Model Work Breakdown Structure of BIM-Based Concrete Bridges with Revit and Python

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Abstract. Building Information Modelling (BIM) is a digital representation and collaborative process among stakeholders working together in the design, construction and operation phases of a building project. Data and information in BIM are used to enhance of communication and coordination between stakeholders so that decision making can be carried out properly. Basic data that is much needed for the project management process is data on the type of work in the form of a Work Breakdown Structure (WBS). WBS data can be used for various activities in the project life cycle, for example for scheduling, making cost plans, planning construction methods to safety activities. The purpose of this study is to determine the model of a Work Breakdown Structure (WBS) database using Revit's 3D Building Information Modelling (BIM) and MySQL with the Python programming language. The tools used in this research are Revit 2023 software, API Revit, Python and MySQL software. Buildings are modelled using Revit software, Revit API is used to bridge data collection and Python is used to organize data extraction from building models into sheet form. Extraction data is stored in MySql database. The research results applied to concrete bridges showed that data extraction from the bridge model with Autodesk Revit obtained data on the type of elements of the bridge. Data extraction was carried out using the Autodesk Revit and Python API facilities, the data elements were then processed and supplemented to produce a WBS model. WBS data is stored in a MySQL database that can be used for later stages, such as for schedules or safety.

1. Introduction

The application of Building Information Modelling (BIM) in the Indonesian construction sector has been regulated by the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia [1], which regulates the use of the building information modelling method in road technical planning, construction and maintenance, and bridges under the Directorate General of Highways. Therefore, the importance of applying Building Information Modelling (BIM) in construction projects in Indonesia is very significant. Then, Building Information Modelling (BIM) in the construction industry will become more accessible to all parties involved. With the program for Database Building Information Modelling (BIM), Access and efficiency in the construction industry will increase in the future.

Building Information Modelling (BIM) is performed using the Autodesk Revit application, which includes creating a 3D model and translating it into a Work Breakdown Structure (WBS). Work Breakdown Structure (WBS) is a project basis that defines tasks according to project objectives and determines the task structure until completion. The WBS becomes a basic project management tool

that describes the steps towards creating schedules, cost estimates, reports, measuring progress, and controlling execution [2], [3].

Building Information Modelling (BIM) of concrete bridges can only output structural work in concrete and steelwork. Work Breakdown Structure (WBS) concrete bridges generally include preparatory, substructure, and superstructure work. In the example, the prep work is not listed in the output, which is in Autodesk Revit. In pile cap work, there is a Work Breakdown Structure (WBS), namely formwork, reinforcement, and concrete work. Not all jobs are listed, so specifying them using a Work Breakdown Structure (WBS) is necessary. Refinement of the data will be carried out in this study by creating a database Work Breakdown Structure (WBS). Work Breakdown Structure (WBS) will look for various aspects of construction work safety [2]. Database driver is software that gives Access to an application to connect to the Database [4]. The Python programming language requires these drivers to connect with Python API databases. The driver used in this research is MySQL Connector/Python for MySQL. MySQL has a server-based RDBMS, unlike SQLite, which we can use directly. One server can have more than one Database.

The choice of MySQL as the Database in this study was due to several factors. The main factor is the use of the Database MySQL Databases MySQL supports integration with the Python programming language and supports multiple users [5]. In addition, MySQL is also open source and has a free database management system. MySQL is a lightweight database and does not require a lot of RAM space [4], [6] The diversity of data that can be stored in the Database MySQL and the ease of use of the table structure are also supporting factors for choosing a database MySQL in this research. This research is doing database creation from Work Breakdown Structure (WBS) applied to Autodesk Revit concrete bridge with a span of 12 meters using Python and MySQL programming language software. Next, a database is created to provide data storage, control, and security in the Autodesk Revit BIM. So that it can be used by parties who have Access now and in the future. This can lighten the task of the BIM operator and save the time required for the user to retrieve data.

2. Theoretical basis

Building Information Modelling (BIM) is a technology concept based on 3D models that contains all data and in-formation about the actual object from the model [7]. This provides insight that BIM is not an application or software. BIM is a process of digitizing a project or construction work, starting from creating a 3D model (virtual building) and inputting all the building information to utilizing the model and information as a means of communication for all parties involved in the project [8], [9].

BIM technology changes the traditional construction process with its limitations, where conflicts and mis under-standings often occur between relevant stakeholders because the flow of information is unclear and not well recorded [8], [9]. Poor information synchronization will give rise to waste problems, which can be in the form of material waste, rework, unproductive job sites, over budget, and the potential for large delays [10]. The rework process due to planning asymmetries will be known during implementation because the traditional planning process cannot provide comprehensive information about plans regarding real conditions [9]. The consequences of rework will result in additional costs and implementation time [10].

BIM is a technology that can distribute information related to the project life cycle. X. Xu et al., (2014) created a BIM framework that divides project phases into three life-cycle phases, namely Design [D], Construction [C], and Operations, to manage construction information effectively during the project life cycle [O].

Building modelling with BIM at the planning stage can be used during planning, procurement, construction operation, and maintenance because, in BIM technology, much information can be used at each stage of the project cycle. This will increase the resources needed from the initial phase of the project cycle, namely the planning phase. In BIM technology, the planning work phase requires more complete planning than traditional planning [12]. The data and information attached to BIM technology can be utilized and analysed according to the purpose of each stage of a construction project [8], [9].

The number of Indonesian engineers proficient in BIM still needs to grow, and only a few construction projects are being carried out. BUMN and large private companies in DKI Jakarta have

utilized BIM as a communication medium in an effective stakeholder collaboration process. By using BIM as a communication tool, achieving the best understanding and achievement of design and integration of data, ideas, designs, and stakeholder perceptions will be easier.

Studied the application of BIM in the Indonesian construction industry from the user's perspective. Although still limited, BIM has been used by several construction projects in Indonesia. The different factors vary from one company to another, but the BIM adoption process can be bottom-up or top-down [13], [14]. Januar Pantiga and Anton Soekiman, (2021) apply the BIM process in construction. Although still limited, BIM is only used in the design and engineering phase for large projects but has begun to be applied to several construction projects. Among these difficulties are the varying levels of awareness and desire of construction actors to adopt BIM.

WBS (Work Breakdown Structure) Standard for Building Projects regarding the importance of WBS (Work Breakdown Structure) in every construction project. Control and implementation will be easier by determining the scope of tasks from the start of the project [2], [3].

3. Research method

This research used various methods of studying quantitative analysis literature, studies libraries, and experiments. Collected data consists of two types, namely quantitative data and literature data or studies library. Study quantitative based on philosophy positivism and use For observe population or sample certain. Data collection was carried out using instrument research, and data analysis was performed in a manner quantitative/statistical For test the hypothesis that has been set. To study this, the researcher used various tools, including a laptop or PC, Software Revit 2023, Software Python, and Software MySQL.

The study focuses on the project development of bridge concrete structural. To support the object study, data that has been available covers the picture plan, estimated budget cost, and scheduled work project. In addition, the research also involves practitioner BIM-related experience with the use of Open BIM software to understand convenience integration and collaboration between stakeholders.
Research Process. Process stages that can used in research, namely:

1. Study This involves literature with various reference-related writing research and a book guide or manual from the software Revit, Python, and MySQL.
2. Data was collected in the form of estimated plan budget cost For structural work, with combined method conventional and deep detailed engineering drawings (2D). We were planning structure.
3. In stages, they did data entry using Software Revit based on the data obtained from the project. The data con-sists of detailed engineering drawings (2D) and plans budget costs earned _ through method conventional.
4. Study This involves modelling structure using Software Revit with several different Approaches. _ Approach First is using an architectural template for add-in modelling based on detailed architectural engineering drawings (2D). After it is done, use Structural templates with Enter detailed Structural (2D) engineering drawings in 3D models. The resulting models will then be analysed To get quantity take-off and detect useful clashes detection in the calculation to estimate the final quantity take-off material for structural work.
5. In the making Work Breakdown Structure (WBS), Framework WBS or appearance structure whole from WBS For bridge concrete arranged based on some Bill of Quantities (BoQ). Every element in WBS is Then defined dictionary WBS (WBS dictionary) that contains information about duration, aspect technical, and Plan Required Work and Conditions (RKS).
6. Development Process: The preliminary stage by the researchers before creating a simulation program calculating house gas emissions glass is doing studies. References to book references, journals, and theses with a relevant topic.
7. Database Preparation requires some data, i.e., 3D BIM Database Program Revit Autodesk for construction bridge concrete. In the making application, This needed a database was used as a data source. Data-bases used MySQL Servers.
8. Database Design, i.e., stages database design, i.e. Database Planning (Database Planning), Definition System, Requirement Collection Analysis, Conceptual Database Design, Logical Database Design, Physical Database Design, and Implementation.

9. Display Program, namely Program Database Autodesk Revit BIM and Work Breakdown Structure (WBS), will served on the skills page, mainly consisting of some menus, i.e., identity projects and Database.

4. Results and discussion

The computer program developed in this paper is web-based which can be accessed by stakeholders from anywhere, making it easier for users to coordinate. A website-based application was created by combining a 3D building (bridge) model from Autodesk Revit and data extraction in the form of WBS. The data stored in the building model will be processed into image output and WBS. The WBS data is combined with work accident risk data resulting from respondents' assessments which in the future will be used for an early warning system for work safety. The extraction is processed using the Python programming language and stored in a Database Management System (DBMS)..

This research models a concrete bridge with a span of 12 meters using the Building Information Modelling (BIM) application. Among the popular BIM adopting software, one of them is Autodesk Revit software. Autodesk Revit software is a product of the United States company, Autodesk, Inc. Autodesk Revit software used is the academic version. This software is a BIM-based modelling tool, which enables effective modelling of construction projects. The bridge model used can be seen in Figure 1. In this research, Autodesk Revit was used to produce various types of data, such as 2D images, technical specifications, 3D images, take-off quantity calculations, clash detection, and other data.

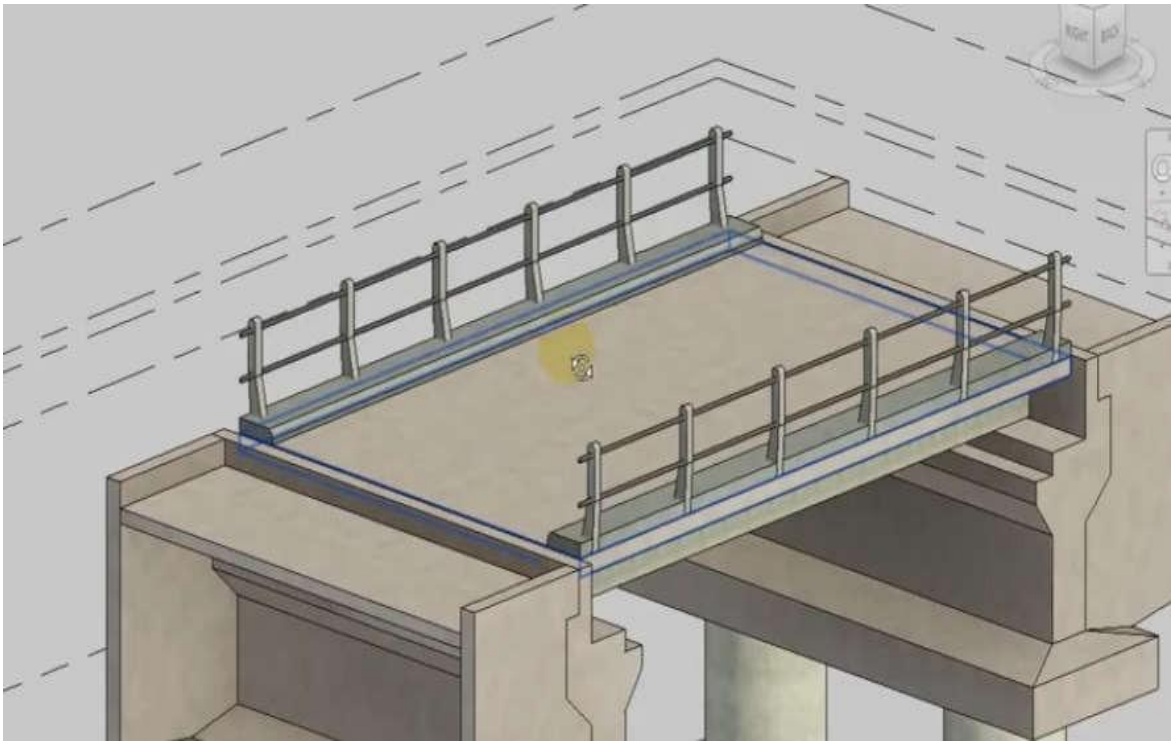

Figure 1 3D Modelling of Concrete Bridges

The Work Breakdown Structure (WBS) is arranged in levels based on the type of concrete bridge work. In this research, there are 4 levels of WBS planned. The WBS level refers to the General Specification document for roads and bridges in Indonesia [16], [17]. The WBS grouping is as follows:

1. WBS level 1: identify the name of the concrete bridge project,
2. WBS level 2: identify groupings of work divisions, then called project work families,
3. WBS level 3: identify groupings of work sections, then referred to as project work types,

4. WBS level 4: is the identification of work articles, which are then referred to as work packages.

Preparation of the Work Breakdown Structure (WBS) based on the bridge model created in Revit, the work components are identified from the model. The job component reading data is then grouped by job level in the form of a WBS. To complete and organize the WBS, elaboration was carried out with General Specification documents for roads and bridges in Indonesia [16] and General Specifications for Freeway Roads [17]. The identification results obtained 10 WBS (Work Breakdown Structure). An example of WBS decomposition of the drawing model and general specification documents for roads and bridges can be seen in Figure 2:

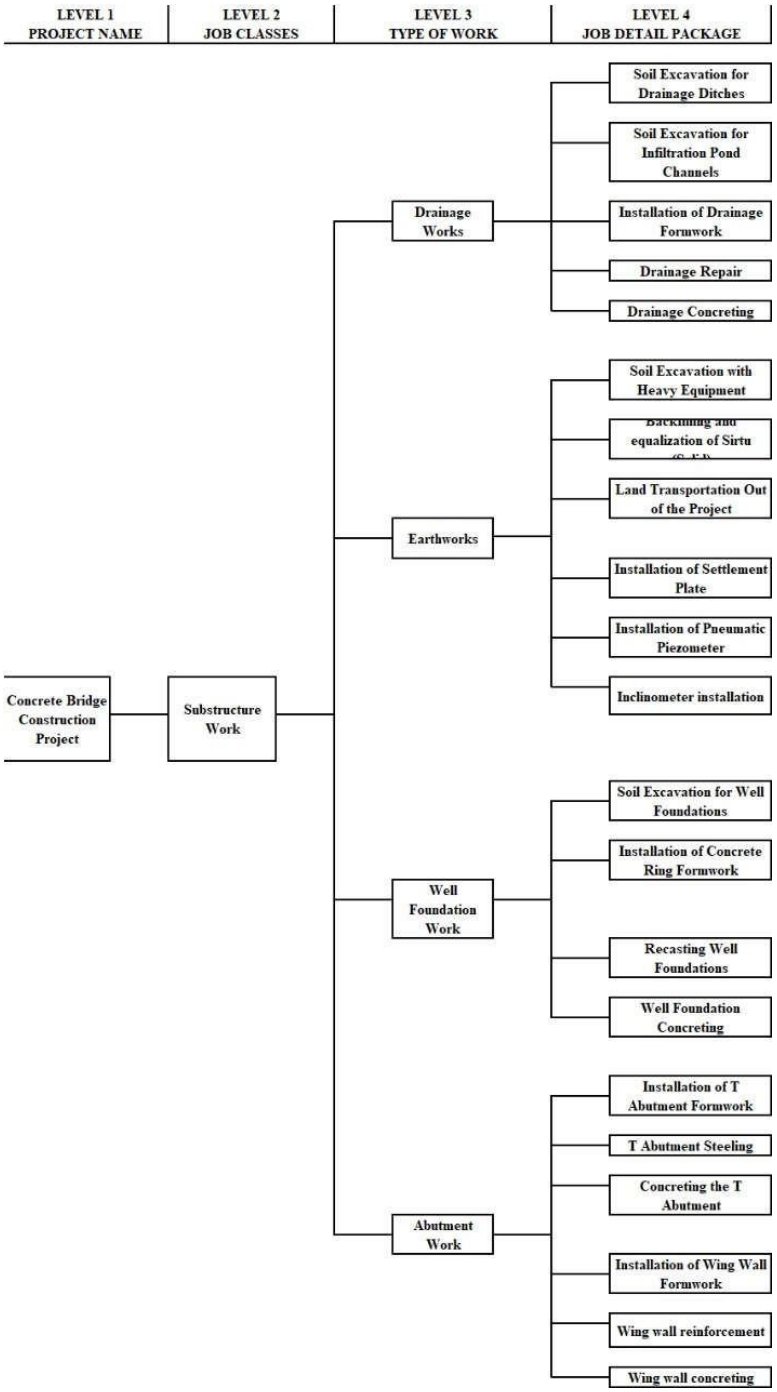

Figure 2 Work Breakdown Structure (WBS) chart Construction Concrete Bridge on Sub-Structure Work

The database is designed to store Work Breakdown Structure (WBS) data that has been identified from bridge model data acquisition. WBS data is identified for its data type and function, followed by creating a database table consisting of fields for the type of data used. Data base tables are created to make it easier to manage data, these tables are interconnected with each other so that if there are changes to the data in the table, the related data in the other tables will be updated. Data connectivity between tables is called a relationship. The database table used can be seen in Table 1, this table contains data related to WBS. The relational table model can be seen in Figure 3. The division of tables and relational data makes it easier to manage data both during input and data processing.

Table 1 Identification need for Table Work Breakdown Structure (WBS)

Name	Data Type	Description
id	int	id from WBS
Id_Section _	Varchar	Section Id from selected project _
name	Varchar	WBS name
Levels	Varchar	Description of the level of WBS
Code_ WBS	Varchar	Information code from WBS
Parent_ WBS	Varchar	Information parent For WBS
Create d_at	datetime	Information time when make or edit _ WBS

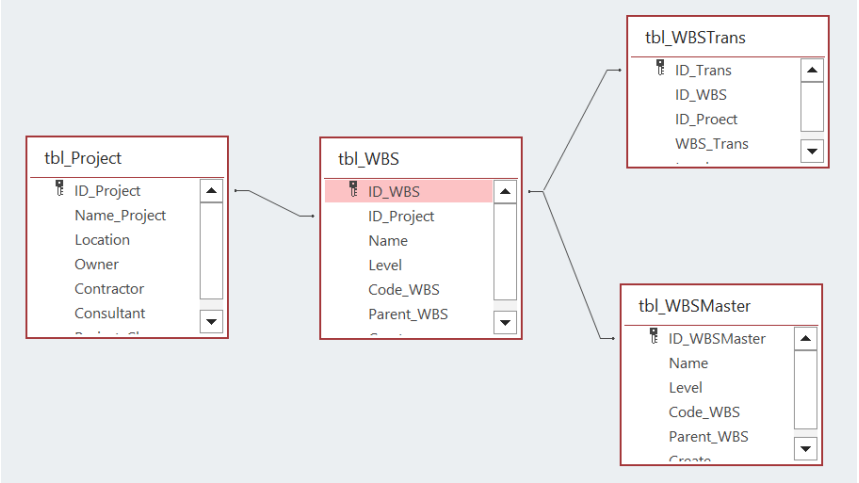

Figure 3 Model Tabel Relationship

The user interface was created in Python to organize data acquisition in the model into basic WBS data, then the WBS model was refined so that it could be used to create an early warning system model for work safety which will be carried out in the next stage. Data extraction from the bridge model uses an API (application programming interface) that reads family, family and Type, and family name data. The data that has been read is then stored in the WBS basic data. The next step is to organize and complete the WBS structure to make it better. The user interface design can be seen in Figure 4.

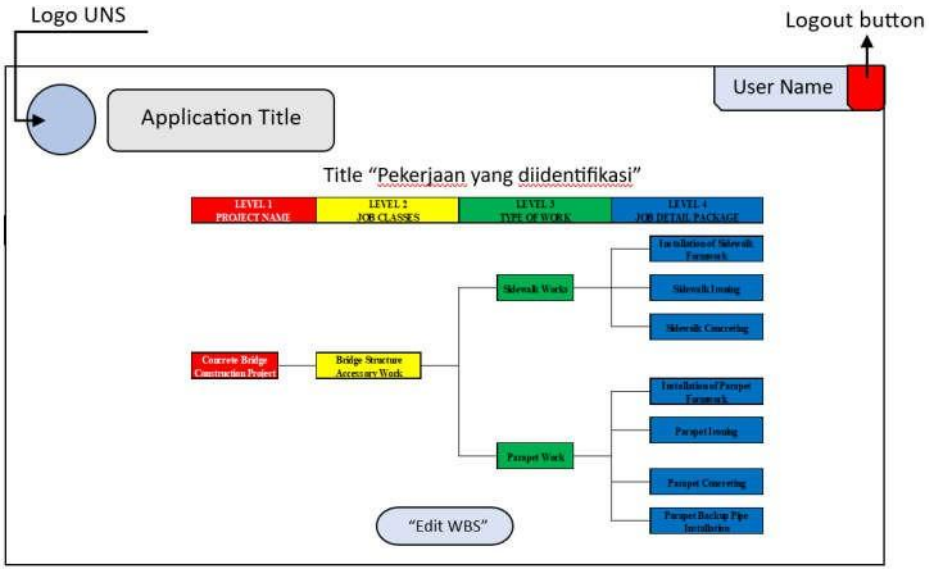

Figure 4 Preliminary Design Display of the Work Breakdown Structure (WBS) Menu on the Web

The user interface is divided into several parts, including the initial part which requires the user to log in, after logging in there is a menu of options for creating a new project or opening an old project. A new project is started by filling in the project identity such as building name, building type, location, start date and then end date. Users can input bridge model image data into the system, then the system reads and displays the bridge model. The information from the bridge model is extracted in the form of family, family and Type, and family name to be compiled in the form of a WBS (Figure 5). The resulting WBS structure was refined to be used to create an early warning system for work safety.

Figure 5 Register view on the Web

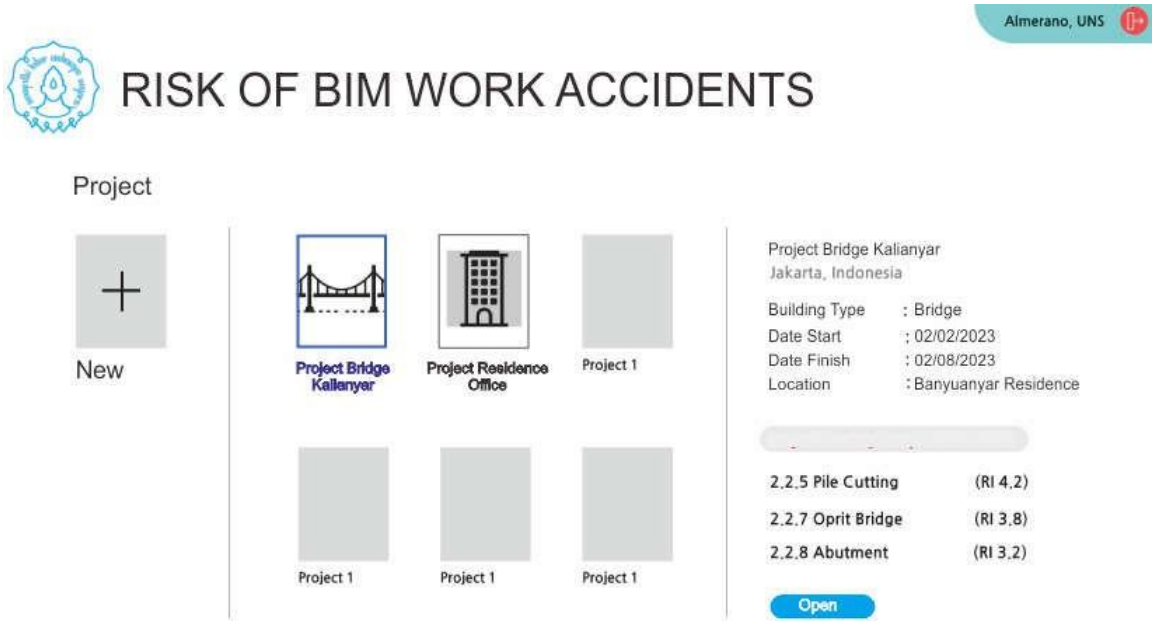

Figure 6 Dashboard start screen menu

The input image data that is successfully acquired becomes text data (worksheet) which is then formed and saved into a basic WBS model (Figure 6). This WBS data is then organized and equipped with the facilities in the program so that the desired WBS is obtained. The WBS list formed will be used for work safety analysis. The WBS model after refinement can be seen in Figure 7. Data extraction from the bridge model and creation of the WBS model have been successfully carried out, so this model will simplify the next steps in developing BIM technology.

Figure 7 Display of the Work Breakdown Structure (WBS) Menu on the Web

5. Conclusion

In the development of the construction world, the Building Information Modelling application can be developed to issue several data outputs. In this study, Building Information Modelling (BIM) of concrete bridges using Autodesk Revit software can be extracted into a Work Breakdown Structure (WBS) of concrete bridges. The extraction results are processed and stored in the Database MySQL with the Python programming language. So that the data can be accessed and used for future development. This database development can combine databases Work Breakdown Structure (WBS) with safety database, Risk-Based Activity (RBA), and Analytical Hierarchy Process (AHP).

6. References

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