Pre-Engineering Building Design Study as an Conventional Design Replacement Alternative to get the Efficiency Value

by Agus Suroso

Submission date: 25-Jan-2019 11:24AM (UTC+0700)
Submission ID: 1068281615
File name: Pre-Engineering_Building_Design_Study.pdf (488.87K)
Word count: 3271
Character count: 16318

ISSN No:-2456-2165

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Agus Suroso, Tedy Cahyadi Trenggono
Civil Engineering
Mercu Buana University

Erry Rimawan
Industrial Engineering
Mercu Buana University

Abstract:- Steel construction buildings generally use conventional systems with the main element is a standard wf hot rollet which we often encounter in the market, usually heavier than non prismatic where fabrication is carried out in the field. Pre-engineering building steel construction method is a construction method developed to produce cheaper steel construction, efficient and fast implementation by minimizing the risk of errors, and producing erection methods that can be done in stages, relatively easily and quickly. This study was conducted to determine the value of the cost efficiency of the Pre-Engineering Building design towards conventional design as an alternative design. This research method is carried out based on two stages, namely, literature studies from related institutions as a basis for problems and direct observation methods. The cost analysis process of the Pre-Engineering Building design and conventional design uses secondary data that is in accordance with the conditions in the field so that the resulting cost efficiency can approach the actual situation. It starts by looking for differences in the weight of steel construction to the cost factor in the two constructions. In the end we can find out the extent of the cost efficiency of the Pre-Engineering Building design towards conventional designs. From the results of the analysis, the total cost of the Pre-Engineering Building design is obtained more efficiently with a difference of Rp.3,850,122,944.85, - from a conventional design with a percentage of 3.29% of the project value.

Keywords:- *steel construction, cold formed, pre-engineering building, cost efficiency.*

I. INTRODUCTION

Along with the development of technology, especially in computerized based design, led to the emergence of various innovations in various fields. One of them is in the field of steel construction, ranging from material innovation to the development of pre-construction based design (Pre-Engineering Building). The Pre-Enginering steel construction concept is pre-fabricated from a construction building where the overall design needs of the building have been prepared in the form of a standard building. Then designed with complete building standards and the most economical. The steel material in this concept is designed based on the needs of moment distribution (B.M.D) on the rigid frame portal due to working loads. A profile like this is called Tempered Profile. This profile is not produced like hot rolled in general. The Tempered Profile is formed by combining 3 plate material which is assembled into a tempered component. This material plate is thinner and uses high specifications called high strength. Usually in Indonesia using the SM490 specification YES / YB or SS540. Whereas in conventional system steel construction, fabrication is carried out in the field with the main material in the form of hot rolled or commonly called WF profiles. Characteristics of the Pre-Engineering Building concept:

- Non-prismatic cross sections are based on moment distribution.
- Steel profiles use a combination of built-up cross sections of the main elements, hot rolled section, and cold formed section.
- Design and fabrication are carried out at the factory and brought to the field for installation.
- Connection using bolts.

This Pre-Engineering Building System was developed to produce cheaper steel construction, efficient and fast implementation by minimizing the risk of errors, and producing erection methods that can be done gradually, relatively easily and quickly. Connecting components when erection is done without welding and does not require experienced experts, because in the Pre-Engineering Building system is equipped with a manual erection guide. So that costs can be known to be more accurate and economical. In general this method can save 15% - 20% of development costs. This system refers to design standards (AISC, MBMA, AWS, AISI & JIS), image, fabrication, and manual erection guides.

This design development has begun in the 1960s in the United States, which at that time designed the manufacture of various kinds of shelves / cabinets. According to the Metal Building Association (MBMA) survey that 60% of non-residential buildings in the United States already use this system. From several research results and claims from large companies and problems in conventional construction design, it can be said that the Pre - Engineering Building design is more economical and can accommodate different steel profile standards from each country. Similar research has been carried out by Abhyuday Titiksh (2015), Abhinav Dewangan (2015), Ankur Khandelwal (2015), and Akshay Sharma (2015) in

India who say that the cost of pre-engineering building steel construction is lighter with a 30% percentage of design conventional. Some identification of problems that will be discussed in this study are:

- How big is the difference in the weight of steel construction between pre-engineering design and conventional design.
- How big is the difference in shipping costs and installation of steel construction

The object of the research is the Palm Oil Mill Proposed 45/90 TPH Palm Oil Mill Construction Project. Synergy Argo Industry.

II. LITERATURE REVIEW

A. Manufacturing Procedure

➢ *Pre Engineering Building.*

The manufacturing process begins with the design drawings that have been approved by the buyer then continued with detailed structure planning with Tekla Software. After that, the order of manufacturing is as follows:

- Forming a steel plate into a main frame.
- Cutting steel plate into connection parts of the main frame.
- The welding process becomes main frame.
- Then check dimensions and visuals, magnetic testing (MRI), and ultrasonic.
- Shot blast preparation and painting.
- And finally, Dry Film Thickness Checking, which checks the thickness of the painting.

B. Installation Procedure (Erection Procedure)

Basically, the installation process between the Pre engineering Building Method and the Conventional Method is no big difference. It's just that the Pre engineering Building method is recommended to use at least 2 units of crane cars with the installation of columns first and not directly into a single frame, this is due to anticipation of twisting in the horses section. The following are the main stages of the installation process based on "Erection Manual For Site Engineer" by PEB Steel:

➢ *First Stage*

- Install all columns and complete one side first.
- Adjust the bolt on the anchor in the base plate for the settings during installation.
- Install girts and temporary winds drag.

➢ *Second step*

- Prepare and connect the easel components below.
- Lift the horses parallel and balance with the connection bolt holes in the column.
- Hold the height of the horses until the anchor bolts are set and the column connection to the horses is finished.
- Continue installation of the horses until they are finished and keep installing several purlins and temporarily pulling the wind.

➢ *Step Three*

- Install the column beam, starting from one side.
- Install the purlin (roof cover holder) and girts (wall cover holder).
- Attach the roof and wall wind bonds.
- Install all sagrods (purlin and girts).

➢ *Step Four*

- Install the roof cover.
- Install the ridge caping.
- Install flashing and fascia, if any.
- Install gutters and upright pipes and their brackets.
- Install cladding (wall coverings).

➢ *Step Five (Final Check)*

- Check the bolts and connections on the frame.
- Check roofs and gutters for seepage and rainwater channels.
- Check all bracing and bolt connections.
- Check the damaged paint and repair it.
- After all have been checked clean the site and ready for handover.

III. RESEARCH METHODS

The methodology used in this study is a qualitative approach in the form of elaborating descriptive analysis using literature study data related to the object of research. This research is divided into 8 stages. Each stage has relevance in the next stage. The following is the flow chart of this research:

ISSN No:-2456-2165

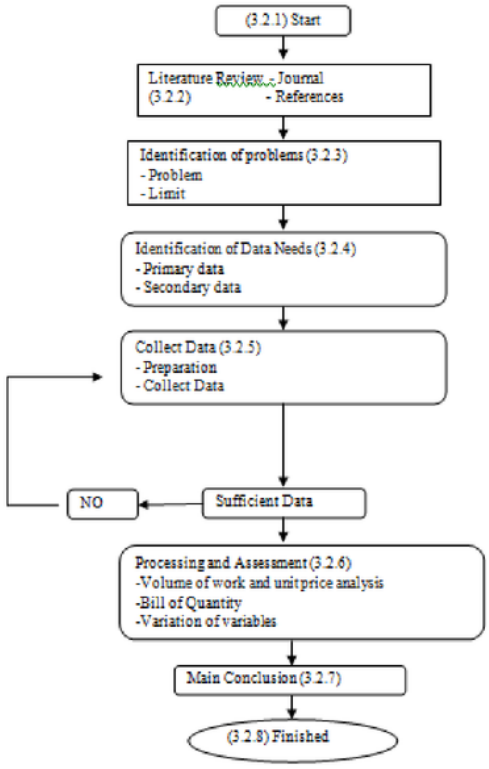

Fig 1:- Research Methodology Chart

A. Study of literature

This study began from literature and literature in the form of scientific journals on the comparison of advantages and disadvantages in the application of Pre - Engineering Building methods and Conventional methods, direct observation in the field and discussions with project leaders on the palm oil mill construction project Proposed 45/90 TPH Palm Oil Mill For PT. Synergy Agro Industry, and actively follow developments and problems related to this study from several civil engineering forums.

B. Identification of problems

Problem identification is an activity of researching, categorizing problems and gathering information from field needs after literature study and data analysis. By identifying the problem, it can clarify the problem and its limitations so that it can be assessed in an efficient scope.

C. Identification of Data Needs and Data Collection

Identification of data needs is the activity of compiling data needed to support the analysis of research, both from relevant institutions and institutions that can be used as a data source. Data needed in the form of primary and secondary data. The primary data in this study are data obtained directly both formally and informally from the manager of the palm oil mill construction project Proposed 45/90 TPH Palm Oil Mill For PT. Agro Industry Synergy as the study case.

Secondary data are data obtained indirectly or from previous records. While the secondary data in this study are the data obtained from the previous records sourced from:

- Brochure document introducing Pre Engineering Building
- Document price quotes
- Civil engineering scientific journal related to the last 5 years Pre-Engineering Building which is accompanied by a relevant theoretical basis.

D. Data Processing and Assessment

Data processing includes calculation of work volume, analysis of work unit prices, and bill of quantity, then proceed with grouping based on data types and assessment process by comparing the two designs based on the Pre - Engineering Building method and Conventional methods so as to get conclusions in the form of factors that affect allocation costs of both designs.

IV. ANALYSIS AND DISCUSSION

A. Project Data

In the palm oil mill construction project Proposed 45/90 TPH Palm Oil Mill For PT. Agro Industry Synergy, with a land area of 196,436,313 m2 and an implementation time of 270 working days. Technically there are 3 main building units which consist of 9 stations with varying dimensions ranging from 18 meters to 39 meters and building lengths between 30 meters to 117 meters. The steel construction used is the Pre-Engineering Building.

B. Analysis of Steel Construction Costs

➢ *Job volume*

In calculating the volume of steel construction, the first thing that must be done is to determine the steel profile to be used and the quantity of the required components based on the specifications desired by the project owner or recorded in the tender. The volume of steel construction is the result of multiplication between the number of steel components needed for a construction building with the unit weight of the steel profile.

In this project there are 3 building units that will be analyzed, resulting in a volume value that will be a variable in the calculation of the Budget Plan (RAB).

No	Work Item	CSB	
		Volume	Unit
1	Building 1		
1.1	Heavy Steel Construction	508,713.30	kg
2	Building 2		
2.1	Heavy Steel Construction	168,075.67	kg
3	Building 3		
3.1	Heavy Steel Construction	67,552.04	kg
Grand Total		744,341.01	kg

Table 1. Volume Recapitulation of Steel Conventional Methods

No	Work Item	PEB	
		Volume	Unit
1	Building 1		
1.1	Heavy Steel Construction	235,418.32	kg
2	Building 2		
2.1	Heavy Steel Construction	86,484.20	kg
3	Building 3		
3.1	Heavy Steel Construction	41,299.24	kg
Grand Total		363,201.76	kg

Table 2. Volume Recapitulation of Steel Construction Pre - Engineering Building Method

➢ *Unit price analysis*

After calculating the volume, the next step is to calculate the unit price analysis for the work. Unit prices in this calculation are obtained from secondary data on offers and employment contracts.

No	Description	Koef	Unit	Unit Price
1	1 kg of materials and steel fabrication Steel Material & Fabrication includes Blasting SA2.5, Prime, Intermedite, and Finish Coat	1	Kg	21,450.00
2	1 Kg Cost of Installing Steel Construction Installation fee	1	Kg	2,500.00
3	1 kg of construction cost Postal fee	1	Kg	1,725.61

Table 3. Calculation of Analysis of Steel Construction Unit Prices with Conventional Methods

No	Description	Koef	Unit	Unit Price
1	1 Kg of Material and Steel Frame Manufacturing Steel Material & Fabrication	1	Kg	Rp29,433
2	1 Kg Supporting Materials & Accessories Steel Material & Fabrication	1	Kg	Rp25,997
3	1 Kg shot Blast S.A 2.5 & Paint 250 Wages & Materials	1	Kg	Rp6,097
4	1 Kg Cost of Installing Steel Construction Installation fee	1	Kg	Rp2,500
5	1 kg shipping cost Vietnam to Jakarta Postal fee	1	Kg	Rp5,247
6	1 Kg Ongkos Kirim Jakarta ke Site Postal fee	1	Kg	Rp1,726

Table 4. Calculation of Analysis of Steel Construction Unit Prices with Pre-Engineering Building Methods

➢ *Bill of Quantity*

After calculating the volume of work and unit price analysis then proceed with calculating the budget plan of the two steel construction designs. Bill of Quantity is the multiplication between Job Volume and Unit Price Analysis.

ISSN No:-2456-2165

No	Material	Volume	Unit	Unit Price	Total price
1	Building 1				
1	Steel Material & Fabrication	508,713.30	Kg	21,450.00	10,911,900,285
1	Installation Wages	508,713.30	Kg	2,500.00	1,271,783,250
1	Shipping costs for Jakarta to Site	508,713.30	Kg	1,725.61	877,840,758
2	Building 2				
2	Steel Material & Fabrication	168,075.67	Kg	21,450.00	3,605,223,122
2	Installation Wages	168,075.67	Kg	2,500.00	420,189,175
2	Shipping costs for Jakarta to Site	168,075.67	Kg	1,725.61	290,033,057
3	Building 3				
3	Steel Material & Fabrication	67,552.04	Kg	21,450.00	1,448,991,258
3	Installation Wages	67,552.04	Kg	2,500.00	168,880,100
3	Shipping costs for Jakarta to Site	67,552.04	Kg	1,725.61	116,568,476
				Subtotal	1,734,439,834
Grand Total		2,233,023.04			19,111,408,066.36

Table 5. Calculation of BOQ Steel Construction Conventional Methods

No	Material	Volume	Unit	Unit Price	Total price
1	Building 1				
1	Main Material & Fabrication Frame	212,709.05	Kg	29,433.38	6,260,745,684.53
1	Supporting Materials & Accessories	22,709.27	Kg	25,997.02	590,373,460.33
1	Shot Blast S.A 2.5 & Paint 250	126,635.27	Kg	6,097.30	772,133,671.89
1	Installation Wages	235,418.32	Kg	2,500.00	599,545,802.35
2	Shipping costs of Vietnam to Jakarta	235,418.32	Kg	5,246.57	1,235,138,975.37
2	Shipping costs for Jakarta to Site	235,418.32	Kg	1,725.61	406,239,743.39
2	Building 2		Kg		
2	Main Material & Fabrication Frame	76,509.67	Kg	29,433.38	2,251,938,073.58
2	Supporting Materials & Accessories	9,974.53	Kg	25,997.02	259,307,973.14
2	Shot Blast S.A 2.5 & Paint 250	49,694.86	Kg	6,097.30	303,004,642.59
2	Installation Wages	86,484.20	Kg	2,500.00	216,210,497.05
3	Shipping costs of Vietnam to Jakarta	86,484.20	Kg	5,246.57	453,745,504.13
3	Shipping costs for Jakarta to Site	86,484.20	Kg	1,725.61	149,237,827.35
3	Building 3				
3	Main Material & Fabrication Frame	37,904.77	Kg	29,433.38	1,115,665,389.89
3	Supporting Materials & Accessories	3,394.47	Kg	25,997.02	88,246,110.93
3	Shot Blast S.A 2.5 & Paint 250	29,448.75	Kg	6,097.30	179,557,965.72
3	Installation Wages	41,299.24	Kg	2,500.00	103,248,099.33
4	Shipping costs of Vietnam to Jakarta	41,299.24	Kg	5,246.57	216,679,400.50
4	Shipping costs for Jakarta to Site	41,299.24	Kg	1,725.61	71,266,299.43
				Subtotal	1,774,663,265.80
Grand Total					15,261,285,121.51

Table 6. Calculation of BOQ Steel Construction Pre-Engineering Building Method

C. Data Comparison

No	Work Item	CSB		PEB		Difference	
		Volume	Unit	Volume	Unit	Volume	Unit
1	Building 1						
1.1	Heavy Steel Construction	508,713.30	kg	235,418.32	kg	273,294.98	kg
2	Building 2						
2.1	Heavy Steel Construction	168,075.67	kg	86,484.20	kg	81,591.47	kg
3	Building 3						
3.1	Heavy Steel Construction	67,552.04	kg	41,299.24	kg	26,252.80	kg
Grand Total		744,341.01	kg	363,201.76	kg	381,139.25	kg

Table 7. Comparison of Steel Construction Volume

No	Work Item	CSB Construction Costs	PEB Construction Costs	Construction Cost Difference
1	Building 1	13,061,523,258	9,853,177,338	3,208,345,920
1.1	Heavy Steel Construction			
2	Building 2	4,315,445,132	3,633,444,518	682,000,614
2.1	Heavy Steel Construction			
3	Building 3	1,734,439,676	1,774,663,266	-40,223,590
3.1	Heavy Steel Construction			
Grand Total		19,111,408,066.00	15,261,285,122.00	3,850,122,944.00

Table 8. Comparison of Steel Construction Costs

V. CONCLUSION

From the discussion and analysis in this study. The results of the approach to construction weights and costs of steel construction are obtained:

- The weight of PEB design steel construction material is lighter with a weight of 381,139.25 kg or 51.20% of the weight of CSB design steel construction material.
- Due to the difference in the weight of the steel construction material the shipping costs at the PEB design from Jakarta to the field are cheaper by Rp. 657,696,952.48 than the CSB design, but require shipping from Ho Chi Minh to Jakarta for Rp. 1,905,563,880.00 due to imported materials.
- The cost of installing PEB design construction is cheaper by Rp. 952,848,131.92 from CSB design.
- So if it is totaled, then the efficiency of the cost of steel construction for the design of PEB is cheaper by Rp. 3,850,122,944.85 from CSB design.

From the results of the above conclusions, it can be said that the Proposed 45/90 TPH Palm Oil Mill For PT. Agro Industry Synergy has a weighting percentage of construction cost efficiency of 3.29% of the work contract value of Rp. 117,000,000,000.00 if using the Pre-Engineering Building method.

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