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The Application of Critical Path Method (CPM) Analysis on Traditional Ship Production Process (Case Study: Bintan - Indonesia)

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Abstrak

Most of the traditional ships in Indonesia were built without a special design. Traditional ship design is the result of learning from nature, so there is no planning and calculation of a standard design before the ship was built, but the skills acquired by generations of his predecessors. This study is trying to determine the project schedule and the critical path in the traditional shipbuilding by using Critical Path Method. The data for this study was obtained from observing and interview method. Overall analysis found the completion time of a traditional boat building process for the size of 300 gross tonnage require the approximately completion time of 4.4 months. In the production process, there are four critical part which is cannot be delayed the process such as main stiffener/keel assembly, frames assembly, hull assembly and ship launching. Delay work on the point of the critical part will create delays overall production process.

Keywords : Traditional Ship, Critical Path Method, Project Schedule

Abstrak

Sebagian besar kapal tradisional di Indonesia dibangun tanpa desain khusus. Desain kapal tradisional merupakan hasil belajar dari alam, keterampilan diperoleh dari generasi sebelumnya, sehingga tidak ada perencanaan perhitungan standar sebelum kapal dibangun. Penelitian ini mencoba menentukan jadwal pembangunan kapal tradisional menggunakan metode CPM (Critical Path Method). Data didalam penelitian ini diperoleh melalui wawancara dan pengamatan secara langsung. Hasil dari penelitian menemukan bahwa proses penyelesaian pembangunan kapal tradisional dengan ukuran 300 GT (gross tonnage) membutuhkan waktu sekitar 4,4 bulan. Dalam prosesnya, ada 4 (empat) bagian penting yang tidak dapat ditunda yaitu stiffener/keel assembly, frames assembly, hull assembly and ship launching. Tertundanya ke empat pekerjaan tersebut akan membuat pekerjaan pembangunan kapal akan tertunda secara keseluruhan.

Kata kunci: Kapal tradisional, Critical Path Method, Project Schedule

1 Introduction

Indonesia is a country consisting of thousands of islands, both small islands and large islands. Overall, Indonesia has more than 17,508 islands with an area of sea and river waters more than 75% and reached 81,000 km of coastline [13]. This situation allows Indonesia is known as a maritime nation. For connecting one island to another island that is required for the transport of a traditional ships or boat.

Traditional boat/ships is one of the ships construction that most of the material derived by wood and traditionally made. According to Great Dictionary of Indonesian (1999), traditional is the attitudes and ways of thinking and acting that is always sticking to the norms and customs that there are hereditary. Traditional boat has the form and characteristics according to each territory [7][9].

Traditional ships are diverse kinds, this can be seen on almost every coast of Indonesia have a different form of design. Development of this evolved ship design based on the experiences of the ancestors and the myth is believed by local people.

Traditional ships building process consists of the design and construction phases. Most of the traditional ships in Indonesia were built without a special design. Traditional ship design is the result of learning from nature, so there is no planning and calculation of a standard design before the ship was built, but the skills acquired by generations of his predecessors [5].

Construction of a traditional boat consists of lunas (keel), linggi haluan (stem-post), buritan (stern-post), gading (frames), galaran/geladak (deck), pisang-pisang/cang cipo (sheer), sekat (bulkhead), palka (hatch), pondasi mesin (engine's foundation), propeller shaft hole and kulit (hull) [3][17][21][22][23].

This study is trying to determine the project schedule and the critical parts in the traditional shipbuilding. [6] explained about project scheduling as a contractual network diagram of the project's planned activities, their sequence determined by job logic, the contractual time in

working days required for completion (activity duration), and the conditions necessary for their completion (contract specifications).

Methodology used in this study is Critical patch Method (CPM). The CPM formally identifies tasks which must be completed on time for the whole project to be completed on time, Identifies which tasks can be delayed for a while if resource needs to be reallocated to catch up on missed tasks, identify the minimum length of time needed to complete a project, CPM determines both the early start and the late start date for each activity in the schedule. In this study, the critical path will be found by using CPM method on analysis of project scheduling in the traditional ships building process

2 Literature Review

Study of traditional ships and traditional shipyards have conducted by many researchers, especially from Indonesia. Some research on it has been done by such as [12] who did study about condition of production factors on wood shipyard business in Indonesia, especially in Dumai Island. Study evaluated the production factors of wood shipyard that related to the natural resources, manpower, capital, expertise and entrepreneurship by observing, questionnaire and interview method.

[19] Analyzed the transformation process of wooden boats in the second half of the twentieth century in Indonesia, in which modern technology played an important role, in order to understand the technological adaptation of the local people to the changing circumstances. The study was conducted through literature surveys, interviews with local people, and observation and measurements of the boats, and revealed that the modern technologies were effectively adopted and combined into the local people's existing knowledge system.

Several study on hull form of traditional ships conducted by [16] and [5]. [16] Study on advanced design on traditional ship about fishing vessels design using catamaran hull form and sail propulsion system for alive fish cargo. [5] Analyzes the performance of hull form on traditional ships by using form data method. Before [16] conducted a study on design of traditional ships using catamaran hull form, [9] conducted a study about comparison of hull performance on fishing vessels design concept with multi-function catamaran hull. The study provide a new concept of fishing vessels to capable suppress the use of fuels and environmentally friendly.

Several study on the traditional ships design and construction carried out by several researchers in paper conducted by [11] [17][18][21][22][23]. Another study revealed the existence of the traditional ship's type conducted by [1] studied about local knowledge of traditional ship building by Biak ethnic in Warsa subdistrict, Biak Numfor District and [14] revealed the existence of the traditional ships in Spermonde, South Sulawesi.

Economic studies in the field of traditional ships have been carried out by [3] evaluate the technical- economic evaluation of the wooden traditional ships building. [20] Studied about the economic analyses the use of power engine on traditional ships.

Scheduling in a production scheme is needed. As generally, scheduling on ships production process (steel ships) studied by [2] is about schedule risk assessment in planning ship production. Study presented a risk assessment approach for evaluating the goodness of ship production scheduling and planning. Paper was to utilize the probabilistic analysis to assess the goodness of the proposed planning of ship production in shipyard by using Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT).

Study on applying of Critical Path Method (CPM) to manufacturing routing conducted by [8]. Study proposes taking these ideas to continuous production systems, and to implement the CPM not just at the outset but throughout the process.

3 Methodology

Data of traditional shipbuilding process and the completion time of each part of the process for this study obtained from observing, interview and literature method. The collecting data will be analyzed using Critical Path Method (CPM) to identify those tasks which are on the critical path in traditional shipbuilding process, i.e. where any delay in the completion of these tasks will lengthen the project timescale. Limitation of the data is only for ships with Gross Tonnage 300 GT with a normal number of workers.

3.1 Observed Data

Observation data obtained by directly visits to the traditional shipyards in one of the regions in Indonesia. Observations conducted in April 2012 in Bintan regency, Riau Archipelago province. In addition, the observation is also conducted interviews to obtain information about the duration for each process of working. Data which is obtained from this method is not complete because the ship was built at the shipyard is not finish yet, the process just finish on frames assembly. The data which is obtain from this part are :

1. Number of worker : 7 workers
2. Traditional principle dimension
3. Loa = approximately 25 m
4. Breadth/Beam = approximately 8 m
5. Gross tonnage = approximately 300 GT

Figure 1: Traditional ship side view

Figure 2: Traditional ship backside view

Figure 3: Traditional ship backside view

3.2 Additional Data

Additional data for this study were obtained from the literature. Additional data was taken from studies conducted by [3] and [8]. The data is taken about the time duration of completion on the several part of traditional ship building process. Limitation of the data only ships with Gross Tonnage 150-300 GT with a normal number 4-5 workers and the overall duration of completion on traditional ship production process approximately 3-5 months.

3.3 Critical Path Method (CPM) Analysis

Critical Path Method (CPM) will be used in the analysis of project planning on traditional shipbuilding in this study. The method used in project planning of traditional Shipbuilding to obtain some of the following:

1. A graphical view of the project
2. Predicts the time required to complete the traditional Shipbuilding project.
3. Shows which activities are critical to maintaining the schedule and which are not.
4. The slack time during shipbuilding process

The Methodology used for project planning analysis on traditional shipbuilding in this study shown on graph below.

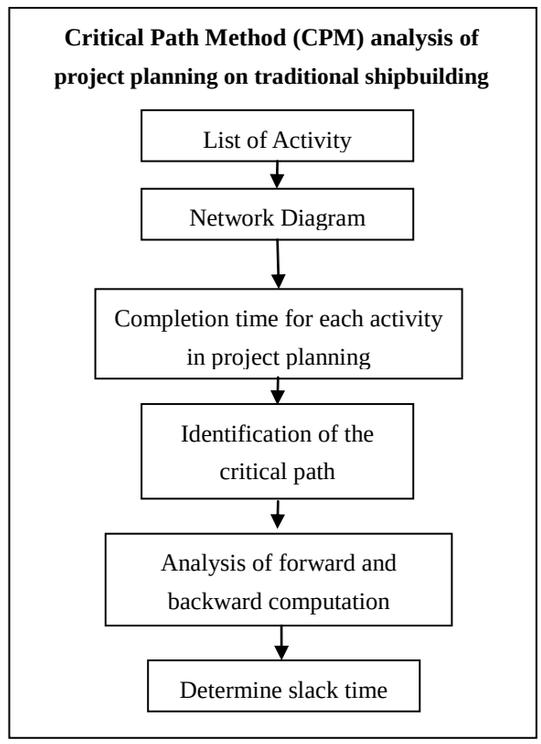

Figure 4: Methodology for analysis of project planning on traditional shipbuilding

The slack time for an activity is the time between its earliest and latest start time, or between its earliest and latest finish time. Slack is the amount of time that an activity can be delayed past its earliest start or earliest finish without delaying the project.

4 Traditional Ship Production Process

Data of traditional shipbuilding process and the completion time of each part of the process for this study obtained from observing, interview and literature method. The collecting data will be analyzed using Critical Path Method (CPM) to identify those tasks which are on the critical path in traditional shipbuilding process, i.e. where any delay in the completion of these tasks will lengthen the project timescale. The Limitation of the data is only for ships with Gross Tonnage 300 GT with a normal number of workers.

The Production processes on a traditional ship building are:

1. Main Principle Dimension (Length, breadth and depth)
2. Wood cutting
3. keel assembly
   (a). Keel foundation
   (b). Main stiffener/keel assembly
4. Saok/linggi haluan (stem-post)
5. Linggi buritan (stern-post)
6. Taikong
7. Gading-gading (frames)
8. Cang cipo (sheer)
9. Kulit (Hull assembly)
10. Hot fire process on hull
11. Hull lubrication
12. Dempul
13. Geladak (deck frame)
14. Deck frame cover
15. Asoi assembly (inside frame cover)
16. Floor assembly
17. Ship launching (front side launching)
18. Accommodation house (superstructure)
19. Outfitting (Piping and ventilation)
20. Engine

(a). Engine's foundation
(b). Engine assembly
21. Propeller assembly
22. Delivery

5 Analysis of Project Planning

5.1 Activity & Time and Network Diagram

Network diagram is based on the sequence activities of the table activity and time above and diagram as shown on Figure 5.

TABLE I

LIST OF TIME AND ACTIVITIES

Activity	Description	Required precedessor	Duration (day)
A0	Main Principle Dimension (Length, breadth and depth)	None	10
A1	Wood cutting	A0	4
A2	keel assembly	-	-
A2.1	(a). Keel foundation	A1	1
A2.2	(b). Main stiffener/keel assembly	A2.1	3
A3	*Saok/linggi haluan* (stem-post)	A2.2	2
A4	*Linggi buritan* (stern-post)	A2.2	2
A5	*Taikong*	A2.2	10
A6	*Gading-gading* (frames)	A3, A4, A5	10
A7	*Cang cipo* (sheer)	A6	2
A8	*Hot fire process on hull*	A6	40
A9	Hull lubrication	A8	2
A10	Kulit (Hull assembly)	A7	40
A11	*Dempul*	A9	5
A12	*Geladak* (deck frame)	A10	5
A13	Deck frame cover	A12	15
A14	*Asoi* assembly (inside frame cover)	A10, A11	20
A15	Floor assembly	A14	10
A16	Ship launching (front side launching)	A13, A15	1
A17	Accomodation house (superstructure)	A16	15
A18	Outfitting (Piping and ventilation)	A16	15
A19	Engine	-	-
A19.1	(a). Engine's pondation	A16	3
A19.2	(b). Engine assembly	A19.1	6
A20	Shaft and Propeller assembly	A19.2	6
A21	Delivery	A17, A18, A20	1

5.2 Completion Time and Schedule

Table IV shown the schedule used to determine the Critical Path Method (CPM) on this study.

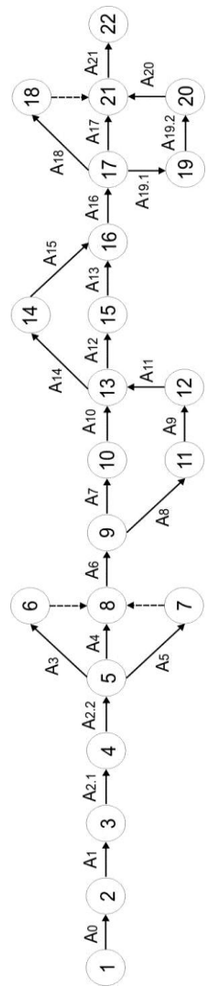

Figure 5: Network diagram of project planning on traditional shipbuilding

5.3 Identification of critical path

Gantt chart from previous chapter can analyze several critical paths on project scheduling of traditional ship production. The longest (path and time) on the analysis of the traditional ship production process is described on the Table III.

For the process, There are four critical part process i.e. A2.2 (main stiffener/keel assembly), A6 (frames assembly), A8 (hull assembly) and A17 (ship launching). This indicates that the delay of each critical path in the process will decelerate the finishing of overall project. The extremely critical path in this analysis is launching process. Launching process affect the completion of the following process such as hull lubrication process, dempul process, deck framing, inside frame cover process and floor assembly. The launching process should be carried out on time to make sure that the following process is not delayed. This analysis also applies to others critical path on the traditional ship production.

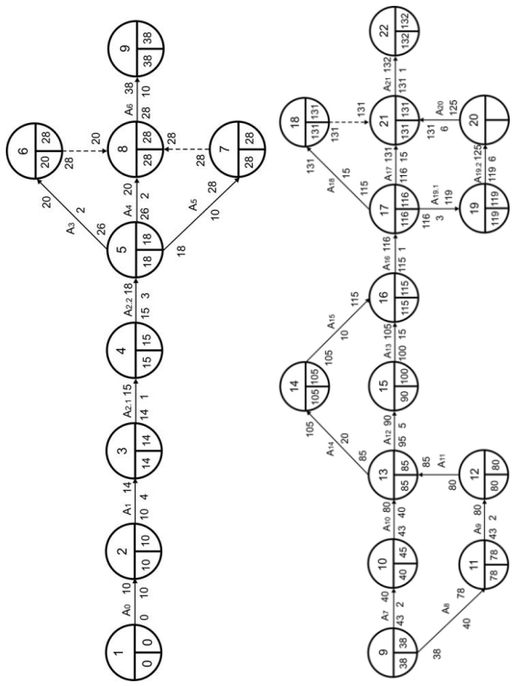

Figure 6: Network diagram of forward and backward computation on CPM

TABLE II

FORWARD (EARLIEST) & BACKWARD (LATEST) COMPUTATION AND SLACK TIME

Activities		Time (Day)	Earliest Time		Latest Time		Slack time (days)
i	j		Start (ES)	Finish (EF)	Start (LS)	Finish (LF)	LS – ES
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	2	10	0	10	0	10	0
2	3	4	10	14	10	14	0
3	4	1	14	15	14	15	0
4	5	3	15	18	15	18	0
5	6	2	18	20	26	28	8
6	8	0	20	20	28	28	-
5	7	10	18	28	18	28	0
7	8	0	28	28	28	28	0
5	8	2	18	20	26	28	8
8	9	10	28	38	28	38	0
9	10	2	38	40	43	45	5
10	13	40	40	80	45	85	-
9	11	40	38	78	38	78	0
11	12	2	78	80	78	80	0
12	13	5	80	85	80	85	0
13	14	20	85	105	85	105	0
14	16	10	105	115	105	115	0
13	15	5	85	90	95	100	10
15	16	15	90	105	100	115	-
16	17	1	115	116	115	116	0
17	18	15	116	131	116	131	0
18	21	0	131	131	131	131	0
17	21	15	116	131	116	131	0
17	19	3	116	119	116	119	0
19	20	6	119	125	119	125	0
20	21	6	125	131	125	131	0
21	22	1	131	132	131	132	0
						TOTAL SLAG TIME	31

6 Conclusions

Overall analysis found the completion time of a traditional boat building process for the size of 300 gross tonnage require the approximately completion time of 4.4 months or 132 days. In the process, there are four critical path which is cannot be delayed the process such as main stiffener/keel assembly, frames assembly, hull assembly and ship launching. Delay work on the point of the critical part will create delays overall production process.

This analysis is performed without considering the flow of material. The real condition in the process of traditional ship building is shipbuilder have a lot problem with raw material, especially for wood [4][15]. Problem of material such wood as a main material for traditional shipbuilding process will affect to completion of the process. This analysis also using simple Critical path Method (CPM) so that the results obtained is less satisfactory, for further analysis recommended to use advance analysis for this method.

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TABLE III

CRITICAL PATH OF PROJECT PLANNING ON TRADITIONAL SHIPBUILDING

Critical Path 1																	
Activity	A0	A1	A2.1	A2.2	A5	A6	A8	A9	A11	A14	A15	A16	A19.1	A19.2	A20	A21	Total Days
Node (Start)	1	2	3	4	5	8	9	11	12	13	14	16	17	19	20	21	
Node (End)	2	3	4	5	7	9	11	12	13	14	16	17	19	20	21	22	
Time	10	4	1	3	10	10	40	2	5	20	10	1	3	6	6	1	132

Critical Path 2															
Activity	A0	A1	A2.1	A2.2	A5	A6	A8	A9	A11	A14	A15	A16	A17	A21	Total Days
Node (Start)	1	2	3	4	5	8	9	11	12	13	14	16	17	21	
Node (End)	2	3	4	5	7	9	11	12	13	14	16	17	21	22	
Time	10	4	1	3	10	10	40	2	5	20	10	1	15	1	132

Critical Path 3															
Activity	A0	A1	A2.1	A2.2	A5	A6	A8	A9	A11	A14	A15	A16	A18	A21	Total Days
Node (Start)	1	2	3	4	5	8	9	11	12	13	14	16	17	21	
Node (End)	2	3	4	5	7	9	11	12	13	14	16	17	18	22	
Time	10	4	1	3	10	10	40	2	5	20	10	1	15	1	132

TABLE IV

PROJECT SCHEDULING ON TRADITIONAL SHIPBUILDING

Activity	Required precedessor	Duration (day)	1st Month	2nd Month	3rd month	4th month	5th month
A0	None	10					
A1	A0	4					
A2	-	-					
A2.1	A1	1					
A2.2	A2.1	3					
A3	A2.2	2	SL				
A4	A2.2	2	SL				
A5	A2.2	10					
A6	A3, A4, A5	10					
A7	A6	2					
A8	A6	40					
A9	A8	2					
A10	A7	40			SL		
A11	A9	5					
A12	A10, A11	5					
A13	A12	15				SL	
A14	A10, A11	20					
A15	A14	10					
A16	A13, A15	1					
A17	A16	15					
A18	A16	15					
A19	-	-					
A19.1	A16	3					
A19.2	A19.1	6					
A20	A19.2	6					
A21	A17, A18, A20	1					