

Development of work breakdown structure (WBS) dictionary for the construction works of precast concrete bridge

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Abstract. Nowadays, precast concrete structure system is one of the alternatives of construction methods that is mainly used in the construction projects. In its implementation, this method provides time and energy efficiencies and supports environment preservation. This method is also currently chosen as the main preference for bridge construction projects. However, along with the advantages that it provides, the construction works of precast concrete bridge is a complex project and should be planned and managed effectively. Also, full consideration of each aspect in the scope of this project, such as its defined methods, activities and resources in the construction works, which depend on the site and working condition, is essential. A standardized work breakdown structure (WBS) including the detailed WBS dictionary for its construction works for precast concrete bridge can provide in breaking down the abovementioned aspects and guide the constructor to execute the project. The WBS and its dictionary should be developed in the planning phase of the construction project. This paper explains the development of the WBS dictionary for the construction work of precast concrete bridge. The methodologies used are archive analysis, Delphi method and validated by experts. The WBS dictionary of the precast concrete bridge construction works consists of six (6) levels of WBS (including two supplementary levels), which itemize the work packages, work methods, activities, and resources.

1. Introduction

Concrete bridge construction is one of the dominant bridge construction materials used in Indonesia. Concrete construction contributes for 40 percent of building materials used in infrastructure projects in Indonesia. This is in line with the strategic plan of the Directorate General of Construction Development of the Ministry of PUPR targets the capacity of the concrete industry to be pushed up to 41 million tons or 30 percent by 2019. The precast concrete structure system is one of the technological alternatives in construction development in Indonesia that supports time efficiency, energy efficiency, and supports environmental preservation [1].

Nurjannah [2] explained that the structure of precast elements has several advantages over the conventional structure, among others: Simplifying the construction implementation, Time of rapid implementation, Time of execution of the structure is a major consideration in the development of a project because it is very closely related to the cost of the project. The structure of precast elements can be carried out at the plant together with the implementation of the foundation in the field, the use of the optimum material and the quality of good materials.



Implementation of a precast bridge project is a complex set of work activities which are limited by time, resources and selection of appropriate methods of execution. Due to its complexity, the success of a project is strongly influenced by the defining phase of the project, the lack of definition and the scope of the project are the critical factors affecting project failure. The process of defining the project management process, creating project scope documents can help control the scope, time and cost to stay on track [3].

The planning, implementation and management of such work refers to a basis called Work Breakdown Structure (WBS). WBS is a framework for project implementation, as well as a means for planning, monitoring and controlling a project. According to PMBOK and the standard practice for work breakdown structure-5th edition, WBS can be used to effectively describe project scope to improve project estimates, to control project implementation better and to verify more accurately the completion of a project. The definition of WBS according to practice standard for Work Breakdown Structures is the breakdown of the project scope into smaller components to be more manageable. "In order for a project to be properly managed, there is a need to derive its work breakdown structure and determine the work package, so that it can be assigned to the unit organization" [4].

In Indonesia, there were some bridge failure cases (including precast concrete bridge) which did not use a complete WBS to detail their construction works. Hence, this issue is considered as one of the main cause for construction failures [5, 6]. Also, there is extensive research evidence that the project failed because the technical content of the program was not planned and controlled efficiently. The use of WBS contributes significantly to the probability of project completion. The proper formulation of WBS allows all sections, customers, suppliers and so on to apply the project's entire life-time information, engagement, regulation, and monitoring network [7, 8].

WBS dictionary is a document that describes every WBS element, including scope, deliverables, specifications, schedules, resource requirements, and so on. The WBS dictionary will often generate project or contract employment statements [9]. Furthermore, developing a detailed WBS dictionary as the supplementary document of the WBS can comprehensively details each element in the WBS work packages [10]. Considering this matter, a standardized WBS including its WBS dictionary for the construction works of precast concrete bridge can provide in breaking down the elements in the structure and guide the contractor to execute the project more comprehensively. The purpose of this study is to develop a WBS dictionary of the precast concrete bridge based on WBS.

2. Literature Review

2.1. Precast Concrete Bridge

There are 3 ways of concrete work, namely concrete monolith (conventional), concrete formwork and precast concrete, in the planning procedure of precast concrete and pre stress for bridges. Compared with two other ways of choice, precast is more popular because of the reasons of the speed of work, quality control and friendliness towards environment [2]. According to Desiyandri [6], project location is very influential on the methods used in the use of precast segmental girder for bridges, including implementation time, funding, specified specification and subcontractor management work. Precast concrete bridges are widely used as the construction method due to its characteristics, which are the fabrication of segments that can be done when sub-structures are being worked on, thus accelerating the erection speed of the upper-structure.

2.2. Work Breakdown Structure (WBS)

According to Devi & Reddy [11], a complex project can be managed by splitting it into individual components in a hierarchical structure, known as the detail of the structure of the work or WBS. Such structures define tasks, facilitation, resource allocation, assignment of responsibilities, and project measurement and control. The importance of WBS is in the planning, implementation and control phase. The project manager's and project team's ability to define WBS accurately greatly affects the three key items required for project success: scope, schedule and cost [7]. Suanda [12] explained that in construction project, regardless of how successful the constructor develop and perform their work, project component failures can still occur, which was often due to the cause of incomplete WBS. A poor-quality WBS for construction work can lead to adverse projects such as messy work, inconsistent scope, budget overruns, deadlines and procurement problems. Therefore, it is most advantageous to complete the WBS before starting the project.

2.3. WBS Dictionary

By detailing each WBS element to an item such as a dictionary that contains descriptive explanations about each element, it allows us to breakdown the scope of the project into a more manageable and controllable structure that could be used for planning and controlling. A WBS dictionary is a supporting document that provides detailed information about each element in the WBS. For each WBS element, the WBS dictionary explains a brief definition of the scope or statement of work, defined deliverable, list of associated activities and resources. The benefit of developing the WBS dictionary is to provide clarity for all stakeholders to understand the work packages of the project [9].

3. Methodology

In order to develop the WBS dictionary for the construction works of precast concrete bridge, the methodology in this study is based on the following descriptions:

- The WBS standard for precast concrete bridge were developed through archive analysis, which was compiled based on Bina Marga and BadanPengaturJalanTol (BPJT) specifications.
- The WBS standard for precast concrete bridge was used to determine the initial WBS dictionary format, which were benchmarked from literatures.
- The proposed WBS dictionary for precast concrete bridge was then validated for its format and contents by experts of precast concrete bridge in Indonesia, using Delphi Technique.

4. Result and Discussion

This WBS level of research is based on the preparation of four WBS levels, with nine divisions/clusters of work, which refers to the specifications of Direktorat Jenderal Bina Marga and Badan Pengatur Jalan Tol (BPJT) as archive analysis data. Then benchmarking the 4-level WBS with BoQ (Bill of Quantity) from 27 roads and bridge projects, and making details of its activities and resources. Each level on the WBS diagram is defined as follows:

- Level 1 WBS Level 1 : Project Name.
- Level 2 WBS Level 2 : Work Division
- Level 3 WBS Level 3 : Type of Work
- Level 4 WBS Level 4 : Work Package.
- Level 5 WBS Level 5 : Activities
- Level 6 WBS Level 6 : Resources (Man, Material and Machine).

The result of standardization of WBS level to resource, WBS then developed by doing validation to expert. For this validation phase, a questionnaire tool is used to obtain appropriate suggestions, feedback and comments regarding the WBS standard of precast concrete bridge works. Experts who made the respondents amounted to five people, who have a background of WBS-based project planning knowledge, especially precast concrete bridge with a minimum of 15 years of work experience. The most dominant work on precast concrete bridge project is the erection girder construction method, then the determination and study of the chosen method is crucial. However, at the WBS level, the method of construction and selection of technology is unincluded in the level list. Due to the nature of the environment, the risks and the decisions of the associated companies, it is necessary to develop a WBS dictionary that details the method down to resources, updating changes in methods that have been affected by changes in resources as well. So in this paper, which will be discussed further is Division 7 (Structure works), as illustrated in Figure 1.



Figure 1.WBS levels of precast concrete bridge (Division 7).

After obtaining the final WBS standard of precast concrete bridge works, which is the result of the development with validation to the expert, the initial format of the WBS dictionary based on literature study and previous research was made. In developing the WBS dictionary, the 5th and 6th level of the WBS which are the activities and resources of the respective work package, were detailed more comprehensively. The 5th and 6th level of WBS (the activity and resource levels) will depend on the construction methods that will be used for the work package.

The layout of the dictionary was based on Queensland Government's Department of Transport and Main Roads WBS dictionary standards [13]. Each work package of the precast concrete bridge were described in the form of this layout. The layout of the dictionary was based on Queensland Government's Department of Transport and Main Roads WBS dictionary standards [13]. Each work package of the precast concrete bridge were described in the form of this layout. The contents of the WBS dictionary are:

- Breakdown on level 1 – 4 WBS work element
- Level on each work
- Work code
- Person in charge
- Activities of the work package
- Resources of each activity
- Work package description
- Deliverables of the work package
- Reference

After developing the WBS dictionary, the validation process was conducted. The first is the validation of the format itself, according to suggestions and input from experts, what kind of format that allows users to a WBS Dictionary. Then Validation stage 2, is the final validation of the format, content, and application of the WBS Dictionary itself, then validated to 5 experts and 1 practitioner from the ongoing precast concrete bridge project with the help of a questionnaire as a tool to get advice, inputs and comments as an analysis material for the end result of the dictionary. Table 1 shows an example of WBS dictionary for the work package of precast girder installation / erection.

Table 1. Validated WBS dictionary for precast concrete – example

WBS DICTIONARY OF PRECAST CONCRETE BRIDGE			
DIVISION 7 / STRUCTURE			
UPPER STRUCTURE			
7	Work Family / Division	:	Structure
7.2	Sub of Work / Section	:	Upper Structure
7.2.8	Work Packages	:	Installation (Erection) with the method of launching gantry
	Person in Charges	:	
	Description	:	This work includes assembling the launcher and connecting it with the girder as a weight, and moving the launcher and girder to the planned span, positioning the launcher for erection, connecting the gear with the hanging end of the launcher and placing the girder.
	Deliverable	:	Launched girder
	Reference	:	Contract Document (BOQ) Expert Validation

Code	Activities	PIC	Resources			Cost
			Man	Material	Equipment	
7.2.8.1	Resources preparation		1. Worker	1. Link Set Steel Beam	1. Sling Wire Rope	
			2. Foreman	2. Bolt	2. Shackle Chain Block	
			3. Operator		3. Iron Grip	
			4. Surveyor		4. Jack Hydraulics	
7.2.8.2	Cantilever balance setting on placements		1. Worker	1. Steel Counter Wight	1. Sling Wire Rope	
			2. Foreman		2. Shackle Chain Block	
			3. Operator			
			4. Surveyor			

From the results, it was found that what had been defined in the WBS of the precast concrete bridge had been further described in the WBS dictionary, where every method options and its activities were explained, including its resources. This is beneficial for the project managers to monitor the progress of each construction work activities based on the construction methods that they have used. As an example from table 1, when the project used a launching gantry for erecting the girder of the precast concrete bridge, the WBS dictionary provided the detailed construction methods, person in charge, deliverable, references for the work, activities and their resources. These descriptions will not be the same as other optional methods for erecting girder, such as using the formwork method.

The final validation process was conducted in February – April 2018, in a precast concrete bridge project, constructed in Jakarta by Company X. The process validated the use and benefit of the WBS dictionary in the project. It was found that in this specific project, the company did not use any WBS dictionary. Hence, the proposed WBS dictionary was found to be advantageous for the company, particularly its field construction team. They viewed that the WBS dictionary can be the guideline to be used during the construction works and as the monitoring document during the process. Furthermore, the respondent from Company X

suggested that the WBS dictionary's content can be described in more details in terms of integrating the resources description per activity for the project's schedule, cost, and quality plan.

5. Conclusion

To conclude, this study developed a WBS Dictionary precast concrete bridge, which is a derivative of standard WBS that has gone through analysis and expert validation phase. The WBS dictionary for precast concrete bridge is made to specify the less obvious or unspecified parts of the standard WBS, such as construction method, activity, and resources. Also, it can be used as the guideline in managing the project.

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