the stadium is also used for football matches. The methodology was divided into three parts, i.e.: rating for each parts of the utility, descriptive qualitative for regulatory identification, and stakeholders analysis, and they are developed to create a maintenance system. The result is a system that is proposed to find out the most important stakeholders in the maintenance of the highest priority of lighting utility based on official assessment.

Keywords: stadium, maintenance, regulation, lighting utilities, stakeholders

1. Introduction

Since it was built in 2002, Gelora Sriwijaya Jakabaring (GSJ) Stadium was functioned for the first time in the National Sports Week (PON) in 2004. In the meantime, there was no planned maintenance system. Maintenance was only did when there were great-scale sports events such as Asian Football Cup (2007), SEA Games (2011), Islamic Solidarity Games (2013), ASEAN University Games (2014), and Asian Games (2018). Maintenance was only carried out during the implementation of project construction, and it ended when the executive contractor conducted the second handover.

The maintenance of project construction was not conducted by maintenance-specialist contractors. Every time the maintenance would be performed, the contractor qualification auctioned was general contractor qualification. Moreover, the maintenance merely fixed major damages on existing installation network and seemingly easy installations, for instance, arena lighting.
Aragones [1] say that the most influential stakeholders are the contractor and the signaling systems provider with almost 40% of influence on the project, because these two stakeholders have problems (delays, overruns or lack of specifications), the project will be severely affected.

Before 2018, the budgeting process involved many parties. Afterward, the Provincial Government established a Municipally Owned Corporation named PT. Jakabaring Sport City (PT. JSC). This corporation was in charge of managing the area of Jakabaring Sport City, including maintenance of the whole venues. As a newly established corporation, the maintenance process done by PT. JSC, however, was not sufficient due to several reasons as follows: a small number of personnel (organization structure compared to the number of venues), great coverage of task but no capable personnel who was responsible for each venue. The applicable regulations had not been fully implemented by the company.

Based on Chanter [2], in a nutshell, maintenance can be divided into two types: Planned Maintenance and Unplanned Maintenance. Planned maintenance is divided into preventive maintenance and corrective maintenance. For preventive maintenance, there are two types: scheduled maintenance and condition/situational maintenance. According to Chen [3], preventive maintenance (PM) is required for good equipment management and protection of company assets. Minimum standard of PM company must be applied. Special maintenance procedures must be available from the equipment department on the most major equipment. If certain standards are not available, the recommendations of manufacturer's minimum maintenance must be used. Stakeholders are people, groups, or institutions having interests in policies, programs or projects [8].

According to AFC regulation, the lighting system has a significant assessment score. The stadium lighting system is the most numerous system and the most electricity-consuming system. Arena lighting is an absolute qualification to fulfill the Olympic Organization and international broadcasting television standard. The complexity of the requirements of each standard influences the final assessment of the feasibility of the stadium.

Maintenance of stadium lighting systems was influenced by the involvement of various stakeholders, both internal and external. Each of them had an influence on each maintenance process. Based on these influences, they were divided into two categories: internal and external. The involvement of various parties in stadium maintenance was also based on applicable regulations in Indonesia and international standard.

As stated early, maintenance of the stadium could be categorized as incidental maintenance. It only held as the requirements of certain sports events. The Provincial Government has established a regional company to maintain the stadium. However, the effort was constrained by: many rules, complicated technical aspects and the involvement of stakeholders. In order to solve these problems, this study proposed a planned maintenance system of the lighting utility network of GSJ Stadium specifically.

2. Steps to be considered in the development of planned maintenance
In developing a planned maintenance system of stadium, holistic identification was needed. Technical aspects in maintenance were important but it still need to aware on another aspects that affected such as applicable regulations and stakeholders. Therefore, this paper tried to build a maintenance system that was composed of various influenced aspects.

2.1. Component, Installation and Network Rating
Based on installed parts, the GSJ stadium lighting utility could be divided into three categories, namely: network, installation and components. The component referred to an electrical object that could be functioned when strung together with another electrical objects. An installation is a series of components arranged for an electrical function. A network is a group of several similar installations.

At this stage, the scoring method is used for each component, installation and network. The network is a combination of all similar installations. Installation is an arrangement of components that
are arranged into one part and function properly. The scoring system used is the division of levels into 10 parts or a scale of 1 to 10. This division is based on the assessment in accordance to the building regulations of the Ministry of Public Works. In the regulation, it was stated that the value for minor damage worth <10%, so the building could be considered in good condition [5],[6].

2.2. Identification of Regulation
Regarding building maintenance, each country has its own regulations. These regulations were applied to all buildings, especially government-owned buildings that are used for public purposes. Thus, it was necessary to collect data on all regulations that apply in Indonesia related to buildings, electrical installations and stakeholders. All collected regulations were grouped according to the category and issuing agency. With a qualitative descriptive method, the next step was to identify the regulations that contain the most explanation regarding the maintenance of the utility of the lighting system in special building buildings. With comparative study techniques, identification of regulations was carried out to see the relationship between the regulations which became the main reference with the regulations that become supporters' references.

2.3. Stakeholder Analysis
As a public building, the stadium must be well maintained. With the complexity of the installed utilities, its maintenance involved many parties. Stakeholders were involved in the aspects of implementation of maintenance and verification. Therefore, beside the technical aspects, stadium maintenance must consider the level of involvement of each stakeholder.

Based on PMBOK in 5th Edition [9], the steps in conducting stakeholder analysis are as follows:
• Identifying all stakeholders and related information such as roles, departments, interests, knowledge, expectations, and level of influence.
• Analyzing the potential impacts or support for each stakeholder that can be developed and classified for strategy development. In a large stakeholder community, it is necessary to prioritize stakeholders to ensure efficient efforts to communicate and manage their expectations.
• Assessing how key stakeholders react or respond to various situations to plan how to influence them in order to increase their support and anticipate the negative impacts that might arise.

In conducting this analysis, there are various classification models, namely:
• Power/interest grid, based on the level of power and interests of the stakeholders based on project results/outcomes (see Figure 1).
• Power/influence grid, based on the level of power and their influence/involvement in the project.
• Influence/impact grid, based on the level of influence/involvement in the project and their ability to provide the impact towards the project (plan - implementation).
• Salience model, which describes stakeholder classes based on their power, level of importance, and legitimacy.

The rating scale is in the form of a range of 1-5 with the following conditions: Power level. Level (1) means very low - Level (5) means very high
Interest level. Level (1) means very small - Level (5) means very large
Support level. Level (1) means very inhibiting - Level (5) means very helpful
Influence level. Level (1) means very small - Level (5) means very high.
3. Proposed Maintenance System of the Stadium

As a special building that has high utility complexity and certain characteristics, the stadium requires a maintenance system that is prepared according to the applicable regulations and the existing conditions of the building.

Based on Minister of Public Works Regulation No. 25/2007 [6], GSJ Stadium was included in the special building category. Until now there are no guidelines for the maintenance of special buildings in Indonesia. Maintenance guidelines for public building buildings are Minister of Public Works Regulation No. 16 of 2010 [4]. This regulation is the main reference for assessing the extent of damage to the utility of electrical lighting systems for buildings in general.

As a sports building, Stadium had a lot of constituent components that must be installed according to the standards of various organizations. Each stadium has a unique structure, architecture and MEP that is different from other stadiums. In order to organize certain events, the stadium must fulfill the organizer's qualifications. In addition, the utility of lighting as an electrical system is also required to be installed according to Indonesia's national standards in Electrical Installation (SNI 0225: 2011) [6].

3.1. Component, Installation and Network Rating

The first step in the preparation of a maintenance system for electrical installations for the lighting of stadium buildings was to compile the rate of each network listed in Table 1. The type of the lighting network was sorted from the highest score to the lowest one. Assessment scores were calculated based on location, power, difficulty in loading and unloading, duration of use, and the number of points. Each type of light network was also weighted by rating again for each point, based on location, price, and difficulty in loading and unloading. At each point of the light, an assessment is also carried out to determine the Rating of each constituent component, based on location, price, and difficulty in unloading.

| Table 1. Type of Lighting Network Ratings |
|-------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Lighting Network               | Place            | Power (watt)    | Price (Rupiah)  | Duration (per year) | Installation | Total Score   |
| Area                           |                  |                 |                 |                  |               |                |
| Mini 300                       |                  |                 |                 |                  |               |                |
| Roof Facade                    |                  |                 |                 |                  |               |                |
| Tango                         |                  |                 |                 |                  |               |                |
| Songket Area                   |                  |                 |                 |                  |               |                |
| Under the Tribune              |                  |                 |                 |                  |               |                |
| VVIP                           |                  |                 |                 |                  |               |                |
| Downlight                      |                  |                 |                 |                  |               |                |
| TL                             |                  |                 |                 |                  |               |                |
| Ordinary Fittungs              |                  |                 |                 |                  |               |                |

Figure 1. Grid Power/interest of Stakeholders
Table 2. Example ratings of difficulty level of repair

| Category | Score | SNI coefficient | Interpolation | Salary (*) (Rupiah) | Value (Rupiah) | Amount |
|----------|-------|-----------------|---------------|---------------------|----------------|--------|
|          |       | (a1) helper     | (b1) helper   | (c1) helper         | = [(a1)*(b1)*(c1)+ (a2)*(b2)*(c2)] |        |
|          |       | (a2) worker     | (b2) worker   | (c2) worker         |                |        |
| hardest  | 10    | 0.01            | 1.5           | 43,000              | 645            | 6,292.5 |
|          |       | 0.06            | 1.5           | 62,750              | 5,647.5        |        |
|          | 9     | 0.01            | 1.4           | 43,000              | 602            | 5,873   |
|          |       | 0.06            | 1.4           | 62,750              | 5,271          |        |
|          | 8     | 0.01            | 1.3           | 43,000              | 559            | 5,453.5 |
|          |       | 0.06            | 1.3           | 62,750              | 4,894.5        |        |
|          | 7     | 0.01            | 1.2           | 43,000              | 516            | 5,034   |
|          |       | 0.06            | 1.2           | 62,750              | 4,518          |        |
|          | 6     | 0.01            | 1.1           | 43,000              | 473            | 4,614.5 |
|          |       | 0.06            | 1.1           | 62,750              | 4,141.5        |        |
|          | 5     | 0.01            | 1.0           | 43,000              | 430            | 4,195   |
|          |       | 0.06            | 1.0           | 62,750              | 3,765          |        |
|          | 4     | 0.01            | 0.9           | 43,000              | 387            | 3,775.5 |
|          |       | 0.06            | 0.9           | 62,750              | 3,388.5        |        |
|          | 3     | 0.01            | 0.8           | 43,000              | 344            | 3,356   |
|          |       | 0.06            | 0.8           | 62,750              | 3,012          |        |
|          | 2     | 0.01            | 0.7           | 43,000              | 301            | 2,936.5 |
|          |       | 0.06            | 0.7           | 62,750              | 2,635.5        |        |
| easiest  | 1     | 0.01            | 0.6           | 43,000              | 258            | 2,517   |
|          |       | 0.06            | 0.6           | 62,750              | 2,259          |        |

*) note: salary follow the current inflation

The coefficient above comes from the unit price standard issued by the Ministry of Public Works and Housing [6]. Unit price is the price issued by the local Regency/City Government and experiences adjustments every year. For interpolation, it is standardized that the easy category has the same value as the coefficient multiplied by the unit price that applies to the count per light point, without taking into account the different comparisons of the length of cable used for similar networks. Cable length affects the calculation of the price column. For the power column, the score is calculated based on the wattage capacity used. As it is presented in the table below:
Table 3. Scoring based on power requirements

| Category | Scale | Percentage |
|----------|-------|------------|
| lowest   | 1     | < 10 %     |
|          | 2     | < 20 %     |
|          | 3     | < 30 %     |
|          | 4     | < 40 %     |
|          | 5     | < 50 %     |
|          | 6     | < 60 %     |
|          | 7     | < 70 %     |
|          | 8     | < 80 %     |
|          | 9     | < 90 %     |
| highest  | 10    | < 100 %    |

Calculation of price scores; the duration and calculation of the next lighting ratings also follow the pattern above. Compilation of network ratings is done by considering the real conditions in the field. Because the utilities that will be prioritized on each network, have their own characteristics.

3.2. Identification of Regulation

After determining the network hierarchy, the next step is to identify the relevant valid rules from various agencies. The total number of related rules are 65 items, consist of: 21 of (high state institutions); 29 (Ministry of Public Works and Housing); 16 (Ministry of Energy and Mineral Resources); 1 (Ministry of Youth and Sports); 1 (Ministry of Industry); 1 (PT. PLN) and 6 SNI (National Standardization Agency).

The results of identification of regulations with comparative methods, comparing between rules. The fact is that in general there are fundamental technical differences between regulations originating from technical ministries and applicable SNI. these differences are not contradictory, but are used to complement each other.

Technically, the Ministry of Public Works regulation was based on visual observations, while SNI is more likely to do a lot of testing with sufficient time long. However, the implementation of maintenance measures based on visual observations must still meet SNI requirements in general, so that the main reference to be used in this paper is Minister of Public Works Regulation No. 16 of 2010 [4] and National Electrical Standard of Indonesia 2011 [7].

Visual evaluation for maintenance used the forms according to the Minister of Public Works Regulation No. 16 of 2010. The form is solely taken in the sections which contain utilities in general and electrical installations in particular as shown in the figure below:
### Assessment Form (based on Regulation Ministry of Public Works No. 16/2010 page 136)

**Lamp Type: TL 2x36**

|   |   |
|---|---|
| 1. Location/Code | East / 4.a T.3.30 |
| 2. Chamber | 3rd Floor (under tribune) |
| 3. Chamber type | □ Class □ Library □ Meeting/conference □ Lobby □ Gym/sport □ Office □ Toilet □ Building connector □ Others: ............ |
| 4. Feature type | □ Inside □ Hung □ On surface □ Others: ............ |
| 5. Diffuser type | □ Metal □ Plastic □ None □ Parabolic □ Others: ............ |
| 6. Lamp type | □ TL (Tube Luminescent) |
| 7. Ballast type | □ Electronic □ Magnetic |
| 8. Feature amount | 2 |
| 9. Lux of lighting | 30 |
| 10. Controller type | □ Automatic □ Manual (on/off) □ Dimmer □ Others: ............ |
| 11. Age | 15 year |
| 12. Damage level | □ None □ Bad □ Worse □ Worst |
|   | 0% | < 1% | 1 - 10% | > 10% |
| > Decreased quality | □ | □ | □ | □ |
| > Faded color | □ | □ | □ | □ |
| > Blink rate | □ | □ | □ | □ |
| > Glowing level | □ | □ | □ | □ |
| > Less control | □ | □ | □ | □ |
| > Repair need | □ | □ | □ | □ |
| > Buzzing level | □ | □ | □ | □ |
| > Instability of light | □ | □ | □ | □ |
| > Light emitting level | □ | □ | □ | □ |
| 13. General condition | □ Bad □ Worse □ Good □ Best |
| 14. Remaining service life | 1 year |
| 15. Comments | ........................................................................................................ |
| 16. Supervisor | ................. date ........................ |

**Figure 2. Assessment form**
3.3. Stage Stakeholder Analysis
The next step is to conduct stakeholder analysis. The first step of stakeholder analysis is to identify all relevant parties and carry out registered stakeholders. There are two types of stakeholders, namely internal and external.

Internal stakeholders consist of: Government of South Sumatra Province: PT. JSC (Directors, ME Division; and Hygiene Task Force); Housing and Environment Agency (Building Management Division); Financial and Asset Agency (Asset Division); PSSI (Football Association of Indonesia) of South Sumatra; KONI (National Sports Committee of Indonesia) of South Sumatra, and Regional House of Representatives of South Sumatra Province: Commission IV of Infrastructure.

External stakeholders consist of: 1) Sports Affairs, e.g: PSSI (Football Association of Indonesia) Center, KONI (National Sports Committee of Indonesia), AFC/FIFA/OCA, Sriwijaya FC; 2) Electricity Affairs: PT. PLN (National Electricity Company), AKLI (Association of Electrical Contractors and Indonesian Mechanics, ME Outsourcing Consultant of PT. JSC; 3) Job Affairs: Contractor, Sub Contractor, Mechanical Electrical Supervisor Consultant.

Table 4. Stakeholders identification

| Stakeholders                                             | internal / external | scale 1-5 (weakest - strongest) |   |   |   |   |
|----------------------------------------------------------|---------------------|---------------------------------|---|---|---|---|
| Director of PT. JSC                                      | internal            | 5                               | 5 | 4 | 4 |
| ME Division of PT. JSC                                   | internal            | 5                               | 5 | 5 | 5 |
| Cleaning Service of PT. JSC                              | internal            | 4                               | 4 | 5 | 5 |
| Building Management Division of Housing and Environment Agency | internal         | 2                               | 3 | 5 | 5 |
| Asset Division of Financial and Asset Agency              | internal            | 5                               | 4 | 2 | 1 |
| Regional House of Representative Assembly of South Sumatera Province | internal       | 2                               | 5 | 4 | 1 |
| AKLI (Electrical Association)                            | external            | 1                               | 1 | 4 | 5 |
| PT. PLN (Electrical Company)                             | external            | 2                               | 1 | 2 | 1 |
| Outsourcing consultant of PT. JSC                        | external            | 2                               | 3 | 3 | 4 |
| Independent Mechanical Electrical Supervisor Consultant   | external            | 1                               | 2 | 4 | 4 |
| Main Contractor                                          | external            | 5                               | 5 | 5 | 5 |
| Sub Contractor                                           | external            | 5                               | 3 | 5 | 5 |
| PSSI (National Football Association)                      | external            | 4                               | 2 | 5 | 3 |
| AFC (Asian Football Confederation)                       | external            | 1                               | 2 | 1 | 2 |
| KONI (National Olympic Committee)                        | external            | 1                               | 2 | 1 | 2 |
| OCA (Olympic Committee of Asia)                           | external            | 1                               | 2 | 1 | 2 |
| PSSI Province Level                                      | internal            | 5                               | 2 | 4 | 4 |
| KONI Province Level                                      | internal            | 4                               | 1 | 4 | 3 |
| Team and Management of Sriwijaya FC                      | external            | 1                               | 1 | 2 | 1 |
| Supporter of Sriwijaya FC                                | external            | 4                               | 1 | 5 | 1 |

Based on the assessment score in Table 4, it was recognized that the highest urgency level with the highest influence for the maintenance of lighting system utilities is the Director of PT. JSC and ME Division of PT. JSC. See the figure below:
Maintenance System of Electrical Lighting Utilities

Stakeholders Identification

Stakeholders Analysis

Figure 3. Analysis model stakeholder internal

Figure 4. Analysis model stakeholder external

Figure 5. Flowchart of maintenance system
All parts are arranged into a planned maintenance system scheme in the stadium lighting electrical system.

4. Concluding Remark
This paper was expected to be useful to find out 'what' (in component, installation, network ratings); 'where' (also in component, installation, network ratings); 'how' (in identification of regulation); and 'who' (in stakeholder analysis) involved in a planned maintenance system. By ratings the component, installations and networks, the most prioritized of them could be determined. Thorouqh the ratings, the place of each component, installation, network could be known directly. By identifying the selected regulation, the best maintenance steps could be determined clearly. By analyzing the involvement of stakeholders, the highest influence level and the highest interest level were identified easily. Thus, in order to determine 'when/time', the system would be easy to be implemented. In brief, this System was proposed to find out the most important stakeholders in the maintenance of the highest priorities component based on official assessment.

Acknowledgements
The authors are grateful to the Ministry of Public Works and Public Housing of Republic of Indonesia for funding this research as part of scholarship master program in collaboration with Sebelas Maret University. The authors also expressed their gratitude to the Government of South Sumatra Province for providing technical support.

Reference
[1] Aragones P Beltran, M Garcia-Melon, and Montesinos J Valera 2017 How to Assess Stakeholders’ Influence in Project Management? A Proposal Based on The Analytic Network Process Int. J. Proj.Manag. 35:451-462. http://dx.doi.org/10.1016/j.ijproman.2017.01.001
[2] Chanter Barrie and Peter Swallow 2007 Building maintenance management – 2nd ed (Oxford: Blackwell Publishing Ltd)
[3] Chen Wai-Fah, Liew, J Y Richard 2003 Civil engineering--Handbooks, manuals, etc. (New directions in civil engineering) CRC Press LLC (Washington D.C.) ISBN 0-8493-0958-1
[4] Ministry of Public Works and Housing 2010 Periodic Inspection of Building Technical Guidelines Regulation Number 16 (Jakarta)
[5] Ministry of Public Works and Housing 2018 Construction of State Buildings Regulation Number 22 (Jakarta)
[6] Ministry of Public Works and Housing 2007 Building Feasibility Certificate Regulation Number 25 (Jakarta)
[7] National Standard of Indonesia 2011 General Requirements for Electrical Installation 0225:2011, ICS 91.140.50 (Jakarta: National Standardization Board of Indonesia)
[8] Partridge K, Jackson P, Wheeler, and D Zohar A 2005 From Words to Action: The Stakeholder Engagement Manual Volume 1: The Guide to Practitioners’, Perspectives on Stakeholder Engagement Stakeholder (New York: Research Associates Canada Inc., United Nations Environment Programme)
[9] PMI 2013 A guide to the project management body of knowledge (PMBOK® guide) -- Fifth edition (Pennsylvania: Project Management Institute, Inc.)