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Application Of CPM Methode (Critical Path Methode) In Controlling the Time 100 Teus Contrainer Ship Hull Construction Project

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Abstrak

Proyek konstruksi umumnya merupakan usaha yang paling berisiko tinggi khususnya proyek pembangunan kapal. Upaya pengurangan resiko tersebut dapat dilakukan dengan meminimalkan potensi resiko. Penelitian ini bertujuan untuk melihat potensi resiko yang tinggi dan mencegah keterlambatan penyelesaian konstruksi kapal menggunakan Critial Path Method CPM pada PT.XYZ. Dengan menggunakan Critial Path Method CPM jalur – jalur kritis dapat diberikan perhatian lebih sehingga tidak akan mengganggu proyek konstruksi kapal. Selain itu juga menjadi bentuk antisipasi jika ada keterlambatan maka memungkinkan untuk dilakukan penjadwalan kembali.

Kata kunci: Metode CPM, Jalur – Jalur Kritis, Konstruksi Kapal

Abstract

Construction projects are generally the most high-risk businesses, especially shipbuilding projects. Efforts to reduce the risk can be done by minimizing the potential risk. This study aims to see potential high risk and prevent delays in the completion of ship construction using the Critical Path Method CPM at PT. XYZ. By using the Critical Path Method CPM critical paths can be given more attention so that they will not interfere ship construction projects. In addition, it is also a form of anticipation if there is a delay, it is possible to reschedule.

Keywords: CPM Methode, Critical Path, Shipbuilding

1. Introduction

Construction projects are generally the most high-risk businesses [1]. The ship construction project is a competitive project with major risks such as the delay in delivery of the vessel to the owner, work accidents, and production errors that cause the ship not to match the owner's order so with a large level of risk need good planning and control in the field. Based on the Research Report on Shipbuilding Japan Cho et al (1996) it is known that the hull construction process is 48-50% of the shipbuilding process [2]. Delay is defined as the time overrun either beyond the contract's date or beyond the delivery date agreed upon by the project's different parties. PT. XYZ is a ship construction company collaborates with Damen Shipyard Gorinchem for the construction of new ships. In its planning, PT XYZ plans to build a 100 TEUS container ship on time and well managed. Using critical path analysis in ship construction scheduling planning is one of the most effective and efficient methods to prevent delays in ship construction completion.

1.1 Ship Construction

The stages of the hull construction itself are divided into several stages of work. The construction of the ship's hull can be divided into 4 stages [9], namely:

1. Fabrication Part: The fabrication is the earliest level of physical work when building a new ship. The fabrication section consists of several main activities, such as: marking, cutting, roll, press, bending
2. Sub-assembly Part: Sub-assembly process consists of fit-up and welding of production parts that have been carried out at the fabrication stage. Sub assembly process is combining several small components into components per panel.
3. Block assembly Part: Block assembly stage is one of core work on ship construction. Block assembly is the activity combining two or more panels to form a ship block. This merging process usually requires heavy equipment to support its production activities. This stage consists of 4 main activities, namely: JIG preparation, scantling check, fit-up, inspection.

1.2 Critical Path Method

Critical Path Method (CPM) is a technique for analyzing projects by determining the longest sequence of tasks (or the sequence of task with the least slack) through a project network [5]. The function of the critical path is to find out activities that have a very high sensitivity to delays in completing work, or also called critical activities [9]. By concentrating on the most critical tasks it can be ensured that the project is on time and is keeping pace with the schedule set up [3]. The project network is a flow chart that graphically depicts the sequence, inter dependence of the project work plan. One of the functions of the project network is to analyze activities that are on a critical path.

1.3 Project Management

A project is a complex undertaking, non-routine, one-time activity constrained by time, budget, resources, and performance specifications designed to meet customer requirements. The purpose of project management is that these activities can be achieved efficiently and effectively. In general, the project cycle and process from start to finish are as follows:

1. Defining
2. Planning
3. Executing
4. Closure

1.4 Term in Project Networking

Some of the terms often used in project networking are:

- ESij (early start), is earliest start time on activity (i,j) [4]. ES for each element (i,j) is equal with Ei for previous element.

$$S_{ij} = E_i \qquad (1)$$

- EF (early finish), is how fast an activity can be completed. EF for each element (i,j) is equal with ES plus duration of event.

$$EF_{ij} = ES_{ij} + D_{ij} \qquad (2)$$

- LF (late finish), is how late the activity can be completed. At each node we calculate the least finish and start energy for each activity by considering. Lj as the maximum/ latest occurrence of node j [6]. LF for each element (i,j) is equal with LET from previous j.

$$LF_{ij} = L_j \qquad (3)$$

- LS (late start), is how late an activity can be started. LS fo each elemenat (i,j) is equal with LF minus duration of event.

$$LS_{ij} = LF_{ij} – D_{ij} \qquad (4)$$

- Slack / Float, is how long the activity is delayed. Activity i is regarded as a critical activity if its float time is zero [7].

1.5 Arranging of Critical Path Network

1. List project / process activities
2. Draw a diagram
3. Calculate & analyze the earliest event time (EET)
4. Calculate & analyze the latest event time (LET)
5. Determine the critical path

2. Methods

The type of study is case study research. Case study research, through reports of past studies, allows the exploration and understanding of complex issues. It can be considered a robust research method particularly when a holistic, in-depth investigation is required.

The data needed in this study will be taken from production data construction of new hull construction. The primary data needed are: data on the intensity of the occurrence of each type of waste. Data collection the weight of the intensity of the waste is carried out by using a questionnaire method on several respondents in companies that have experience in their fields. Primary data the other is the respondent's data on the priority risk rating for the company.

The data will be processed to see the potential for high risk and prevent delays in the completion of ship construction using the Critical Path Method CPM.

3. Results and Discussion

3.1 Data Collection

Data collection was carried out at PT. XYZ with the object of research on the construction of a 100 TEUS container ship.

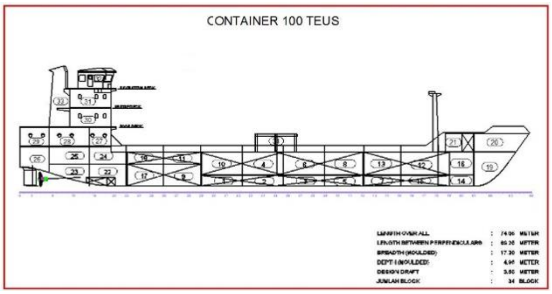

Figure 1. Container 100 TEUS Design Drawing

In the picture above, it can be seen that PT. XYZ builds 100 TEUS container ships with 33 blocks ship assembly part.

3.2 Compile a list of activities and the duration of their completion

The next step is to compile a list of activities and the timing of the activities. The number of activities can be seen based on the picture below, while the duration of activities is obtained from the project activity schedule.

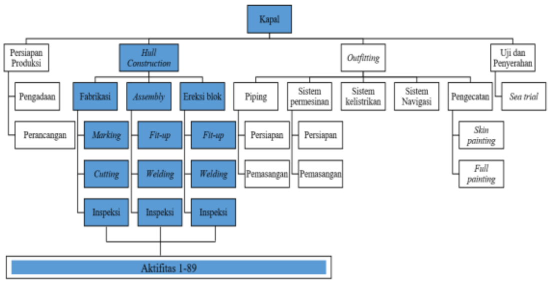

Figure 2. Ship Production Diagram

Then after determining the duration of the activity, perform a logical analysis of the dependence between activities. The logic of dependence between activities is obtained in the following way.

1. Determine the initial activity to be carried out, where the start of the activity does not depend on other activities.
2. Determine the next activity to be carried out when an activity has been completed.
3. Before starting an activity, what activity precedes the activity (dependency logic).

So that the preparation of the logic of dependence and duration of activities on the construction of a 100 TEUS container ship is as in table below:

TABLE 1. DURATION OF EACH PROCESS

No	Activity	Code	Dependency Logic	Duration (days))
1.	Block Fabrication 1	A1	Starting	5
2.	Block Fabrication 2	A2	A1	5
3.	Block Assembly1	B1	A1	26
4.	Block Assembly2	B2	A2	30
5.	Block Fabrication 3	A3	A2	5
6.	Block Assembly3	B3	A3	28
7.	Block Fabrication 5	A4	A3	5
8.	Block Assembly5	B4	A4	25
9.	Block Fabrication 7	A5	A4	5
10.	Block Assembly7	B5	A5	25
11.	Block Fabrication 4	A6	A5	8
12.	Block Assembly4	B6	A6	25
13.	Block Fabrication 6	A7	A6	5
14.	Block Assembly6	B7	A7	29
15.	Block Fabrication 10	A8	A7	5
16.	Block Assembly10	B8	A8	32
17.	Erection Block 1-2-3	C1	B1, B2, B3	40
18.	Block Fabrication9	A9	A8	5
19.	Block Assembly9	B9	A9	42
20.	Block Fabrication 17	A10	A9	5
21.	Block Assembly17	B10	A10	45
22.	Block Fabrication 11	A11	A10	5
23.	Block Assembly11	B11	A11	30
24.	Block Fabrication18	A12	A11	5
25.	Block Assembly18	B12	A12	46
26.	Block Fabrication13	A13	A12	5
27.	Block Assembly13	B13	A13	45
28.	Block Fabrication8	A14	A13	5
29.	Block Assembly8	B14	A14	29
30.	Block Fabrication12	A15	A14	5
31.	Block Assembly12	B15	A15	31
32.	Block Fabrication15	A16	A15	5
33.	Block Assembly15	B16	A16	50
34.	Block Fabrication16	A17	A16	5
35.	Block Assembly16	B17	A17	50
36.	Block Fabrication14	A18	A17	5
37.	Block Assembly14	B18	A18	40
38.	Erection Block 5-7	C2	B4, B5	46
39.	Block Fabrication19	A19	A18	5
40.	Block Assembly19	B19	A19	55
41.	Block Fabrication20	A20	A19	5
42.	Block Assembly20	B20	A20	53
43.	Erection Block 9-17	C3	B9, B10	43
44.	Block Fabrication21	A21	A20	5
45.	Block Assembly21	B21	A21	58
46.	Erection Block 9-10	C4	C1, B8, B9	25
47.	Block Fabrication22	A22	A21	5
48.	Block Assembly22	B22	A22	52
49.	Block Fabrication23	A23	A22	5
50.	Block Assembly23	B23	A23	60
51.	Block Fabrication24	A24	A23	5
52.	Block Assembly24	B24	A24	49
53.	Block Fabrication25	A25	A24	5
54.	Block Assembly25	B25	A25	66
55.	Block Fabrication26	A26	A25	5
56.	Block Assembly26	B26	A26	70
57.	Block Fabrication27	A27	A26	5
58.	Block Assembly27	B27	A27	57
59.	Erection Block 4-6	C5	C1, B6, B7	32
60.	Block Fabrication28	A28	A27	5
61.	Block Assembly28	B28	A28	67
62.	Block Fabrication29	A29	A28	5
63.	Block Assembly29	B29	A29	65
64.	Erection Block 11-18	C6	B11, B12, C3	56
65.	Block Fabrication30	A30	A29	5
66.	Block Assembly30	B30	A30	72

67.	Block Fabrica-tion31	A31	A30	5
68.	Block Assem-bly31	B31	A31	75
69.	Block Fabrica-tion32	A32	A31	5
70.	Block Assem-bly32	B32	A32	70
71.	Block Fabrica-tion33	A33	A32	5
72.	Block Assem-bly33	B33	A33	48
73.	Erection Block 8-13	C7	B14, B13, C2	50
74.	Block Fabrica-tion34	A34	A33	5
75.	Block Assem-bly34	B34	A34	36
76.	Erection Block 12-15	C8	B16, B15	45
77.	Erection Block 22-23	C9	B22, B23	63
78.	Erection Block 24-25	C10	B24, B25, C9	66
79.	Erection Block 26	C11	B26	68
80.	Erection Block 27-28-29	C12	B27, B28, B29, C10, C11	71
81.	Erection Block 30	C13	B30, C12	60
82.	Erection Block 14-16	C14	B17, B18	50
83.	Erection Block 19	C15	B19	55
84.	Erection Block 20-21	C16	B20, B21, C14, C15	50
85.	Erection Block 34	C17	B34, C5	28
86.	Erection Block 31	C18	B31, C13	60
87.	Erection Block 32	C19	B32, C18	57
88.	Erection Block 33	C20	B33, C12	41
89.	Launch prepa-ration	C21	Finish	

Basically, this critical chain calculation aims to determine the critical activities in the overall project activity. The way to determine critical activities in critical chain analysis is to calculate the float time available for activities. Float time is waiting time for an activity before moving on to the next activity. The float time calculation is according to the formula in sub-chapter 2. In the construction of a 100 TEUS container ship, the critical activities for each of the entire project series are described in table below.

TABLE 2. CRITICAL ACTIVITY

Activity Code	Dependency Logic	Duration (days)	Time (Days)					Information
			EST	EFT	LST	LFT	Float	
A1	Start	5	0	5	0	5	0	Critical
A2	A1	5	5	10	5	10	0	Critical
B1	A1	26	5	31	457	483	452	
B2	A2	30	10	40	453	483	443	
A3	A2	5	10	15	10	15	0	Critical
B3	A3	28	15	43	455	483	440	
A4	A3	5	15	20	15	20	0	Critical
B4	A4	25	20	45	434	459	414	
A5	A4	5	20	25	20	25	0	Critical
B5	A5	25	25	50	434	459	409	
A6	A5	8	25	33	25	33	0	Critical
B6	A6	25	33	58	498	523	465	
A7	A6	5	33	38	33	38	0	Critical
B7	A7	29	38	67	494	523	456	
A8	A7	5	38	43	38	43	0	Critical
B8	A8	32	43	75	498	530	455	
C1	B1, B2, B3	40	43	83	483	523	440	
A9	A8	5	38	43	38	43	0	Critical
B9	A9	42	48	90	432	474	384	
A10	A9	5	48	53	48	53	0	Critical
B10	A10	45	53	98	429	474	376	
A11	A10	5	53	58	53	58	0	Critical
B11	A11	30	58	88	469	499	411	
A12	A11	5	58	63	58	63	0	Critical
B12	A12	46	63	109	453	499	390	
A13	A12	5	63	68	63	68	0	Critical
B13	A13	45	68	113	460	505	392	
A14	A13	5	68	73	68	73	0	Critical
B14	A14	29	73	102	476	505	403	
A15	A14	5	73	78	73	78	0	Critical
B15	A15	31	78	109	524	555	446	
A16	A15	5	78	83	78	83	0	Critical
B16	A16	50	83	133	505	555	422	

A17	A16	5	83	88	83	88	0	Critical
B17	A17	50	88	138	108	158	20	
A18	A17	5	88	93	88	93	0	Critical
B18	A18	40	93	133	118	158	25	
C2	B4, B5	46	50	96	459	505	409	
A19	A18	5	93	98	93	98	0	Critical
B19	A19	55	98	153	395	450	297	
A20	A19	5	98	103	98	103	0	Critical
B20	A20	53	103	156	452	505	349	
C3	B9, B10	43	98	123	474	499	376	
A21	A20	5	103	108	103	108	0	Critical
B21	A21	58	108	166	447	505	339	
C4	C1, B8, B9	25	90	115	530	555	440	
A22	A21	5	108	113	108	113	0	Critical
B22	A22	52	113	165	126	178	13	
A23	A22	5	113	118	113	118	0	Critical
B23	A23	60	118	178	118	178	0	Critical
A24	A23	5	118	123	154	159	36	
B24	A24	49	123	172	192	241	69	
A25	A24	5	123	128	159	164	36	
B25	A25	66	128	194	175	241	47	
A26	A25	5	128	133	164	169	36	
B26	A26	70	133	203	169	239	36	
A27	A26	5	133	138	227	232	94	
B27	A27	57	138	195	250	307	162	
C5	C1, B6, B7	32	67	99	523	555	456	
A28	A27	5	138	143	232	237	94	
B28	A28	67	143	210	240	307	97	
A29	A28	5	143	148	237	242	94	
B29	A29	65	148	213	242	307	94	
C6	B11, B12, C3	56	123	179	499	555	376	
A30	A29	5	148	153	301	306	153	
B30	A30	72	153	225	306	378	153	
A31	A30	5	153	158	358	363	205	
B31	A31	75	158	233	363	438	205	
A32	A31	5	158	163	376	381	218	
B32	A32	70	163	233	428	498	265	
A33	A32	5	163	168	381	386	218	
B33	A33	48	168	216	466	514	298	
C7	B14, B13, C2	50	113	173	505	555	382	
A34	A33	5	168	173	386	491	318	
B34	A34	36	173	209	491	527	318	
C8	B16, B15	45	133	178	510	555	377	
C9	B22, B23	63	178	241	178	241	0	Critical
C10	B24, B25, C9	66	241	307	241	307	0	Critical
C11	B26	68	203	271	239	307	36	
C12	B27, B28, B29, C10, C11	71	307	378	307	378	0	Critical
C13	B30, C12	60	378	438	378	438	0	Critical
C14	B17, B18	50	138	188	158	208	20	
C15	B19	55	153	208	450	505	297	
C16	B20, B21, C14, C15	50	208	258	505	555	297	
C17	B34, C5	28	209	237	527	555	318	
C18	B31, C13	60	438	498	438	498	0	Critical
C19	B32, C18	57	498	555	498	555	0	Critical
C20	B33, C12	41	378	419	514	555	136	
C21	Finish	555						

In the table above, it can be seen that critical activities are activities that do not have waiting time for the next activity. So that critical activities are activity with zero float value. In addition, the critical path can also be seen from the project network diagram shown in fig 3 below.

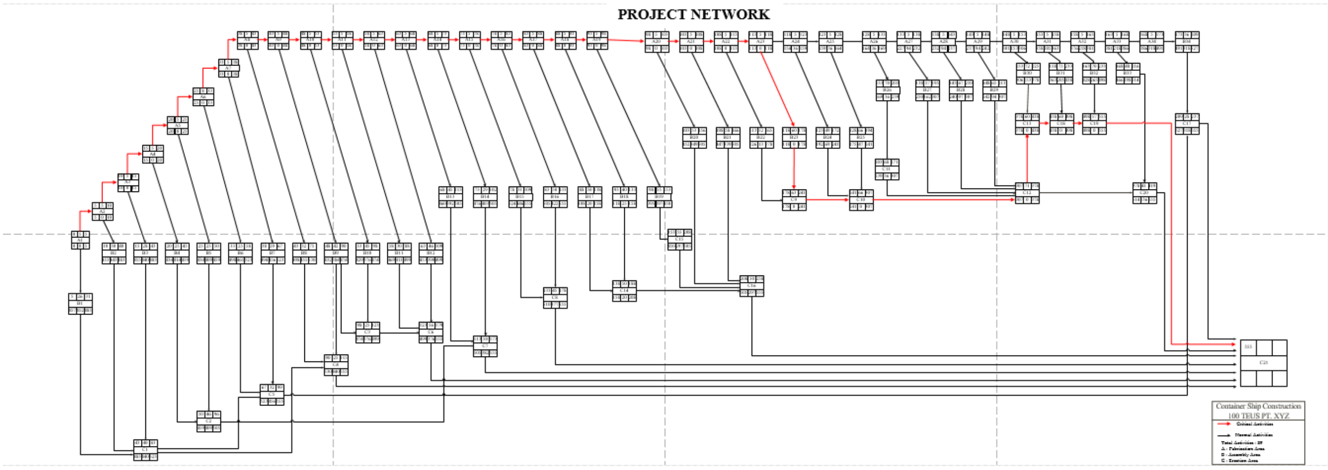

Fig 3. Container 100 TEUS Project Network

Then an analysis of the causes of delays in the project schedule is carried out, especially in the scope of critical activities. Based on the critical activity chain analysis, the activities that have a zero float value are:

1. Fabrication: A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18, A19, A20, A21, A22, A23
2. Assembly: B23
3. Erection: C9, C10, C12, C13, C18, C19

4. Conclusion

From the results of research and discussions that have been carried out, several conclusions are obtained as follows:

1. By using the Critical Path Method CPM in scheduling, it is known that the age for a 100 TEUS ship construction project from start to finish is 555 days
2. Critical Path for a 100 TEUS ship construction project is an activity with the notation A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18, A19, A20, A21, A22, A23, B23, C9, C10, C12, C13, C18, C19.

Suggestions from the results of research and discussion, it can be suggested to the contractor to:

1. Activities/works that are on a critical path can be given more attention because they can disrupt the overall 100 TEUS ship construction project.
2. If there is a delay in returning, the contractor can reschedule with methods of accelerating projects that are on the critical path.

However, this research was conducted at the planning stage of shipbuilding. So the analysis of this critical path method can be a risk prevention of time delays in shipbuilding projects. In addition, the analysis from this research can be used by company as a reference in contractual agreements with ship owners.

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