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Comparative Analysis Study on Construction Cost Between Concrete Structures and Steel Structures Buildings in Surabaya

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Abstract: High-rise buildings in Indonesia must be designed resistance to receiving earthquakes. This is because the earthquake load that occurred in Indonesia has a high intensity. So that existing buildings, especially multi-story buildings must ensure good performance in receiving earthquake loads. This effort aims to maintain the safety of its users. Several aspects that need to be considered in designing earthquake-resistant buildings are structural performance and construction costs. Therefore, in this study, we will discuss the designed of earthquake-resistant structures by making comparisons on concrete structures and also steel structures which will then analyze the cost of the structure for the structures that have been analyzed and designed. From the results of the analysis, for the same conditions, earthquake resisting frame with reinforced concrete construction, it requires cheaper construction costs compared to steel construction. Concrete construction requires a structural cost of Rp 19,030,188,114.0 and for a steel structure of Rp 72,206,697,860.7. This is certainly not a conclusion that concrete construction is superior to steel construction. Because even though it is more expensive in terms of cost, steel construction is quite superior in terms of quality, time efficiency and ease of implementation.

Keywords: *Construction Costs; Earthquake Resistant ; SRPMK.*

1. Introduction

In Indonesia, the design of earthquake-resistant buildings is very important, because many areas are located in earthquake areas ranging from small to large earthquakes. This building has 9 floors and 1 basement. It is located on Surabaya, which is a strong earthquake-prone area, so that in building planning it is necessary to pay attention to the earthquake factor in the area. With the condition of Indonesia which has a fairly high intensity of earthquakes, it is necessary to have the ability to overcome them, especially the impact on the collapse of buildings, so as to minimize the impacts caused by the earthquake such as material losses and loss of life. Therefore, in this research, we try to re-plan and analyze the comparison of the structural costs of the Surabaya Hotel building 9 floors and 1 basement with a reinforced concrete structure system and a steel structure system. So there is a need for an analytical study in order to obtain a more cost-effective building plan and structure, with the hope of getting a building structure that is more resistant to earthquakes.

2. Research Methods and Literature Review

2.1 Bill of Quantity (BOQ)

BOQ is a detailed calculation of the costs required for each job in a construction project, so that an estimate of the total cost required to complete the project is obtained. To determine the costs required for a project, it is necessary to know the components that make up these costs, which consist of:

a. Material and Material Cost Materials are all materials used in the project which are ultimately part of the end of the project. Material costs are obtained based on the unit price multiplied by the volume of work. If quantity data is obtained from drawings, then quality data is obtained from specifications. Generally, these prices come from producers and distributors.
b. Wage Cost Labor costs consist of direct wages and indirect wages. Direct wages are wages paid to workers in each certain period. Indirect wages include insurance and various benefits.
c. Equipment Cost The determination of the number and type of tools is adjusted to the volume of work and field conditions. Costs can be in the form of ownership costs, fuel costs, and maintenance costs.

Type of Budget of Quantity (BOQ):

a. General

In general, the following types of budget costs in managing a business:

- Cost budget for new product introduction by adding and using new machines and equipment.
- Budget for replacement of new machines and equipment.
- Cost budget for product expansion by increasing the capacity of machines and equipment needed by the company.
- Budget for expanding office buildings, shops, factories, warehouses etc

b. Construction Project Budget of Quantity (BOQ)

The Budget Plan is divided into 4 types when viewed based on the project development process from the idea until the project is handed over from the contractor to the owner. This is explained below:

- Detailed Budget Plan (Contractor) This Cost Budget is made by the contractor after seeing the design of the planning consultant such as bestek drawings and work plans and requirements, in the manufacturing process it is more detailed, thorough and thorough because it has taken into account all possibilities such as seeing the field of work in the field and considering the implementation methods. This Budget Plan is then described in the form of an offer by the contractor at the time of the auction, and becomes a fixed price for the owner after one of the partners is appointed as the winner and the Work Agreement has been signed.
- Estimated Budget Plan (Owner) The Budget Plan is required by the owner to decide whether to implementing ideas to build a project or not are usually still assisted by a Project Feasibility Study. This rough Budget Plan is also used as a guide to a carefully calculated cost budget.
- Preliminary Budget Plan (Planning Consultant) It can also be referred to as a preliminary cost budget plan, this cost budget calculation is carried out after the plan drawing (design) has been completed by the planning consultant. The calculation of this cost budget is more thorough and accurate in accordance with the provisions and conditions for the preparation of the cost budget.

2.2 Project Technical Data

- Building function: Hotel building
- Building length: 73.23 m
- Building width: 11.93 m
- Building height: 36.30 m
- Building structure: Reinforced concrete

- Floor plate thickness: 12 cm
- Thickness of the roof plate: 10 cm
- Concrete Quality : K 400
- Quality of Main Reinforcement : BJ TS 40
- Quality of stirrup reinforcement: BJ TS 28

2.3 Planning Stage

The stages of planning this hotel building include the following stages:

a. Study Literature
b. Looking for theoretical references that are relevant to the case or problem.
c. Structural Analysis
d. To get the magnitude of the internal forces acting on the building structure, using the Trial version of the ETABS program.
e. Carry out controls and applicable conditions
f. Controls and requirements are carried out based on SNI regulations for concrete and steel.
g. Unit price analysis
h. Calculating Work Volume
i. The volume of work is calculated using the Trial version of the ETABS aid program.
j. Calculate the total budget and do price comparisons in rupiah units.

3. Results and Discussion

3.1 Mass Participation Ratio Control With Concrete Structure

Table 1. Mass Participation Ratio Control With Concrete Structure

Mode	Period sec	UX	UY	UZ	Sum UX	Sum UY	Description
1	1,607	0,806	0,009	0	0,806	0,009	Arah X
2	1,294	0,010	0,722	0	0,816	0,731	Arah Y
3	0,925	0,000	0,033	0	0,816	0,765	Torsi
4	0,425	0,069	0,000	0	0,885	0,765	Arah X
5	0,31	0,000	0,105	0	0,886	0,870	Arah Y
6	0,243	0,038	0,000	0	0,924	0,871	Torsi
7	0,222	0,000	0,00	0	0,924	0,873	Arah X
8	0,178	0,033	0,000	0	0,958	0,873	Arah Y
9	0,151	0,000	0,041	0	**0,958**	**0,921**	Torsi
10	0,125	0,005	0,000	0	0,964	0,921	Arah X
11	0,107	0,000	0,005	0	0,964	0,926	Arah Y
12	0,102	0,000	0,001	0	0,964	0,928	Torsi

(*Output source: display-show table-analysis-result-modal result-modal participating mass ratio)*

From the table above, it can be concluded that Mass Participation is fulfilled up to Mode 9 and has been able to meet the minimum 90% Mass Partition requirements.

3.1.6 Mass Participation Ratio Control With Steel Structure1

Table 2. Mass Participation Ratio Control With Steel Structure

Mode	Period sec	UX	UY	UZ	Sum UX	Sum UY	Description
1	1,157	0,000	0,816	0	0,000	0,816	Arah X
2	0,889	0,842	0,000	0	0,842	0,816	Arah Y
3	0,845	0,002	0,000	0	0,844	0,817	Torsi
4	0,306	0,000	0,082	0	0,844	0,899	Arah X
5	0,233	0,067	0,000	0	0,912	0,899	Arah Y
6	0,228	0,002	0,000	0	**0,914**	**0,900**	Torsi
7	0,172	0,000	0,048	0	0,914	0,948	Arah X
8	0,142	0,045	0,000	0	0,960	0,948	Arah Y
9	0,133	0,000	0,029	0	0,960	0,977	Torsi
10	0,127	0,000	0,000	0	0,960	0,978	Arah X
11	0,109	0,022	0,000	0	0,983	0,978	Arah Y
12	0,098	0,000	0,000	0	0,983	0,978	Torsi

(*Output source: display-show table-analysis-result-modal result-modal participating mass ratio)*

From the table above, it can be concluded that Mass Participation is fulfilled up to Mode 6 and has been able to meet the minimum 90% Mass Partition Ratio requirements.

3.2 Result of Output Force (Moment Shear Force and Axial Force)

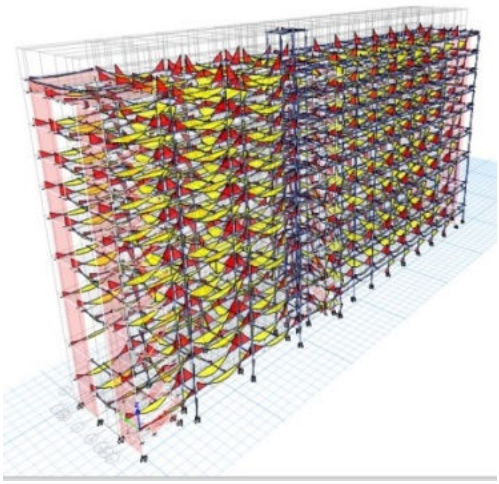

Fig. 2. Moment of building structure with concrete structure

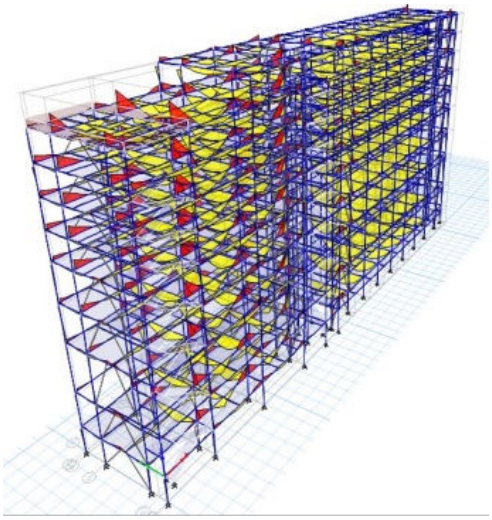

Fig. 3. Moment of building structure with steel structure

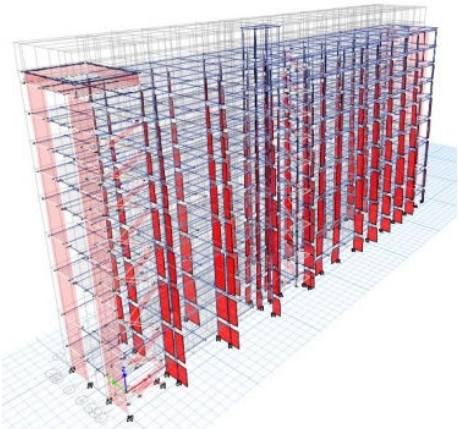

Fig. 4 Axial Force of building structure with concrete structure

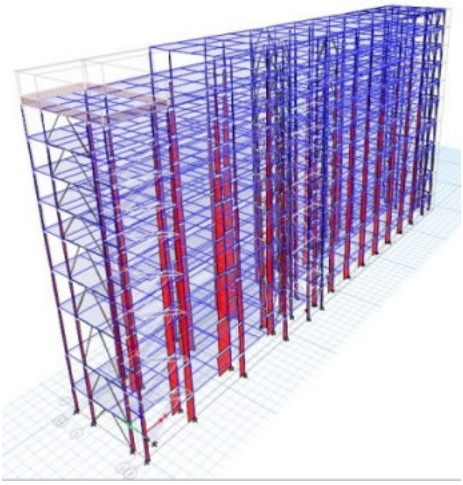

Fig. 5 Axial Force of building structure with steel structure

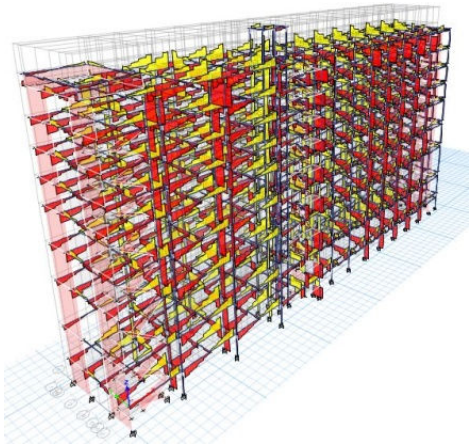

Fig. 6 Shear Force of building structure with concrete structure

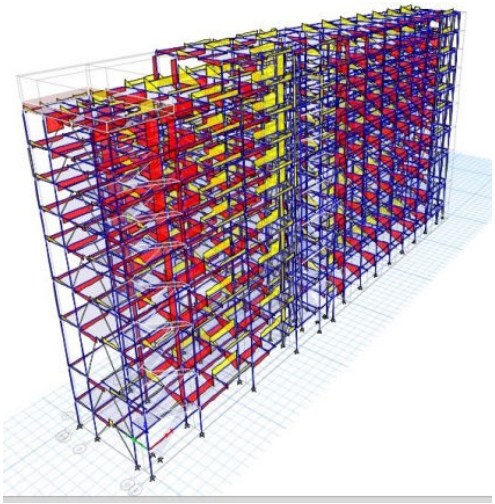

Fig. 7. Shear Force of building structure with steel structure

3.3 Budget of Qeluantity (BOQ)

- **Work Unit Price Analysis**

Table 3. Cost of steel construction work / kg

Type	coefficient		Detail	unit price		Cost
Material	1,15	kg	Profil Steel IWF/C	12000		13.800,00
	0,08	kg	Steel meni	31625		2.530,00
Worker	0,006	Oh	Foreman	149500	897,00	
	0,006	Oh	Blacksmith	135900	815,40	
	0,06	Oh	Worker	115600	6.936,00	
	0,003	Oh	Chief foreman	156400	469,20	
			Sum		9.117,60	18.330,00
			Total			26.447,60

(Source: Work Unit Price Analysis Calculation)

Table 4. Cost of steel reinforcement work / kg

Type	coefficient		Detail	unit price	Cost	
Material	1,05	kg	Reinforcing steel	12000		12.600,00
	0,015	kg	Wire	19500		292,50
Worker	0,0004	Oh	Chief foreman	156400	62,56	
	0,0007	Oh	Foreman	149500	104,65	
	0,007	Oh	Blacksmith	135900	951,30	
	0,007	Oh	Worker	115600	809,20	
			Sum		1.927,71	12.892,50
			Total			14.820,21

(Source: Work Unit Price Analysis Calculation)

Table 5. Cost of concrete casting works fc' = 26,4 Mpa (K-300) w/c=0,52 Slump(12+/-2)

Type	coefficient		Detail	unit price	Cost	
Material	413	kg	Portland cement	1230,5		508.196,50
	681	M2	Concrete sand	146,14		99.523,29
	215	Ltr	Water	215		46.225,00
	1021	M2	Gravel	223,48		228.174,59
Worker	0,03	Oh	Foreman	149500	4.186,00	
	0,28	Oh	Blacksmith	135900	37.372,50	
	1,65	Oh	Worker	115600	190.740,00	
	0,08	Oh	Chief foreman	156400	12.981,20	
			Sum		245.279,70	882.119,38
			Total			1.127.399,08

(Source: Work Unit Price Analysis Calculation)

Table 6. Cost of column framework installation / m2

Type	coefficient		Detail	unit price	Cost	
Material	0,028	M2	Terentang wood	1500000		42.000,00
	0,28	kg	Nail	19400		5.432,00
	0,14	Ltr	Formwork Oil	20000		2.800,00
	0,011	M2	Column formwork	1500000		15.700,00
	2	Btg	wood ∅8/10-4	4200		8.400,00
Worker	0,033	Oh	Foreman	149500	4.933,50	
	0,33	Oh	Carpenter	135900	44.847,00	
	0,32	Oh	Worker	115600	36.992,00	
	0,006	Oh	Chief foreman	156400	938,40	
			Sum		87.710,90	74.382,00
			Total			162.092,90

(Source: Work Unit Price Analysis Calculation)

Table 7. Cost of beam formwork installation / m2

Type	coefficient		Detail	unit price	Cost	
Material	0,028	M2	Terentang wood	1500000		42.000,00
	0,28	kg	Nail	19400		5.432,00
	0,14	Ltr	Formwork Oil	20000		2.800,00
	0,0105	M2	Column formwork	1500000		15.750,00
	2	Btg	wood ∅8/10-4	4200		8.400,00
Worker	0,033	Oh	Foreman	149500	4.933,50	
	0,33	Oh	Carpenter	135900	44.847,00	
	0,32	Oh	Worker	115600	36.992,00	
	0,033	Oh	Chief foreman	156400	5.161,20	
			Sum		91.933,70	74.382,00
			Total			166.315,70

(Source: Work Unit Price Analysis Calculation)

Table 8. Cost of plate formwork installation, Listplank / m2

Type	coefficient		Detail	unit price	Cost	
Material	0,028	M2	Terentang wood	1500000		42.000,00
	0,28	kg	Nail	19400		5.432,00
	0,14	Ltr	Formwork Oil	20000		2.800,00
	0,0105	M2	Column formwork	1500000		15.750,00
	6	Btg	wood ∅8/10-4	4200		25.200,00
Worker	0,033	Oh	Foreman	149500	4.933,50	
	0,33	Oh	Carpenter	135900	44.847,00	
	0,32	Oh	Worker	115600	36.992,00	
	0,033	Oh	Chief foreman	156400	5.161,20	
			Sum		91.933,70	91.182,00
			Total			183.115,70

(Source: Work Unit Price Analysis Calculation)

From the table of work unit price analysis above, a total value of 183.115.70 is obtained for the Shafira Hotel Surabaya building.

- **Volume and Budget of Quantity**

Table 9 Volume and Budget of Quantity Steel Construction

Section	Elemen Type	Total	Total Length (m)	Total Weight (kg)	Volume	Unit Price (Rp)	Total Price (Rp)
BK 20.12	Beam	267	829,78	47820,7	47820,7	25.448	1.216.921.723,5
400.200.9.12	Beam	300	1381,12	90206,8	90206,8	25.448	2.295.547.392,6
400.200.12.22	Brace	198	823,8199	85617,6	85617,6	25.448	2.178.762.731,5
522.485.35.35	Column	550	2131,6	842980,3	842980,3	25.448	21.451.825.743,7
448.417.30.45	Beam	1077	4165,75	1607770,3	1607770,3	25.448	40.913.894.444,8
498.422.45.70	Beam	94	94	55810,2	55810,2	25.448	1.420.236.424,1

P-130	Wall	71177,3	29,7	2.609.420	77.388.101,4
P-130	Floor	40973,7	17,1	2.609.420	44.548.982,5
Plate 13 cm	Floor	2398300,5	999,3	2.609.420	2.607.572.316,7
				Total	72.206.697.860,7

(Source: Volume Calculation and Budget Plan)

From the budget plan table above, the value of Rp. 72.206.697.860,7 is calculated (Seventy Two Billion Two Hundred Six Million Six Hundred Ninety Seven Thousand Eight Hundred Sixty Point Seven Rupiah) for the Hotel Surabaya Building Steel Portal Construction.

Table 10 Volume and Budget of Quantity Cocrete Construction

Section	Elemen Type	Total	Total Length (m)	Total Weight (kg)	Volume	Unit Price	Total Price
K1 70Xx70	Concrete + column reinforcing	99	391,6	459824,9	191,6	4.832.454	925.867.623,3
	Formwork				1096,5	162.092	177.730.636,2
K2 60x60	Concrete + column reinforcing	189	747,6	644949,3	268,7	4.832.452	1.298.619.263,1
	Formwork				1794,2	162.092	290.831.950,1
K3 50x50	Concrete + column reinforcing	162	561,15	336180,7	140,1	4.832.452	676.907.023,0
	Formwork				1122,3	166.315	181.915.851,6
B1 40x70	Concrete + beam reinforcing	428	2297	1390613,2	579,4	4.832.452	2.800.129.575,2
	Formwork				4134,6	166.315	687.645.999,0
B2 40x70	Concrete + beam reinforcing	276	1097,57	655564,3	273,2	4.832.452	1.319.992.708,9
	Formwork				1975,6	166.315	328.575.238,2
B3 30x60	Concrete + beam reinforcing	176	423,74	144841,8	60,4	4.832.452	291.642.161,2
	Formwork				762,7	166.315	126.853.772,6
BA 25x50	Concrete + beam reinforcing	333	1330,31	397141,3	165,5	4.832.452	799.652.597,7
	Formwork				2394,6	166.315	398.250.913,8
SW1	Concrete + wall reinforcing			409491,6	170,6	4.832.452	824.520.162,5
	Formwork				1421,8	183.155	260.361.307,7
Plate 120	Concrete + plate reinforcing			2066312,8	861	7.055.483	6.074.514.598,5
	Formwork				7174,7	183.155	1.313.794.685,3
Plate 100	Concrete + plate reinforcing			66375,0033	27,7	3.350.431	92.660.350,4
	Formwork				230,5	183.115	42.202.287,3

Section	Elemen Type	Total	Total Length (m)	Total Weight (kg)	Volume	Unit Price	Total Price
Plate 100	Concrete + plate reinforcing			32732,0128	13,6	3.350.431	45.694.306,9
	Formwork				113,7	183.155	20.811.536,5
SL 150	Concrete + wall reinforcing			14294,8198	6	7.055.483	42.025.691,3
	Formwork				49,6	183.155	9.088.874,7
						Total	**19.030.188.114,9**

(Source: Volume Calculation and Budget Plan)

From the budget plan table above, the value of Rp. 19.030.188.114,9 is calculated (Nineteen Billion Thirty Million One Hundred Eighty Eight Thousand One Hundred Fourteen Point Nine Rupiah) for the Hotel Surabaya Building Concrete Portal Construction.

4. Conclusions

Based on the results of planning the concrete structure and steel structure of the Surabaya hotel. Then the following conclusions are drawn: Comparison of the quantity and price of the structure on the concrete and steel structure for the building is Rp 19,030,188,114.0 for the concrete structure and Rp 72.206.697.860,7 for the steel structure. From this it can be concluded that the cost of reinforced concrete structures can be more efficient than steel structures in the same case (structure system and its resistance). However, this still needs to be studied for other cases with other quantity calculation methods.

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