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COST BASED ELEVATOR SCHEDULING IN UNIVERSITY OF AL AZHAR INDONESIA

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ABSTRACT

Facility is an important factor for a university. It could become a factor for high school student to decide their university choice. While it is critical for university to provide and maintain the facilities to be as good as possible it could be expensiveto operate hence efficiency effort need to be done. One efficiency target is the elevators operating cost. Currently there are 4 elevators serving university's seven floors.This paper explained an approach on improving elevators' cost efficiency by calculating their electricity power needed then combining them with the class schedule.

Based on commercial social rate for the university, the cost of operating the elevator was Rp 10.192.943,32 in (December 2014*) for working 8 hours and 27 seconds. Included Rp 3.899.139,20. unnecessary cost using by the passenger go along with the elevator to opposite direction, before they reach their destination, or we called it" tamasya". Then we scheduled the number of elevator that operate in every hours based on class scheduled, it could reduce the cost to Rp. 224.026,76. Acquired a lower cost by doing rescheduled the elevator as many as five group. Rescheduled elevator with as many as five groups needed cost Rp. 9.968.916,56.*

Keywords : elevator, cost, "*tamasya*", scheduled

1. INTRODUCTION

High-rise buildings are signature of a modern city. In these buildings, to accommodate speed and free movement between floors, a vertical transportation mode such as elevator is needed. It was Elisha Otis who made the similar elevator we used today, in term of safety. He invented the brake and safety system that secure elevator from free fall to the ground, that revolutionary change the elevator technology. He demonstrated it in 1853 at the Crystal Palace New York.

University of Al Azhar Indonesia's building, a seven floors building in the middle of South Jakarta, also using four elevators to support the movement of its occupant, mostly college student. The busiest time of the elevator is in between the class ending and beginning. Because of crowd elevator, student often should wait to enter the elevator to the desired floor. For example student from 4th floor wants to go to 6th floor, sometimes saw 2 elevator passing him because the elevator did not go upstairs and the other one already full. Sometime it cause student to take any elevator that pass him, even if the elevator is go downstairs. So the student takes the elevator to go down stair first before he reaches the desired floor upstairs. We defined this habit as "*tamasya*". Which cause a unnecessary cost that should be eliminated.

Whilst the cost of operating the elevator already high, added by this "*tamasya*" habit.

The objective of this paper are:

1. Calculate the cost of "tamasya"
2. Scheduling the number and time of elevators that operate to reduce cost.

Scope of the study:

1. Study was made in office hours.
2. Cost was made based on commercial social rate from PLN that divide the cost in 2 time zone. *Waktu Beban Puncak (WBP)* is Rp 955,5 hour at 22.00-17.00 WIB and *Luar Waktu Beban Puncak (LWBP)* is Rp 1433.25 hour at17.00-22.00 WIB.

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2. THEORY

2.1. Elevator

Elevator is a vertical transportation mode that has periodic movement. It could be used by people or goods through a vertical guide rail.Most elevators consist of a cage and pendulum and other components. There are several type of elevator. UAI's elevators hadpassengers limited, up to 17 people.Cage weight is 517 kg And pendulum heavier than the cage added by 45% passenger. Cage and pendulum was set to be always in balance when half full[1]

2.2. Calculation and Current Resource

Electric power is the rate at which electric energy is transferred by an electric circuit. Also could be defined as the speed of an electric energy could be transferred.

The speed of objects can be multiplying with force in speed direction. In the international system unit, unit of power is watt (w) defined as 1 j/s in the british system, a unit of power is ft.lb/s [4].

And the formula of electrical power is:

$$p = v.i \quad \text{.....(1)}$$

The building has 380 volt, 3 phasa. Three phasa is electricity installation using 3 wire phasa and amp 1 wire 0 (neutral), 3 phasa consisting of three cable using electricity and 1 cable neutral. For electric power with 3 phasa the formula is:

$$P = \sqrt{3}.V.I.\cos\theta \quad \text{.....(2)}$$

Cos θ is power factor, the power factor mean is the slope towards motorcycle building the elevator, amounting to 0.92.[2]

Electric current is a flow of electric charge. If the electric charge had some obstacles in a thin wire, it defined as current flows. Current is a quantity of charge that passed a circuit in certain amount of time measured in unit of coulomb per second or ampere[5]. If objects has negative charge it's mean the package have a surplus of electrons. Contains in objects measured by amount have overbalance astir. A charge of an electron, often expressed with symbol *q* or *e*, expressed by a unit of coulomb, that is the sizes of the an electrical current measured in parts of electrons per second.

3. RESEARCH METHODS

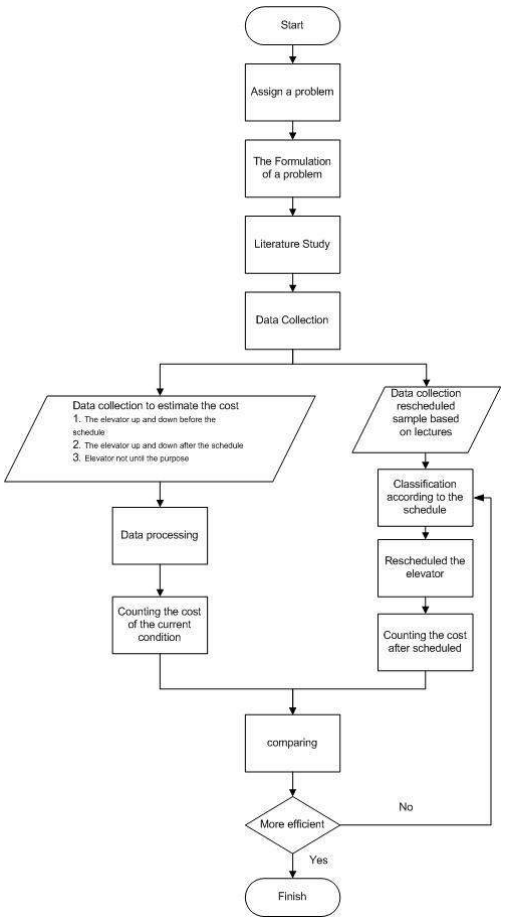

Figure 1. Flowchart Research

4. RESULTS AND DISCUSSION

4.1. Data and Calculation

Table 1. Calculation of Elevator Down

The elevator down a month with the operation of 3 hours			
No	Capacity	Floor	Cost (Rp)
1	1-3 person	7	1129657,15
2	1-3 person	6	1067187,63
3	½ full	5	723605,27
4	½ full	4	655929,96
5	½ full	3	609077,82
6	full	2	281112,84
7	full	G	223849,11
	TOTAL		4,690,419,781

In table 1, is the cost calculation of the elevator down for a month. The maximum operation of elevator down for a day is 3 hours. The elevator down for a month need cost Rp. 4.690.419,781.

In table 2, is the cost calculation of the elevator upstairs for a month. The maximum operation of elevator upstairs for a day is 3 hours. The elevator upstairs for a month need cost Rp. 1.603.384,34.
In table 3, is the cost calculation of the elevator not to appropriate destinations for a month. The elevator not to appropriate destinations for a month need cost Rp. 3.899.139,20.

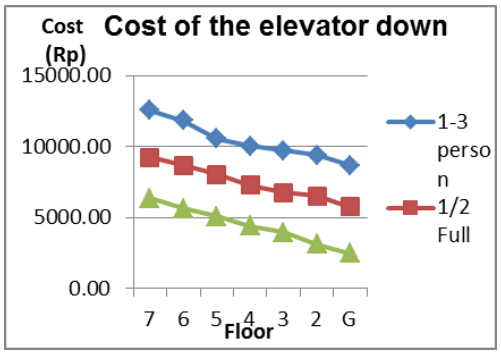

Diagram 1. The Cost of The Elevator Down

Table 2. Calculation of Elevator Upstair

The elevator upstair a month with the operation of 3 hours			
No	Capacity	Floor	Cost (Rp)
1	Full	G	421669,26
2	Full	2	406051,88
3	½ full	3	244672,29
4	½ full	4	203025,94
5	½ full	5	166585,39
6	1-3 person	6	93704,28
7	1-3 person	7	67675,31
	TOTAL		1,603,384,343

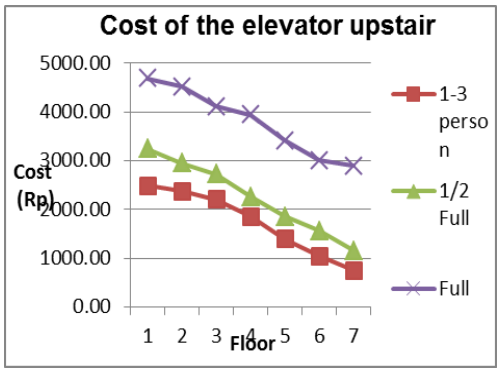

Diagram 2. The Cost of Elevator Upstairs

Table 3. Calculation of Elevator Not To Appropriate Destinations

The elevator not to appropriate destinations	
No	The cost of one month (Rp)
1	5,934,604,385
2	8,901,906,577
3	1192126,67
4	1223361,43
TOTAL	3,899,139,20

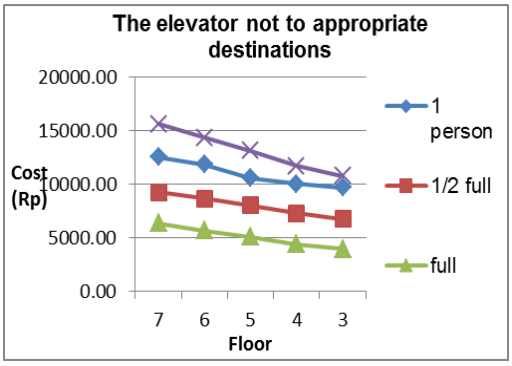

Diagram 3. The Cost of Elevator Upstairs

Table 4. 1st Shedule of The Elevator

Time	Floor	The Number of Students	Rising capacity	Capacity down	The elevator that operates			
					1	2	3	4
07.00 - 09.00	Lt 2	115	1-3 Person	1-3 Person	V	V	-	-
	Lt 3	-	-	-				
	Lt 4	130	Full	Full				
	Lt 5	128	Full	Full				
	Lt 6	88	½ Full	½ Full				
09.01 - 13.00	Lt 2	228	1-3 Person	1-3 Person	V	V	V	V
	Lt 3	169	Full	Full				
	Lt 4	362	Full	Full				
	Lt 5	422	Full	Full				
	Lt 6	63	½ Full	½ Full				
13.01 - and so on	Lt 2	63	1-3Person	1-3 Person	V	V	-	-
	Lt 3	96	½ Full	½ Full				
	Lt 4	231	Full	Full				
	Lt 5	144	Full	Full				
	Lt 6	52	½ Full	½ Full				

In table 4, is scheduling the lift for every day in three groups. Scheduling are based on many students and employees at the university of appropriate with time go to college and out of college. A mark V in table said the total amount of the elevator that on, while a sign minus (-) is a sign the elevator in position standby. Even though the elevator in a state of standby, the elevator could not be used because the elevator is locked. The elevator was left in a position to the cost of standby the elevator remain stable.

Table 5. Cost 1st Schedule of The Elevator

Time	Floor	Cost Elevator	
		Upstair	Down
07.00 - 09.00	2	2371,528068	9428,270124
	3	0	0
	4	1966,633032	2198,001624
	5	1706,343366	2545,054512
	6	780,868998	4338,1611
09.01 - 13.00	2	9486,1	37713,1
	3	8792,0	34705,3
	4	7403,8	37019,0
	5	5552,8	34705,3
	6	4164,6	32160,2
13.01 – and so on	2	5928,8	23570,67531
	3	6796,5	16918,82829
	4	9833,16516	10990,00812
	5	8531,71683	12725,27256
	6	3904,34499	21690,8055
TOTAL 1 DAY		77219,26758	280707,9442
TOTAL 1 MONTH		10737816,35	
TOTAL 1 MONTH + NOT TO APPROPRIATE DESTINATIONS		11517644,19	

In table 5, is the cost calculation of the elevator 1st schedule for a month. The elevator 1st schedule need cost Rp. 11.517.644,19. The cost was obtained from the cost of the elevator upstair a month, the cost of the elevator down a month, and 20% of the cost of not to appropriate destinations.

Table 6. 2nd Shedule of The Elevator

Time	Floor	The Number of Students	Rising capacity	Capacity down	The elevator that operates			
					1	2	3	4
07.00 - 09.00	Lt 2	115	1-3 person	1-3 person				
	Lt 3	-	-	-				
	Lt 4	130	Full	Full	-	V	-	-
	Lt 5	128	Full	Full				
	Lt 6	88	½ Full	½ Full				
09.01 - 13.00	Lt 2	228	1-3 person	1-3 person				
	Lt 3	169	Full	Full				
	Lt 4	362	Full	Full	V	V	V	V
	Lt 5	422	Full	Full				
	Lt 6	63	½ Full	½ Full				
13.01 - 15.00	Lt 2	-	-	-				
	Lt 3	35	1-3 person	1-3 person				
	Lt 4	68	½ Full	½ Full	V	-	-	-
	Lt 5	70	½ Full	½ Full				
	Lt 6	17	½ Full	1-3 person				
15.01 - 17.00	Lt 2	63	1-3 person	1-3 person				
	Lt 3	61	½ full	½ full				
	Lt 4	143	Full	½ full	V	V	-	-
	Lt 5	74	½ full	½ full				
	Lt 6	35	½ full	1-3 person				
17.01 – and so on	Lt 2	1-3 person	1-3 person	1-3 person				
	Lt 3	1-3 person	1-3 person	1-3 person				
	Lt 4	1-3 person	1-3 person	1-3 person	V	-	-	-
	Lt 5	1-3 person	1-3 person	1-3 person				
	Lt 6	1-3 person	1-3 person	1-3 person				

In table 6, is scheduling the lift for every day in five groups. Scheduling are based on many students and employees at the university of appropriate with time go to college and out of college. A mark V in table said the total amount of the elevator that on, while a sign minus (-) is a sign the elevator in position standby. Even though the elevator in a state of standby, the elevator could not be used because the elevator is locked. The elevator was left in a position to the cost of standby the elevator remain stable.

Table 7. Cost 2nd Schedule of The Elevator

Time	Floor	Cost Elevator	
		Upstair	Down
07.00 - 09.00	2	2371,5	9428,27
	3	0	0
	4	1966,63	2198
	5	1706,34	2545,05
	6	780,87	4338,16
09.01 - 13.00	2	9486	37713,2
	3	16427,2	15964,4
	4	15733,2	17584
	5	13650,8	20360,4
	6	6246,8	34705,2
13.01 - 15.00	2	0	0
	3	1,099,001	4858,74
	4	1,127,922	3,644,055
	5	9,254,744	3,383,766
	6	780,869	3,268,081
15.01 - 17.00	2	4,743,056	9428,3
	3	2,718,581	6767,5
	4	3933,3	7288,1
	5	1850,9	8040,1
	6	1561,7	11857,6
17.01 - dst	2	592,882	2,357,068
	3	5,495,004	2429,37
	4	4,627,372	2,516,133
	5	1,041,159	2,646,278
	6	2,602,897	2964,41
TOTAL 1 DAY		90016,76	216286,2
TOTAL 1 MONTH		9,189,088,716	
TOTAL 1 MONTH + NOT TO APPROPRIATE DESTINATIONS		9,968,916,56	

In table 6, is the cost calculation of the elevator 2nd schedule for a month. The elevator 2nd schedule need cost Rp. 9.968.916,56. The cost was obtained from the cost of the elevator upstair a month, the cost of the elevator down a month, and 20% of the cost of not to appropriate destinations.

Table 8. Conclusion

No		Before rescheduled	After rescheduled 1st Schedule	After rescheduled 2nd Schedule
1	The total cost of the elevator for one month	Rp. 10.192.943,32	Rp. 11.517.644,19	Rp. 9.968.916,56
2	Elevator active operate from hour 7 am -- 6 pm	All the four elevator	According to the clock	According to the clock
3	The elevator upstair costs for one month	Rp. 1.603.384,34	Rp. 2.316.578,027	Rp. 2.700.503
4	The elevator down during one month	Rp. 4.960.419,78	Rp. 8.421.238,327	Rp. 6.488.586
5	The cost of not to appropriate destination the elevator for a month	Rp. 3.899.139,20	Rp. 779.827,84	Rp. 779.827,84

In table 8, is the difference table cost given before scheduling and after scheduling. So from the table can be known that the scheduling of the elevator with five times need cost more cheaper, as big as Rp. 9.968.916,56.

4.2. Discussion

From our observation and calculation, we know that cost of elevator going down is more expensive than the cost of elevator going up. Because when the elevator going down, the pendulum should be raised, and need more electricity power, than when the pendulum going down. It showed at graph 1 and graph 2. The number of passengers in the elevator also effect the electricy power. The more people in the elevator, the greater electricity power used. Its mean more people, more cost to operate the elevator. The lift maximum capacity is ± 1150 kg or 15 people. So people who intend to go to some level of floor, and does not want to wait, and take whatever elevator open first, then he/she go another direction before go to the intended floor (we called it "*tamasya*") was wasting money, it should be banned.

Table 3, show our observations on several Mondays on first semester in 2014, each 3 hours. The average cost of 4 elevators at university is Rp 10.192.943,32..per month. In this calculation we were using

Then we made a schedule based on class schedule gathered form academic bureau.

For the scheduling, we use trial and error. First, we try to grouping the schedule of the elevator to 3 groups (table 4). With this schedule the elevators will operate at at 07.00- 09.00 2 elevators , at 09.01 - 13.00 4 elevators, and 13.01 – 07.00 as much as 2 elevators. The cost will be Rp 10737816,35.

Then, we try to grouping the schedule of the elevator to 5 groups (table 8). With this schedule the elevators will operate at at 07.00- 09.00 1 elevator, at 09.01 - 13.00 4 elevators, 13.01-15.00 1 elevator, 15.01-17.00 2 elevators, and finally 17.01- 07.00 will be 1 elevator. With this scheduling the cost will be Rp. 9.968.916,56.

Because scheduling 5 elevators cheaper than scheduling 3 elevators we used the grouping of 5 elevators scheduling.

The implementation of scheduling the elevator would need cooperation from the building management, because their operator to lock the elevator based on the schedule. And not to turn off the elevator, because they turn off the elevator, when they turn on the elevator the cost will be greater than in the stand by mode.

We also recommend the building management a campaign in "no *tamasya* in using the elevator"

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the cost study of elevator operation, we get that the existing average monthly cost of elevator operation was Rp 10.192.943,32. And the wasting cost for people who go "*tamasya*" was Rp 3.899.139,20.

With trial and error, we scheduled the elevator into 5 group, the cost of operating elevator will be: Rp 9.189.088,716 if we add 20% people still do the " *tamasya*" the cost will be Rp 9.968.916,556

5.2 Recomendation

For further study we recommend to use scheduling the elevator with machine scheduling or optimization. And also to make standard format calculation to schedule the elevator day by day based on class schedule.

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