Development of WBS (Work Breakdown Structure) dictionary and checklist of mechanical and electrical works in stadium construction for safety planning

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Abstract. In a construction project, an organizing tool is important to specify every activity that should be done during the project and to keep everything on track. Organizing tool also can be developed to safety planning to ensure safety of the labours. Safety is priority of a project because once accident is happened, it causes many kind of losses; direct cost, indirect cost, time loss, life loss, project delays. Nowadays, not every project has implemented that organizing tool. Here reported the discovery of organizing tool called WBS and developed to safety planning, on mechanical electrical works in stadium construction project. On this research, shows that mechanical and electrical works in stadium construction's work breakdown structure detailed to four levels, and can be developed to WBS dictionary and checklist to bring ease for the construction itself. WBS dictionary and checklist can also developed to safety planning. It shows that WBS complementary such WBS dictionary and checklist can be used for safety planning, and ease project construction’s life.

Keywords: Mechanical and Electrical, WBS, WBS Dictionary, WBS Checklist, Stadium, Safety Planning

1. Introduction
Based on statistic data published by Central Bureau of Statistics (BPS) [1], one of many supporting factors of improving Indonesian economy is incessant infrastructure development with good quality. Moreover, holding an interstate sport championship is also a way to improve the country’s economy. To hold one, Indonesia needs to construct sport facilities and infrastructures; a stadium. A decent and standardized facility and infrastructure is needed to gain public appeal. Therefore, a stadium construction need to be concerned to keep it done according to the procedure and to applicable standards.

One of applicable standards is lighting arrangement, lighting levels and the positions that are parts of mechanical and electrical works. Besides structure, architecture, and finishing, mechanical and electrical work also needs to be concerned to embellish the stadium itself. Because mechanical electrical work is associated to technological development that always change, it makes mechanical electrical work needs to be always updated and has to be detailed.
In construction project, every work detail needs to be itemized so that no details that will be left. This caused by interconnected project life cycle starting from the beginning to the end [2] and the success of a project is related to project performance which measured by the cost, time, and quality. Details of work that are left behind can cause a work accident which also cause time and cost loss. Due to manage the life cycle of a project and minimize chances of work accidents, a specific tool to plan is needed. The planning, implementation and management of construction refers to a basis called Work Breakdown Structure (WBS). In WBS, works are detailed to the smallest part in a level. As a planning tools, WBS can help to organize tasks.

WBS can also be developed into WBS dictionary and checklist. WBS dictionary provides information such milestones, brief description about the project scope which defined as deliverables, activity, and schedule. Besides, there also checklist as an output of WBS development that helps to define the task and milestone certainly so that the quality can be monitored according to criteria [3]. This research is purposed to develop WBS dictionary and checklist on mechanical and electrical works in stadium for safety planning.

2. Literature Review

2.1. Mechanical and Electrical Works in Stadium Construction
Mechanical work is generally associated to tasks that are using large machine tool. Mechanical and electrical work includes plumbing, air system, electrical works, high and low voltage panel, telephone works, and grounding. From year to year, mechanical and electrical work use different specs changing from what is used before, following the rapid technology development to improve the quality of buildings [4].

2.2. WBS
WBS is a planning tools in the form of hierarchy of project works decomposition with deliverable as a basic of project team’s implementation to reach the project’s goal [2]. Deliverable is a measurable output that can be seen, legalized, and has to be achieved to complete the project [5]. To define tasks in a project, a scope planning needs to be done beforehand. WBS hierarchically itemized to four levels, with work package as the fourth level. WBS can be done in outline form, table form, or in the form of tree diagram.

2.3. WBS Dictionary
WBS dictionary is a complementary document which provides details that are needed to complete every work package in WBS. In WBS dictionary, there has to be details such numbering description design in the form of code, cost content, technical content, and work statement [6]. Moreover, there are essentials thing that also has to be inserted in WBS dictionary, and it’s not limited as this mentioned points; identification code, work description, assumptions, and limits (milestone), person or organization in charge, schedule of activities, resources, cost estimation, quality requirements, acceptance criteria, technical reference, and agreement information.

Based on the dictionary format provided by Project Management Institute, author makes a simpler and easy-to-read form, without lessen the existing components of the WBS dictionary. Table WBS dictionary format is the example format that is used in the research:
Table 1. WBS Dictionary Format

2.4. Checklist
Another developed form of WBS is checklist; a document contents milestones list for the project team to be used as an evaluation of the adequacy of a WBS and help to complete the work based on WBS itself [7]. The form of WBS checklist of a project can be different to one and another depends on the regulations given by each project. Considering the importance of the checklist for WBS, author has discovered a comprehensible format for WBS checklist to complete the WBS, as shown in Table 2.

Table 2. WBS Checklist Format

2.5. Safety Planning
Safety is every activity that are meant to prevent every form of accidents, and related to work environment. Safety has a same meaning with free risk or any unacceptable danger. Because safety is priority, every construction project has to have a safety plan. Safety plan is a knowledge and implementation that can be used to prevent every possibilities of accident that may occur at work environment during the construction project.
3. Methodology

The research to develop WBS dictionary and checklist for mechanical and electrical works for sport facility / stadium as a base for safety planning in this study includes:

- Identify WBS standard for each level developed using archive analysis compared to existing sport facility / stadium construction bill of quantity.
- In order to develop the WBS dictionary and checklist, author did an interview to experts with criteria such minimum 25 years’ experience in stadium construction project to get validation for mechanical and electrical work package, activities, and resources benchmarked to bill of quantity of existing sport facility / stadium construction projects.
- After each level of WBS has validated, next interview is held to validate WBS dictionary and checklist in order to ensure the written description in WBS.
- At the end of the research, author did a final interview to find specificity of mechanical and electrical work in stadium that is different from another construction project in order to find out what special treatment that needs to be done on the project.

Figure flowchart method (Figure 1) is a flowchart to describe flow of methods that are used to do this research.
4. Result and Discussion

Based on the WBS dictionary format that has been validated before from previous interviews and studies, several components in WBS dictionary are WBS code number, job package description, deliverables, reference sources, and detailed activities and resources (including labor, materials, and equipment) for each defined work package. In the WBS, mechanical and electrical works divided into two different work division, mechanical and electrical. Mechanical has 50 work packages and dominated by plumbing works, this is caused by plumbing works planned in more detail compared with another work. Whereas the electrical has 56 work packages with high voltage work as majority of it, because there are so many work accidents caused by it so high voltage work also needs to be detailed.

The specialty of mechanical and electrical work in stadium project is the advanced electrical equipment such scoring board and timing system that are only installed in a stadium to support the function of the stadium itself. Timing system has to be installed in a stadium to record the acquisition of running athletes who are competing in held competition. Table WBS dictionary for unit AC is an example of WBS dictionary made for the mechanical and electrical work in stadium construction, Unit AC work package as follows.

![WBS Dictionary of Sport Facility / Stadium](image)

| Code | Activity | Resources |
|------|----------|-----------|
| 111.1 | Split Duct AC Grounding and Installation | AC Panel Board |
| 111.3 | Installation of AC Control | Control AC |
| 111.3 | Installation of AC Well Insulated | Unit AC Control Panel |
| 111.3 | Installation of AC Control | Control AC |
| 111.3 | Installation of AC Ceiling Coaxial | Unit AC Control Panel |
| 111.3 | Installation of AC Control | Control AC |
| 111.3 | Installation of AC Panel Board | Unit AC Control Panel |
| 111.3 | Installation of AC Control | Control AC |

Table 3. WBS Dictionary for Unit AC
As seen in table WBS dictionary for unit AC (Table 3), unit AC work package is a part of VAC type of work. WBS checklist of VAC work includes definitions of each work family, work package, and activities from each work. Table 4 AC is an example of WBS checklist for VAC work.

To develop the safety plan based on the WBS dictionary and checklist, a risk identification was firstly conducted. The correlation between WBS dictionary and risk identification is that WBS dictionary defines each level until the lowest level, which are activity and resources, where the risk factors can be identified based on the description from WBS dictionary and checklist. Therefore, it will be more efficient to do the risk identification based on each activity that needs to be done in the mechanical and electrical works for stadium construction. In the process of identifying potential risks, it is necessary to know possibility of accidents that is likely to happen during an activity, the impacts, and severity that caused by the accident. Afterwards, the severity and the probability needs to be converted into numbers, then the safety risk assessment calculation can be done from the number of probability and severity that occurs, as shown in Table 5.

Table 4. WBS Checklist Unit AC
Table 5. The Frequency Value of Risk Occurrence in Project Construction

| Value | Frequency                      |
|-------|-------------------------------|
| 1 (one) | Rarely happened in project construction |
| 2 (two) | Sometimes happened in project construction |
| 3 (three) | Often happened in project construction |

| Risk Level | Severity | 1 | 2 | 3 |
|------------|----------|---|---|---|
| Probability |          | 1 | 1 | 2 | 3 |
|            |          | 2 | 2 | 4 | 6 |
|            |          | 3 | 3 | 6 | 9 |

Information: 
- : Low risk
- : Medium risk
- : High risk

Table 6. Identification of Safety Risk Hazards

| No | Work Package | Activity | Hazard Identification | Type of Hazards | Requirements | Initial Control | Risk Assessment | Advanced Control | Advanced Risk Assessment | Information |
|----|--------------|----------|----------------------|-----------------|--------------|----------------|----------------|---------------------|--------------------------|-------------|
| 1  | Medium Voltage Panel | Equipment & Materials | Electric shock | Worker accident | Personnel | Using PPE | 2 | 3 | 6 | High | Check the electric current | NA | NA | NA | NA |

As can be seen on the table identification of safety risk hazards, found that hazard that may occur in medium voltage panel installation is electric shock with the value of 6 as risk assessment. Based in table 6, it classified as high risk which indicates that the risk is not acceptable and advanced control is needed to lessen the chance of accident to be happened.

5. Conclusion

From the study that has been done, it was found that validated WBS dictionary and checklist for mechanical and electrical works in stadium construction divided into two divisions; mechanical and electrical, mechanical with 50 work packages and electrical with 56 work packages, and can be developed to safety planning in the manner described before.

Every mechanical and electrical work is unique and may be different one with other project construction, that caused the WBS dictionary and checklist can be adjusted as needed but this study can be a reference for every mechanical and electrical works in stadium construction since this WBS dictionary and checklist has been validated by the experts. For further use, besides for safety planning this study can also be used for schedule planning and financial planning.
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