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## Development of Standardized Work Breakdown Structure (WBS) Based on Risk for Cost Estimate at Dam Project

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# Development of Standardized Work Breakdown Structure (WBS) Based on Risk for Cost Estimate at Dam Project

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**Abstract.** Dam construction project especially earthfill dam can be successful if the scope of works is defined in accordance with the requirement. Work Breakdown Structure (WBS) divides tasks into smaller items which makes them easier to be controlled. WBS standardization has critical impact on the cost of project. The purpose of this research is to develop WBS of dam construction project. The methodology used to develop the WBS of dam is based on the regulation and guidelines related to the implementation of dam construction such as The General Specification of Earthfill Dam, Ministry of Public Works and Public Housing Indonesia (2004) and bill of quantity from earthfill dam projects in Indonesia. The research is conducted by making a questionnaire survey for dam project contractors. The output of this study is WBS standard which comprises of 6 levels by analyzing dominant risk variables that may affect project cost control and WBS standard development with risk responses recommendation. As a result, this research will propose a risk-based WBS standard for earthfill dam projects that can improve the cost estimate of the project.

## 1. Introduction

In construction work, whether small or large, may bring risks in every work activity, especially dam construction. Risk is defined as an uncertain event or condition that has a positive or negative effect on at least one project goal, such as time, cost, or quality [5]. In Indonesia, there are many phenomena related to dam construction. One of them is the project of Tugu Dam in Trenggalek. The budget of this project swelled to more than 100%, from Rp 619 billion to Rp 1200 billion, due to increased work volume, design changes, and some changes in the field. Some of these changes are caused by work that is not in accordance with the field as the consequence of its less precise in making Work Breakdown Structure (WBS).

From the phenomenon it can be seen that cost estimating is very important in an infrastructure project, especially dam project. One approach to cost estimation that is considered a good enough solution is WBS [7]. Using WBS can prove an important role in a project management planning process by dividing the project into phases, deliverables and work packages. It will have a positive impact on other project management processes, such as activity definition, project schedule, risk analysis and response, project organizational control tool [1].

Cost estimates are particularly useful in designing the early stages of a construction project if one can estimate project construction at an early stage of the project [3]. However, there are still mistakes in cost estimation at the planning stage of actual construction costs that are caused less accurately in the making



of WBS. Based on the above findings, it is necessary to develop WBS standardization on dam work based on risk for cost estimation.

## 2. Research Objectives

The objectives of this research are :

1. To create WBS standards for dam construction (RO1)
2. To identify the working method for each dam construction work package (RO2)
3. To identify the activities of each dam construction work package (RO3)
4. To identify the resources based on activities identified in dam construction (RO4)
5. To identify the risk from activities and resource that affect the cost performance of dam construction work (RO5)
6. To develop of risk based WBS standards for cost estimation on dam construction work (RO6)

## 3. Literature Review

### 3.1. Work Breakdown Structure (WBS)

The WBS is the decomposition of the entire scope of work to be undertaken by a team that will work on a project that aims to achieve the objectives of a project and produce a product that is required [6]. The function of the WBS is one of them to be able to control the project, by splitting the phase into stages or tasks, which can eventually be further broken down into subtasks or work packets until an acceptable control structure has been achieved [4]. Initial input for the development WBS of dam is done by reviewing the regulation in the form of guidelines related to the implementation of dam construction such as The General Specification of Earthfill Dam, Ministry of Public Works and Public Housing Indonesia (2004).

In this guideline the implementation of dam construction is arranged into 10 (ten) divisions, namely as follows:

- Field Preparation Work
- River Diversion Work
- Excavation and Foundation Improvement Work
- Land and Rock Material Retrieval Work
- Main Dam Embankment Work
- Instrumentation System Work
- Complementary Building Work
- Hydromechanical and Electrical Works
- First Filling Reservoir Works
- Environmental Management and Monitoring Work

### 3.2. Risk Management

The definition of risk is the potential that will occur which will have a negative impact on a situation / event / event against the business target. In risk management can be used to measure and identify all risks so that in the project can be made the right decision-making in risk management [7]. Managing risks is an integral part of good management and fundamental of achieving good business and effective procurement of goods and services. The benefits of risk management are to minimize the risks of not achieving the objectives and take advantage of opportunities; facilitate better business; provide insight, knowledge and confidence for better decision making; increase certainty; and reduce overall risk exposure [5]. Risk management steps:

- Identification: Identify source of risk.
- Assessment: Assess risks in terms of severity of impact and likelihood of occurrence.
- Mitigation: Develop a strategy to reduce possible damage and develop contingency plans.
- Analysis: Implement risk strategy monitor and adjust plan for new risks.
- Updating: Change management.

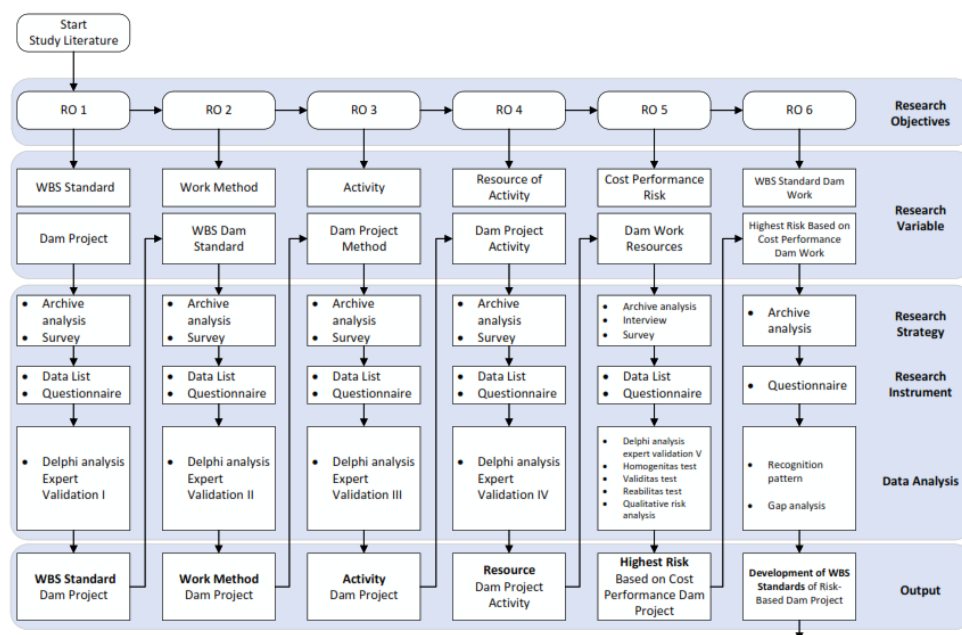
### 3.3. Performance Concept of Cost Estimation

The level of detail required to address direct costs is dependent on the project design phase and the magnitude or impact of a particular item in the Work Breakdown Structure (WBS) on the overall project cost. Generally speaking, the cost estimator should spend the most amount of time developing detailed cost estimates for those items in the WBS that have the most impact on the overall project cost [8]. As a practical matter, many contractors break their costs down into four distinct cost types:

- Labor
- Equipment
- Materials
- Subcontracts

## 4. Methodology

This research was conducted with a qualitative descriptive approach. The qualitative method with descriptive design, is a research that gives a careful description of the phenomena experienced by research subjects by means of descriptions in the form of words and languages that utilize various natural methods. Based on the existing stages, the research stages are as follows in Figure 1. In Figure 1, shown the flow diagram of methodology.



**Figure 1.** Flowchart of Research.

Identify any potentially hazardous risks in dam construction obtained from literature studies. Variety of variables Risks that were initially collected based on existing literature were then validated by experts to become an appropriate risk event and had occurred in the dam project. Then the risk that has been validated is distributed to respondents - respondents selected by questionnaires that produce a dominant risk that often occurs in the project. Once the probability and impact are determined, the risk score can be calculated by following:

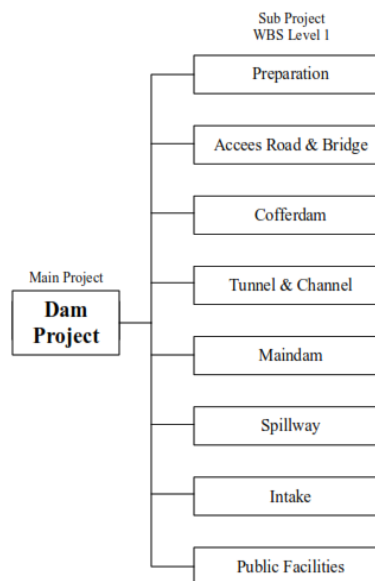
$$R = P \times I \quad (1)$$

Where R = Risk Factor, P = Probability and I = Impact

## 5. Result & Discussion

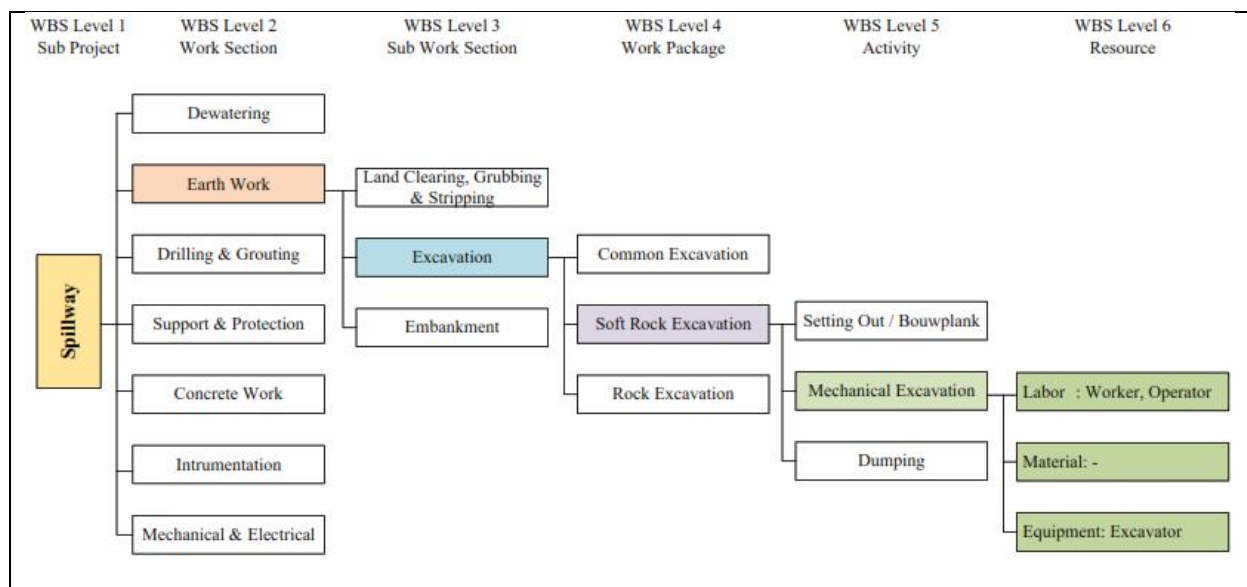
### 5.1. Standarization WBS of Port Project (RQ 1 - RQ 4)

Based on literature review on the regulation and guidelines related to the implementation of dam construction such as The General Specification of Earthfill Dam, Ministry of Public Works and Public Housing Indonesia (2004) and 13 (thirteen) previous earthfill dam projects data in Indonesia are categorized into 8 (eight) works consist of preparation, access road & bridge, cofferdam, tunnel & channel, maindam, spillway, intake, and public facilities. In Figure 2 is shown division of the dam project.



**Figure 2.** Diagram Tree of Dam Project.

WBS is divided into the smallest part, starting from the main project to the resource. Main project is a dam project, and the sub-project of the dam project becomes a Level 1 WBS to Level 6 WBS which is a resource



**Figure 3.** WBS for Spillway's Construction at Dam Project.

As shown in the picture with WBS Level 1 the name of the project / sub-project is spillway. WBS Level 2 work section from spillway work consisting of dewatering, earth work, drilling & grouting, support & protection, concrete work, instrumentation, and mechanical & electrical. WBS Level 3 sub work section of earth work consists of land clearing, grubbing & stripping, excavation, and embankment. WBS Level 4 work packages from excavation are common excavation, soft rock excavation, and rock excavation. WBS Level 5 activity from soft rock excavation consists of setting out / bouwplank, mechanical excavation and dumping. WBS Level 6 consists of resources consists of labor, materials, and tools.

### 5.2. Development of WBS Standard for Cost Estimating Based Risk (RQ 5 and RQ 6)

Based on expert responses, it can be concluded that there are 7 dominant risks that affect the performance of the costs of dam construction work

RISK VARIABLE		SCORE	RANK	LEVEL
X2	Changes in the scope of work (less work added)	0.334	1	High
X1	Insufficient geological and geotechnical information and data	0.287	2	High
X37	High intensity rainy weather	0.280	3	High
X3	Added volume of work package from owner	0.270	4	High
X4	The volume of work package realization is over than estimated	0.234	5	High
X5	The price of work packages is higher than estimated	0.184	6	High

**Figure 4.** Dominant Risk Variables on Quality Performance at Dam Project.

Preventive and corrective actions obtained from experts are risk responses that are recommendations for developing WBS standards and can be grouped into:

1. Addition to managerial item
2. Addition to another WBS
3. Addition to related WBS
4. Addition to activity requirement
5. Affecting WBS coefficient

NO	WBS	RISK RESPONSE	CATEGORY					RECOMMENDATION
			1	2	3	4	5	
X1 Insufficient geological and geotechnical information and data								
1	Drilling and Grouting Spillway Work Section	Work Package: Conducting a field survey in detail and accompanied by experts		●				Add detailed geological and geotechnical conditions survey work package at Preparation Work

**Figure 5.** Risk Response for Spillway Works

\* ■ : Development

WBS L. 3	WBS L. 4	Alt. Method/ Design	WBS L. 5 Activity	WBS L. 6 Resources	Requirement
Review and Adjustment of Design for Field Conditions	Investigation of geological and geotechnical		The Geological Engineering and Mechanics Survey includes: Seismic Surveying, Drilling, etc.	Specialist : Geological and Geotechnical Engineer	* certified geological and geotechnical engineer

**Figure 6.** Risk-Based WBS Standar for Preparation Work at Dam Project

## 6. Conclusion

Based on the results of the research in the creation of risk-based WBS standards, the WBS of dam project is divided into 8 divisions namely preparation, access road & bridge, cofferdam, tunnel & channel, maindam, spillway, intake, and public facilities. Each division consists of 6 WBS levels, namely Level 1: project name / sub project, Level 2: work section, Level 3: sub work section, Level 4: work package, Level 5: activity, and Level 6: resource. The WBS standard is based on The General Specification of Earthfill Dam, Ministry of Public Works and Public Housing Indonesia (2004) and bill of quantity from earthfill dam projects in Indonesia.

Risk-based WBS standards can be used to estimate costs, to help dam projects stakeholders identify project work to the smallest items and set cost objective for each item in greater accuracy. However, to improve the results of the Risk-based WBS standards, it is necessary to research about the WBS dictionary and the WBS checklist. Cost performance of the research can be measured if it has been completed by the WBS dictionary and the WBS checklist.

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