Identification of Precast Box Girder Erection Activities to Develop Work Breakdown Structure in Elevated Railway Infrastructure Project

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ABSTRACT

The railway infrastructure development is being a concern to the government of Indonesia nowadays. One of construction methods mostly applied in building the railway infrastructure is box girder erection with launching gantry. After observing several big projects with this construction method, some problems are identified. One of the problems is different work activities conducted during box girder erection. According to this situation, this research was conducted to identify precast box girder erection activities to develop work breakdown structure. The Work Breakdown Structure (WBS) will enhance the efficiency and effectivity of similar projects in the future. To conduct the analysis, there are three steps to be executed. They are archive analysis, expert judgement and surveys. For archive analysis, two big projects are observed and compared. Secondly, the judgements are obtained from five experts who have fulfilled more than ten years working experiences especially in public infrastructure construction. Thirdly, the direct surveys were held to thirty elected respondents regarding this topic. Finally, the descriptive analysis was applied to draw the result. This research conveys the WBS which has been developed according to aforementioned analysis method. There are 13 identified activities. They are preparation, box girder transportation, box girder lifting, position setting, epoxy gluing, temporary PT bar stressing, alignment surveying, PC stand and accessories installment, permanent stressing, patching, grouting and bearing installation re-surveying. This WBS is necessary to be used as a reference standard for future similar projects.

Keywords: Activities, Box Girder, Erection, Work Breakdown Structure, Railway, Infrastructure.

1. INTRODUCTION

The government of Indonesia currently concern with railway infrastructure development. The commencement of Mass Rapid Transit construction in Jakarta has been a new milestone in railway infrastructure construction in Indonesia. The construction phase was begun in 2013 and completed in 2019 [1]. After that milestone, there were so many other train infrastructures had been started, such as the LRT Jakarta, the Jakarta Double Double Track, high speed rail and LRT development plans in other major cities in Indonesia. According to President rule in 2017, 15 intercity railway projects and 8 intra city railway projects are included in the national strategic infrastructure project acceleration in all around Indonesia [2].

Railway infrastructure is mostly built using the box girder with launching gantry method nowadays. Differences in work activities on segmental box girder erection are problems for future similar projects. Though, in guiding the construction process effectively and meeting project requirements, detailed activities are required [3] hence it should not be any differences.

Activities are things that the project team does to achieve project goals [4]. A construction project cannot be separated form a series of tasks or activities [5]. The complex level of activity is generated by work breakdown structure [6] or work breakdown structure is used to define project activities [5].

Girder erection work had been studied in previous research. However, the previous research was only
explained precast concrete highway bridge work breakdown structure and precast girder erection generally [7] with no specific materials and methods. And another research explained about PCI girder erection with double crane method [8] and launching gantry method [9]. Whereas, a different construction method in work package level will determine different activities [10]. The research about activities on box girder erection with launching gantry method in elevated railway has not been conducted before even though this is very important since there will be a lot of elevated railway infrastructure projects to be constructed in recent time.

It is very important to do research in identifying activities of precast box girder erection in railway infrastructure project. In the line with urgency, the purpose of this research is to identify activities of precast box girder to develop work breakdown structure in elevated railway infrastructure project by conducting archive analysis, asking the experts and surveying respondents. This research can develop activities which will complement the standardized work breakdown structure that has been developed in several previous research. Hopefully, the result of this research can become a standard reference for future similar projects even though each construction project is unique and has its own characteristics, but mostly they are almost similar and possible to be standardized [7].

2. METHOD

There are three steps to answer the research question. The first step is to analyze the archives and create a comparison table of the observed project samples. The projects observed are international and national railway infrastructure projects in Indonesia. The Mass Rapid Transit (MRT) CP 103 Elevated section and Double Double Track (DDT) Manggarai - Jatinegara project will become samples in this study. The second step is to ask for experts’ judgment according to PMI [11] or in other words experts’ validation (see Table 1.). The final step is to conduct a survey of 30 respondents who are considered to have the capacity and competence in the construction of box girder bridges and elevated trains.

Table 1. Expert profile

| No | Expert  | Position     | Working Experience | Education         |
|----|---------|--------------|--------------------|-------------------|
| 1  | Expert 1| Project Manager | 20 Years           | Master Degree     |
| 2  | Expert 2| Project Manager | 17 Years           | Master Degree     |
| 3  | Expert 3| Site Manager  | 14 Years           | Bachelor Degree   |
| 4  | Expert 4| Site Manager  | 12 Years           | Bachelor Degree   |
| 5  | Expert 5| Engineering Manager | 10 Years       | Bachelor Degree   |

Descriptive analysis was applied to know the opinion from experts and respondents. Their opinions were “yes” or “no” opinion based on Guttman scale applied to the questionnaire which were distributed [12]. After finishing data analysis, the latest process was to develop wbs tree diagram which explains more detail about box girder erection activities. Table 2 show comparison of box girder erection activities.

Table 2. Comparison of box girder erection activities

| No | MRT CP 103 Project | Double Double Track Project | LRTJ Project                                      |
|----|--------------------|------------------------------|--------------------------------------------------|
| 1  | Delivery Box Girder| Delivery Box Girder          | Delivery Box Girder                               |
| 2  | Hanging Up Segment | Hanging Up Segment           | Hanging Up Segment                               |
| 3  | Setting Position   | Setting Position             | Setting Position                                  |
| 4  | Gluing Works       | Gluing Works                 | Gluing Works                                     |
| 5  | Temporary PT Bar Stressing | Temporary PT Bar Stressing | Temporary PT Bar Stressing                        |
| 6  | Survey Alignment   | Survey Alignment             | Survey Alignment                                  |
| 7  | Installing PC Strand and Accessories | Installing PC Strand and Accessories | Installing PC Strand and Accessories |
| 8  | Permanent Stressing | Permanent Stressing          | Permanent Stressing                               |
| 9  | Patching Works     | Patching Works               | Patching Works                                    |
| 10 | Grouting Works     | Grouting Works               | Grouting Works                                    |
| 11 | Re Survey for Bearing Installation | Re Survey for Bearing Installation (Geometric Control Check) | Re Survey for Bearing Installation (Geometric Control Check) |
3. RESULT AND DISCUSSION

3.1. Results

The result of analysis show that there are 11 activities in precast box girder erection work. Starting from delivery box girder, lifting box girder segment, position setting, epoxy gluing works, temporary PT bar setting, alignment surveying, installing PC strand and accessories, permanent stressing, patching work, grouting work and the latest is resurveying for bearing installation. Table 3 show the results of data analysis.

Table 3. Results of expert judgment

| No | Validated Activity                                         | Expert Judgement | Conclusion |
|----|-----------------------------------------------------------|------------------|------------|
|    |                                                           | Yes % | No % |               |
| 1  | Delivery Box Girder                                        | 100.00% | 0.00% | Yes          |
| 2  | Lifting Box Girder Segment                                | 100.00% | 0.00% | Yes          |
| 3  | Position Setting                                           | 100.00% | 0.00% | Yes          |
| 4  | Epoxy Gluing Works                                        | 100.00% | 0.00% | Yes          |
| 5  | Temporary PT Bar Stressing                                | 100.00% | 0.00% | Yes          |
| 6  | Alignment Surveying                                       | 100.00% | 0.00% | Yes          |
| 7  | Installing PC Strand and Accessories                      | 100.00% | 0.00% | Yes          |
| 8  | Permanent Stressing                                       | 100.00% | 0.00% | Yes          |
| 9  | Patching Works                                            | 80.00% | 20.00% | Yes          |
| 10 | Grouting Works                                            | 100.00% | 0.00% | Yes          |
| 11 | Resurveying for Bearing Installation                     | 100.00% | 0.00% | Yes          |

Almost all experts agree with the activities shown. It can be seen from table above that the total percentage of expert to agree is greater than 80%. However, some experts add suggestions by adding “preparation” activity at the beginning and “finishing” activity at the end. Thus, in the next stage the two activities are added to the survey and data analysis.

After finishing the data analysis from expert judgement, the respondent survey is conducted. There were 30 respondents who were asked about their opinions regarding the box girder erection activities. Respondent categories are consisting of education, position and experience. There are 26 respondents who had bachelor degree, 2 respondents had master degree and 2 respondents had diploma degree. Most respondents are managers who are practitioners in their fields. And most respondents have 10 – 15 years work experience. The detail respondent category is shown in Table 4.

Table 4. Respondent category

| No | Education       | Total Sample | Position                  | Total Sample | Experience        | Total Sample |
|----|-----------------|--------------|---------------------------|--------------|-------------------|--------------|
|    | Diploma Degree  | 2            | Manager                   | 26           | 10 - 15 Years     | 21           |
| 2  | Bachelor Degree | 26           | Assistant Manager         | 1            | 16 - 20 Years     | 8            |
| 3  | Master Degree   | 2            | Staff / Engineer          | 3            | > 20 Years        | 1            |
|    | Total Sample    | 30           |                           | 30           |                   | 30           |

According to table 5 below, the total percentage of respondents to agree is greater than 90%. It means that almost all respondents agree with the activities which were asked in questionnaire. Additionally, preparation and finishing work activities which were proposed by the experts were also agreed by the respondents. Only two activities which have percentage of agreeing below than 100%. They are Position Setting and Patching Works. Although those two activities agreeing percentage is below than 100%, it still show more or equal to 90%. It means the activities are not having problem to be validated. The detail results of analysis are available in Table 5.

3.2. Discussion

Activities are important things to achieve project goals [4]. Activities are identified hence the project team can manage their project easily [13]. In standardized work breakdown structure, activity is level 5 after project name (level 1), work section (level 2), sub work section (level 3), and work package (level 4) [7]. In this case, box girder erection is at level 4 or work package level. The level of Box girder erection work package is developed by identifying activities under its level. The launching gantry method is also a determinant in activity identification because different construction method in work package level will determine different activities [10].
Table 5. Results of respondent survey

| No | Validated Activity                              | Respondent Survey | Conclusion |
|----|------------------------------------------------|-------------------|------------|
|    | Validation Activity                            | Yes/No            |            |
| 1  | Preparation                                    | 100.00% / 0.00%   | Yes        |
| 2  | Delivery Box Girder                            | 100.00% / 0.00%   | Yes        |
| 3  | Lifting Box Girder Segment                     | 100.00% / 0.00%   | Yes        |
| 4  | Position Setting                               | 93.33% / 6.67%    | Yes        |
| 5  | Epoxy Gluing Works                             | 100.00% / 0.00%   | Yes        |
| 6  | Temporary PT Bar Stressing                     | 100.00% / 0.00%   | Yes        |
| 7  | Alignment Surveying                            | 100.00% / 0.00%   | Yes        |
| 8  | Installing PC Strand and Accessories           | 100.00% / 0.00%   | Yes        |
| 9  | Permanent Stressing                            | 100.00% / 0.00%   | Yes        |
| 10 | Patching Works                                 | 90.00% / 10.00%   | Yes        |
| 11 | Grouting Works                                 | 100.00% / 0.00%   | Yes        |
| 12 | Resurveying for Bearing Installation           | 100.00% / 0.00%   | Yes        |
| 13 | Finishing Works                                | 100.00% / 0.00%   | Yes        |

According to the analysis results, the activities consisting of 13 activities starting from preparation, delivery box girder, lifting box girder segment, position setting, epoxy gluing works, temporary PT bar setting, alignment surveying, installing PC strand and accessories, permanent stressing, patching work, grouting work, resurveying for bearing installation and finishing work.

These activities are sequential activities according to a predefined construction method using the launching gantry. In other words, this sequence of activities can also be called the “span by span” method. Figure 1 shown detailed activities of box girder erection work in wbs tree diagram.

Figure 1 Detailed activities of box girder erection work in wbs tree diagram
The complex level of activity is generated by work breakdown structure [6] hence the identified activities are depicted in a work breakdown structure tree diagram in figure 1. In the diagram above, it can be seen that there is a work breakdown structure development starting form level 4 to level 5. This work breakdown structure development shows hierarchical levels ranging from general to specialized and complex, according to its definition [11]. Based on its function, this work breakdown structure is important thing to manage project scope [14], time or schedule, cost estimation, human resources, communication, risk, supervision, monitoring and control [11]. Thus, it will be useful for future similar project.

4. CONCLUSION

There are 13 activities in box girder erection starting from preparation, delivery box girder, lifting box girder, position setting, epoxy gluing work, temporary PT bar stressing, alignment surveying, installing PC strand and accessories, permanent stressing, patching work, grouting work, resurveying for bearing installation and finishing. The detailed activities on the precast erection box girder can be included as part of work breakdown structure and can be used as a reference standard for future similar projects. The results of this research can be developed into further research to calculate cycle times for erection girder, development of standard operational procedure of erection girders, development of safety plans, quality plans and building information management (BIM) integration.

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REFERENCES

[1] https://jakartamrt.co.id/id/sejarah access October 2nd, 2020 at 09.00 am
[2] Peraturan Presiden Republik Indonesia Nomor 58 Tahun 2017 Tentang Perubahan atas Peraturan Presiden Nomor 3 Tahun 2016 Tentang Percepatan Pelaksanaan Proyek Strategis Nasional
[3] Y. Latief, D. Nurdiani, L. S. R. Supriadi, “Development of Work Breakdown Structure (WBS) Dictionary for The Construction Works of Lower Structure Steel Bridge”, MATEC Web of Conference, 258, 02003, 2019.
[4] P. F. Rad, “Advocating a deliverable-oriented work breakdown structure,” Cost Engineering, 41(12), 35, 1999.
[5] V. Elsye, Y. Latief, and L. Sagita, “Development of Work Breakdown Structure (WBS) Standard for Producing the Risk Based Structural Work Safety Plan Of Building”, MATEC Web of Conferences, 147, 06003, 2018.
[6] D. N. Inayah, Y. Latief and L. S. Riantini, “Development of Work Breakdown Structure Based on Risk for Safety Planning on Dam Construction”, IOP Conf. Series: Materials Science and Engineering, 420, 012003, 2018.
[7] R. F. Kurnia, Y. Latief and L. S. Riantini, “The Development of Risk Based Standardized WBS (Work Breakdown Structure) for Cost Estimation of Concrete Precast Bridge Construction”, (Proceedings of the International Conference on Industrial Engineering and Operations Management), Bandung, Indonesia, March 6-8, 2018.
[8] P. D. Saputra and Y. Latief, “Analysis of Safety Cost Structure in Infrastructure Project of Precast of Precast Concrete Bridge base on Work Breakdown Structure (WBS)” IOP Conf. Series: Materials Science and Engineering, 830, 022074, 2020.
[9] P. D. Saputra and Y. Latief, “Development of Safety Plan Based on Work Breakdown Structure to Determine Safety Cost for Precast Concrete Bridge Construction Projects. Case Study: Girder Erection with Launching Gantry Method”, Civil Engineering and Architecture, 8(3A): 31-38, 2020.
[10] Y. Latief, G. R. Kusumaningtyas and L. S. R. Supriadi, “ Work Breakdown Structure (WBS) Dictionary Development for The Construction Works of Fly Over Projects”, IOP Conf. Series: Earth and Environmental Science, 195, 012003, 2018.
[11] PMI, “Project Management Body of Knowledge” Pennsylvania : Project Management Institut, Inc., 2017.
[12] Sugiyono, “Metode Penelitian Kuantitatif” Bandung: Alfabeta, 2018
[13] M. Yılmaz and R. Kanıt, “A practical tool for estimating compulsory OHS costs of residential building construction projects in Turkey,” Safety Science, 101, p 326–331, 2018.
[14] L. Su, “WBS-based Risk Identification for the Whole Process of Real Estate Project and Countermeasures”, National Conference on Information Technology and Computer Science (CITCS 2012), 2012.