Development of dictionary and checklist based on Work Breakdown Structure (WBS) at seaport project construction for cost estimation planning

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Abstract. A construction project consists of many activities. To be more easily managed, activities are divided into smaller called work packages. The elements of construction project work are relatively similar, and these can be standardized and used as a basis for a universal program for construction project. The WBS standards can be developed into a dictionary and checklist that will help the project planning process and is expected to minimize the occurrence of cost management errors on the project. The purpose of this research is to develop a dictionary and checklist standard based on Work Breakdown Structure (WBS) for planning cost estimates for seaport project construction, identifying sources that can potentially have an impact on a project's cost overrun. This research method uses a survey method to seaport expert's validation and interviews using questionnaires to find the WBS-based dictionary and checklist standards. This research is expected to be a standard reference dictionary and checklist based on Work Breakdown Structure (WBS) at seaport construction projects for cost estimation planning. The importance of this research to knowledge is to know the steps of construction work especially at seaport project and to know WBS dictionary and checklist as a format that can be used as a reference base and easy-to-understand guide for seaport project, which provide work methods, activities, and resources.

1. Introduction

The port is a sea transportation building facility which has an important role in supporting economic activities. Knowing the important role of the port, making the port needs to have a development plan to keep up with the times, the port development plan is realized with well-planned planning before project implementation. Therefore, Work Breakdown Structure (WBS) is needed to determine the work packages, activities, and project resources [1].

WBS is one of the main tools for planning, monitoring, and controlling the work package of a project. WBS is the process of dividing work into smaller parts and making it easy to effectively describe the scope of the project. The aim is to improve project estimates, to better control project implementation and to verify project completion more accurately [2].

In implementing the port project, various problems have been found that will have a negative impact on the project target. Many factors cause problems in port projects, one of them is the cost estimation problem. There are several phenomena related to the problem of cost estimation in port projects due to
inaccuracies when planning WBS. One of them is the case of the Tanah Ampo Cruise Port project, which was carried out in 2007 to 2012. According to Balitribune (2017), Tanah Ampo Cruise Port has cost up to Rp 86 billion, but at this time it cannot be used because the length of the pier is still not appropriate and the current waves that cause the yacht cannot lean on pier. To overcome this problem, a budget of Rp 50 billion is allocated from the state budget for water break construction so that yachts can pier at this port by lowering anchors at sea, then being picked up by lifeboats to get to the port.

Inaccurate cost estimates can have a negative impact on the entire construction process and all parties involved. Cost overruns that occur at the project implementation stage are very dependent on planning. The causes of problems arising from estimated port project costs are generally caused by several factors such as unclear identification of all the resources needed in project activities, including material, manpower, and equipment. Furthermore, another cause is the complexity of the design and size of the project [3]. These causes must be considered to minimize the risks that arise in the project cost estimation process.

For this reason, a standard or framework for port construction projects planning is needed to assist in the preparation of accurate and detailed WBS, where it also needs the description and requirements of each element of work in the form of WBS dictionary. The WBS dictionary is a work definition tool by explaining the scope of each work element, so that all resources needed in project activities can be identified. The WBS dictionary is expected to be a dynamic tool for terms of reference that can manage the agreed project scope and review estimated costs for each activity.

Besides WBS Dictionary, Checklist is also needed. The checklist is a more detailed work breakdown that covers all work activities of a project. With the identification of risks that arise in each activity in the grouped structure work is expected to be well registered and produce a cost estimation plan that can be used as input for contractors.

This background becomes the author's foundation for conducting research on the topic "Development of Dictionary and Checklist based on Work Breakdown Structure (WBS) in Seaport Project Construction for Cost Estimation Planning". The purpose of this research is to develop a dictionary and checklist standard based on Work Breakdown Structure (WBS) for planning cost estimates for seaport project construction, identifying sources that can potentially have an impact on a project's cost overrun.

2. Literature review

2.1. Seaport

According to Government Regulation No.69 of 2001 Article 1 paragraph 1 concerning Ports, a port is a place that consists of land and waters around it with a certain limit as a place of government activity and economic activity used as a place for ships for lean, passenger up and down to load and reduce objects with safety facilities and intra and inter modes of transportation. The port has the following functions:

1. Interface, the port as a meeting place for two modes of land and sea transportation so that the port must be able to provide various facilities and services needed.
2. Link, the port is a connecting transportation system, so the port is very important for all transportation activities.
3. Gateway, the port functions as a gateway for a country or region, so that it can play an important role for the economy of a country or region.
4. Industrial entities, ports as export-oriented industrial development of a country or region.

2.2. Work breakdown structure

According to the (Project Management Institute, 2006), WBS is a practical tool that can help the project planning team overcome large project uncertainties by making the project a lower level of uncertainty [4]. The function of WBS itself is as follows:

1. To determine project targets into small components so that they are easily managed.
2. To provide project management and progress frameworks for project status.
3. To facilitate communication between project managers and stakeholders about the life of a project.
4. As input for other project management processes.

The best method for preparing WBS is to use a hierarchical decomposition technique for the entire scope planned according to the project goals.

![Decomposition Technique Diagram](image_url)

**Figure 1.** Decomposition technique

The decomposition technique, as shown in figure 1, is a technique that is used to divide the project scope and deliverables into smaller, and easier to manage. The results of the decomposition of each level in WBS are described as follows, and illustrated in figure 2:

1. Level 1: the full scope of work needed to produce the overall product. The top level is represented by a different project name for each WBS.
2. Level 2: the first level of decomposition and as the main field in the scope of work called division.
3. Level 3: describes each of the main areas of level 2 into sections consisting of various sub of work.
4. Level 4: every work in level 3 will be further broken down into a work package and checks are always made on the components formed whether they meet the requirements as a work package, one of which is considered to be sufficient to be managed or planned in terms of cost and time.
5. Level 5: activities that explain the details of each work package
6. Level 6: resources, such as items needed in work package. Resources here are in the form of materials, manpower and equipment.

The 5th and 6th levels will be explained in detail in a format called the WBS Dictionary. The WBS dictionary is a supporting document for the WBS that provides data in the form of detailed deliverables, activities, and resources information for each component in WBS.
2.3. **WBS dictionary**

Based on (Project Management Institute, 2013), the WBS Dictionary is a document that provides data detailed deliverables, work activities, and resources information about each component in Work Breakdown Structure [5]. The WBS dictionary helps identify and explain each work package (the lowest level) available on WBS. Work packages at WBS are represented as names and are not detailed. However, project stakeholders need to communicate in the project with sufficient and complete information about each deliverable. Such information can be found in the WBS dictionary and will improve the communication process between project stakeholders.

The WBS dictionary format varies depending on project needs. Some of the information contained in the contents of the WBS Dictionary is about identification codes, job descriptions, assumptions and limits, responsible organizations, activity schedules, required resources, estimated costs, quality requirements, acceptance criteria, technical references, approval information and still many more are not limited to the ones mentioned before.

2.4. **WBS checklist**

WBS Checklist is a more detailed job breakdown that covers all work activities of a project. Checklists are useful for the project team to achieve the desired level of work detail following from WBS. Checklists can be developed and used in the project management process such as a list of work to be done in the project, documents needed in the procurement process, project meeting agenda, identification of risks to the project, resume of project problems and status of completion and quality that is not according to the works. The development of the checklist depends on each project. But in principle, the checklist will help complete the work related to WBS [5].

2.5. **Cost estimation**

The cost estimation process (Project Management Institute, 2017), based on the figure 3, consists of inputs, which are:

1. The project management plan, which consists of a cost management plan, a quality management plan, and a basic scope
2. Project documents, which consist of lessons learned about project information, project schedule, resource requirements and risk list
3. Company or organization, which consists of corporate environmental factors and organizational process assets. [2]

While the output of the process is cost estimation, basics of estimation and updated project documents.
3. Methodology
The development of dictionary and checklist based on Work Breakdown Structure (WBS) at Seaport project construction use qualitative and descriptive approach, where each identified components are compiled and synthesized using the validated format for WBS dictionary and checklist, with the following data sources and sampling:

1. The validated WBS standards of seaport projects construction are used to form the initial format and content of the WBS-based dictionary and checklist, based on archive analysis.
2. WBS-based dictionary and checklist is made using primary data obtained from questionnaires and also interviews with experts in seaports with a minimum experience of 20 years. The analysis used for this research is descriptive statistical using a mode or value which often arises from respondents' answers on questionnaires related to the WBS-based dictionary and checklist.
3. In addition to primary data, there is also secondary data used in the form of project document files of Project BOQ and RAB data and analysis of literature studies according to Minister of Transportation Regulations Number PM 51 of 2015 concerning Seaport Operations.

4. Result and discussion
Figure 4 shows the four levels of WBS that have been validated for seaport construction projects, from this data finally developed into a WBS dictionary that containing the various activities and resources required for each work package described in details at level 5 and 6 of the WBS. This phase begins with the analysis from archive and related data literature on the WBS dictionary as a reference for determining its format. The WBS dictionary format also includes details of additional important information that is needed in a construction project such as person in charge, description, deliverables, and references for each different work package. These components will relate to WBS, but with more specific content. This is useful to guide project planning. These components can be seen in figure 5.
The 1st Level of WBS
Project Name

The 2nd Level of WBS
Division

The 3rd Level of WBS
Sub of Work

The 4th Level of WBS
Work Package

| Project Name | Division | Sub of Work | Work Package |
|--------------|----------|-------------|--------------|
| Pier         | Lower Structure | Pile Cap | Other Work |
|              | Upper Structure | Slab     |              |
| Mooring Dolphin | Lower Structure | Pile Foundation | Fender/Stepper Block |
| Breasting Dolphin | Lower Structure | Pile Foundation | Bollard |
| Catwalk      | Lower Structure | Pile Cap | Cansteen |
|              | Upper Structure | Slab     |              |
|              |                 | Beam     |              |
|              |                 | Drainage |              |
| Other Work   | Accessories     | Railing  |              |
|              | Drainage        | Gutter and Drains |              |

**Figure 4.** Validated work breakdown structure
DICTIONARY BASED ON WBS AT SEA PORT PROJECT CONSTRUCTION FOR COST ESTIMATION PLANNING

Pile Foundation

| Code   | Activity            | Resources                  |
|--------|---------------------|----------------------------|
|        |                     | Manpower | Material | Equipment                          |
| B.3.1.1 | Material procurement |           | 1. Precast concrete piles |                                   |
| B.3.1.2 | Pile erection       | 1. Workers 2. Foreman | 1. Precast concrete piles | 1. Jack in pile 2. Drop hammer 3. Diesel hammer 4. Hydraulic hammer 5. Vibratory pile driver 6. Crane |
| B.3.1.3 | Joining piles       | 1. Workers 2. Foreman | 1. Precast concrete piles | 1. Welding tools                   |

Figure 5. Dictionary based on WBS

To avoid ambiguities that can occur in the project and clarify descriptions in project activities, checklist based on WBS was also developed. The checklist validation produces a format that consists of breaking down each level of WBS, starting from the name of the project, division, sub of work, to the work package, as shown in figure 6. This is used to adjust WBS by including inspection guidelines that refer to details at each level of WBS and used to provide clarity and understanding as a reference for planning [6]. Then the checklist is also still equipped with a WBS code, this WBS code will function to find out the sequence of activities.
CHECKLIST BASED ON WBS AT SEA PORT PROJECT CONSTRUCTION FOR COST ESTIMATION PLANNING

PIER

| WBS LEVEL | CODE | DESCRIPTION |
|-----------|------|-------------|
| 1         | B    | Pier        | Name of sub-project being worked on. |
| 2         | B.3  | Mooring Dolphin | Mooring dolphin is planned to be able to stand up to the horizontal force caused by the impact of the ship, wind gusts, currents that hit the ship when moored. |
| 3         | B.3.1| Lower Structure | Lower structure is the work of foundations and building structures that are below the surface of the land. |
| 4         | B.3.1.1| Pile Foundation | Pile foundation are the part of the structure used to carry and transfer the load of the structure to the bearing ground located at some depth below ground surface. |
| 4         | B.3.1.2| Pile Cap | Pile cap is a structural member placed on, and usually fastened to, the top of a pile and used to transmit loads into the pile or group of pile, to connect them into a bent. |

Figure 6. Checklist based on WBS

After validation of WBS, dictionary and checklist based on WBS, it can be related to the dictionary and checklist based on WBS with cost estimation planning. In planning project cost, project documents in such as resource requirements and risk registers are used as input to plan costs, because all risks that arise will ultimately affect the cost estimation planning, as shown in figure 7 and figure 8. The risk cost calculation is then performed (H. W. Kang and Y. S. Kim, 2018). The total rate is the direct ratio of risk costs to the total value of the work, which is summed from RC.E (Risk Cost of Engineering), RC.P (Risk Cost of Procurement), RC.C. (Risk Cost of Engineering) [7].
Figure 7. Model risk cost new project

So that for each risk arising from WBS, the WBS dictionary and checklist that has been made can be identified and known for the actual cost of each risk making it easier to estimate project costs.

| Item | Risk Factors | RC E | RC P | RC C | Total |
|------|--------------|------|------|------|-------|
| RF-01 | Error in basic design | 20326 | 10.5% | 444571 | 4.2% | 347718 | 4.7% | 812814 | 4.5% |
| RF-02 | Error in detail design | 27185 | 13.8% | 747895 | 7.2% | 423631 | 5.7% | 1178719 | 6.7% |
| RF-03 | Error in mechanical design | 16747 | 8.5% | 717309 | 6.7% | 206642 | 4.0% | 1030597 | 5.7% |
| RF-04 | Change in construction method | 22831 | 11.0% | 841822 | 7.9% | 474092 | 6.4% | 1338727 | 7.3% |
| RF-05 | Variation in bill of quantity | 32436 | 16.5% | 986519 | 9.4% | 546534 | 7.4% | 1275238 | 6.6% |
| RF-06 | Delay in procurement schedule | - | - | 251317 | 2.2% | 292013 | 3.1% | 465518 | 2.6% |
| RF-07 | Error in fabrication | - | - | 329957 | 3.1% | 182472 | 2.5% | 599029 | 2.8% |
| RF-08 | Error in PID design | 7853 | 4.0% | 313624 | 2.9% | 147019 | 2.0% | 468497 | 2.6% |
| RF-09 | Lack of local manpower | - | - | 442566 | 4.2% | 369951 | 5.0% | 818486 | 4.5% |
| RF-10 | Strike by workers | - | - | - | - | 143734 | 1.9% | 143734 | 0.8% |
| RF-11 | Error in connection (pipe to pipe) | 8422 | 4.3% | 833277 | 5.5% | 553597 | 7.3% | 1172996 | 6.2% |
| RF-12 | Contract change in subcontractor | 18852 | 9.0% | 1008201 | 9.5% | 776836 | 10.5% | 1803889 | 9.9% |
| RF-13 | Delay in construction | - | - | - | - | 363421 | 4.9% | 363421 | 2.0% |
| RF-14 | Change of design (contractor) | 27002 | 14.2% | 779211 | 7.3% | 478783 | 6.5% | 1285886 | 7.1% |
| RF-15 | Construction accident | - | - | - | - | 203903 | 2.8% | 203903 | 1.1% |
| RF-16 | Lack of local material | - | - | 247343 | 2.3% | 133799 | 1.8% | 381142 | 2.1% |
| RF-17 | Variation in material cost | - | - | 515739 | 4.8% | 318674 | 4.3% | 843053 | 4.6% |
| RF-18 | Lack of temporary facilities | - | - | 162547 | 1.0% | 97996 | 1.3% | 200152 | 1.1% |
| RF-19 | Transportation environment | - | - | 444571 | 4.2% | 220729 | 3.0% | 665299 | 3.7% |
| RF-20 | Transportation equipment | - | - | 335657 | 3.3% | 131996 | 1.8% | 487653 | 2.7% |
| RF-21 | Constructional defect | - | - | 384305 | 2.9% | 384372 | 5.2% | 768677 | 3.8% |
| RF-22 | Lack of local manpower | - | - | 346498 | 4.3% | 256382 | 3.5% | 736569 | 4.0% |
| RF-23 | Error in equipment manufacturing | - | - | 346305 | 7.1% | 320477 | 4.3% | 1,081,200 | 5.9% |
| Sum | 196366 | 100% | 10,644,059 | 100% | 7,384,217 | 100% | 10,224,642 | 100% |

Table 15. Model B Totaal Risk Cost of a New Project (Unit: 1,000 KRW)

Figure 8. Actual cost calculation

Moreover, in this study, there are specific works that has been identified and compiled structurally in the WBS dictionary and checklist. In the port construction project, there are special works that characterize the port project differently from other construction projects, which are in preparatory work namely bathymetry surveys and pier construction work, namely dolphin breasting work and dolphin mooring. The layout of these works can be seen in figure 9.

Figure 9. Breasting dolphin and mooring dolphin
Dolphin is a construction used to tether a ship to use a pier to shorten the length of the building. This mooring is planned to be able to withstand the horizontal force caused by the impact of the ship, the blowing of the wind, the current that hits the ship when it is moored.

Breasting dolphin has a larger size, because it is planned to withstand the waves and wind shocks when the ship is anchored, breasting dolphins are also equipped with fenders to withstand boat impacts and boilers to place the ship's rope, in order to move the ship along the pier and withstand the pull of the ship. Mooring dolphin is not used to withstand collisions, but only as a fastening.

5. Conclusion
The Work Breakdown Structure (WBS) dictionary is developed after WBS is created and validated according to WBS standard. The WBS dictionary is more specific than WBS because it explains the person in charge, description, deliverables, and references for each different work package. The difference between the WBS dictionary and checklist is on the content. The contents of the WBS dictionary contain information about the work in detail for each work package, which contains activities from the work package to the resources needed (material, manpower, and equipment). While the contents of the checklist contain a list of descriptions starting from the name of the construction project to the work package on the construction project to reduce the ambiguity that can occur in the project.

The result of the validated dictionary and checklist based on WBS is a format that can be used as a reference and guide for managing seaport construction project, to provide information about work methods, activities, and resources. Also, the detailed contents from the WBS dictionary and checklist can become essential documents for identifying risks in estimating the seaport construction costs. The details in the WBS dictionary and checklist also highlights the specializations of the seaport work packages, which differs from other type of construction projects.

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