Design of Top Traction Elevator in Building 6 Floor

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Design of Top Traction Elevator in Building 6 Floor

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ABSTRACT

Various kinds of technology and scientific discoveries produced by mankind have led to innovations in multi-story construction, especially office buildings that are widely built in the city of Jakarta. This research is under construction, in which to find out whether the design used is appropriate and efficient. From the calculation results, the design of an elevator at a capacity of 1000 kg with a speed of 60 Mpm, a car 1600 X 1400 Hoitsway 2430 X 2240 X 2350 obtains a carrying capacity of 1000 kg (13 people) and a power of 6.19 kW which comes from the Harmoni building (6 floors building). While the tensile stress on the elevator rope is 188.8 kg with an allowable tension of 909.1 kg and the age of the rope is 59.69 months or 4.9 years. The pull on the elevator rope is 131.63 kg with an allowable tension of 909.5 kg and the age of the rope is 1115.3 months or 9.6 years. with an elevator carrying capacity of 630 kg (8 people) and a speed of 105 Mpm (1.75 m/s).

Keywords: Top Traction, Elevator

INTRODUCTION

The development of science and technology is the main driving force to assist human activities in daily life. One of the mobility in question is the elevator as vertical transportation used to transport people or goods [1]. So that the researcher intends to conduct research with the title "top traction lift design with a capacity of 1000 kg and a speed of 60 mpm car 1600 x 1400 hoistway 2430 x 2240 x 2350 6-floors building which is under construction at Harmoni building, where to find out whether the design used is appropriate and efficient so as to increase safety and comfort for all elevator uses including people with disabilities [2].

The initial planning for the harmony building elevator (6 floors building) was 60 mpm (1.5 m/s), carrying capacity of 1000kg (13 people) originating from PT. X. So, in the design analysis, it is expected to get a design that meets the needs of the harmony floor (6 floors building) at a speed of 105 mpm (1.75 m/s) and the carrying capacity of the lift is 630 kg (8 people) and the rope life is longer [3].

The traction machine is driven by an electric motor. The traction machine uses gears that function to control the mechanical movement of the elevator by rolling the steel hoist rope over the drive sheave mounted on the gearbox where the motor used is high speed. When the elevator is turned off or the safety device is working, the elevator brake will hold the brake and stop the elevator to ensure the safety of passengers. In the process of emergency braking, due to the brake shoe effect, the whole elevator traction system will have a strong enough vibration [4][5].

This analysis uses literature and observation methods so that it is expected to be easier. so this study focuses on the appropriate speed, appropriate capacity, and rope age to support the convenience of elevator users and elevator efficiency to be used in a 6-story building (Harmoni building) by estimating the number of population in the building, calculating the elevator needs analysis for the building. The 6 floors, calculate and check the interval (I) according to SNI, calculate the efficiency of the use of elevator capacity that affects the motor power requirement (driver motor capacity), ropes and cabin size, calculates Round Trip Time (RT), and the number of elevators [6].

RESEARCH METHOD

In conducting research, planning for passenger elevators must go through the stages that must be followed, using the flow chart of the method below which aims to make this research work by following the results obtained in the field and what will be planned as shown in Figure 1.

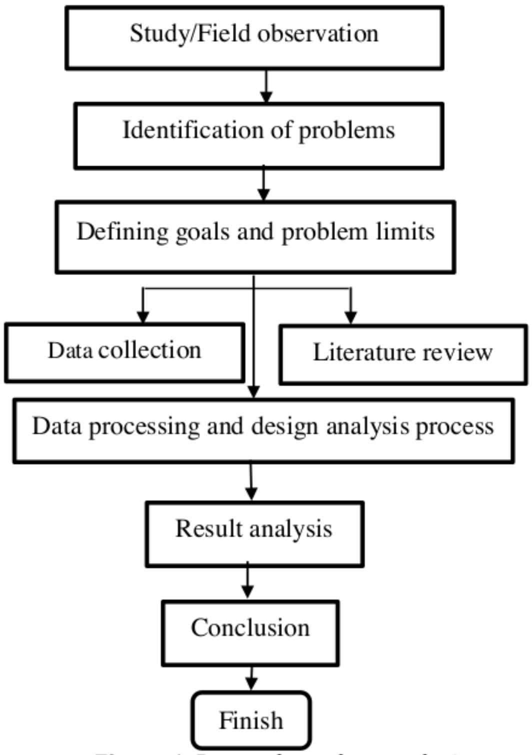

Figure 1. Research on elevator design

RESULTS AND DISCUSSIONS

Based on the data from the field survey, it is known that the area of each floor is 280 m^2. The length of the building is 35 m^2 and the width of the building is 8 m^2, so it can be seen that the total area of the 6-storey building is 1680 m^2. While the area used for the Hostway car elevator is 5.4432 m^2 which is obtained from the length times the width, which is 2.43 m^2 times 2.43 m^2.

The Number of Lifts is Based on The Size and Area of The Building

Building area: $1647\ \mathrm{m}^2$, while the standard for the density of people (in the office) is the need for fresh air per adult in cubic meters divided by the need for fresh air per child in meters $\frac{24\mathrm{m}^3}{2{,}5\mathrm{m}} = 9.6\ \mathrm{m}^2$. Then the number of building users has used the formula: $JPB = \frac{1647\mathrm{m}^2}{9.6\ \mathrm{m}^2} = 171.9$ people, and the number of people transported is: JOA(Hc)=17% x 171.59 people = 29.1703 people.

Elevator Design with a Capacity of 1000 kg with a Speed of 60 m/m (1m/s)

1. Calculation of initial elevator requirements with a capacity of 1000 kg with a speed of 60 m/m (1m/s)

To find the distance in one lift/elevator cycle is the building height x 2 = 2 x 20 m = 40 m. While the travel time of 1 cycle is $\frac{40\ \mathrm{m}}{1\frac{\mathrm{m}}{\mathrm{s}}} = 44\ \mathrm{s}$, so that the maximum time passengers enter the elevator is the number of passengers x 1 s = 10.4 people = 10.4 s (the number of passengers according to the standard provisions in the catalog PT. Daicichi Elevator Indonesia 1000 kg maximum 13 people) [7]. From the above calculation, the elevator capacity (h) in 5 minutes is $h = \frac{300 \times \text{number of people transported one way (P)}}{\text{travel time (RT)}} =$

$\frac{300 \times 10.4}{62.6} = 40.84 \frac{\text{people}}{\text{5 minute}}$. So the number of elevators needed is $N = \frac{\text{JOA Hc}}{h} = \frac{29.17}{40.48} = 0.72$, so it can be concluded, the number of elevators needed (N) is 0.72 = 1 piece (rounded up). While the check interval is $I = \frac{RT}{N} = \frac{61.6}{1} = 61.6$. Meanwhile, the opening and closing time of the door is 2 x 3.5s = 7 s and the downtime is for each floor, which is 5 floors x 0.8s = 4 s. waiting time data is shown in table 1.

Table 1. Suggested elevator interval

Description	Times
Passengerless Elevator Up And Down	40 s
Maximum Passenger Time Entering the Elevator	10,4 s
Open and Close the Door Assuming 2 Times The Door is Open-Closed	7 s
Downtime Each Floor	4 s

Based on the results of the interval calculation above, the data mentioned above are included in the suggested elevator interval category (average waiting time) for an Apartment or Hotel Resort with an interval (in second) of 60-90 [8] so it is not OK considering the building being built is used. for agency office buildings ranging from 30 to 40 (according to SNI-03-6573-2001) [9].

2. Calculation of initial elevator requirements with a capacity of 630 kg at a speed of 105 m/m (1.75m/s)

In designing an elevator with a capacity of 630 kg with a speed of 105 m/m (1.75m/s), the elevator capacity (h) is: $h = \frac{300 \text{ x } 6.4\text{org}}{39.26\text{s}} = 48.90 \frac{\text{people}}{(\text{5 minute})}$, so the number of elevators needed is: $N = \frac{29.17}{49.90} = 0.585$, then it can be simulated, N=0.585=1 (rounded up), while check interval $I = \frac{39.2}{1} = 39.2$. waiting time data is shown in table 2.

Table 2. Suggested elevator interval

Description	Times
Passengerless Elevator Up And Down	22.86 s
Maximum Passenger Time Entering the Elevator	6,4 s
Open and Close the Door Assuming 2 Times The Door is Open-Closed	6 s
Downtime Each Floor	4 s

Based on the data above, the interval is good according to the suggested elevator category, the interval for agency office buildings ranges from 30 to 40 [9].

3. Calculation of load-carrying capacity in the design of an elevator with a capacity of 1000 kgs, 60 M/M

The carrying capacity of an elevator can be calculated using the formula: Capacity (Q) = 13 people x 73 kg/person = 949 kg, while the weight of the cage (G cage) = 300 + 125F, where F is the area of the cage with the formula length x width then, Gs = 300+125(1.6 mx 1.4 m) x kg/m2 = 580kg. By obtaining the weight of the cage, the counterweight (Gcw) is = Cage Weight + 0.45 Capacity = 580 kg + 0.45(1000) = 1030 kg. Then the total weight (Qtotal) = Gs + Q transport + Gcw = 2610 kg (Car/Cabin).

4. Motor power calculation

The driver to be used in the 1000 kgs, 60 Mpm elevator design is Nst = $\frac{Q+Gs-Gcw)}{75.\eta total}$(Hp) or P = $\frac{Q\left(1-\frac{O}{B}\right)xV}{6120\ X\ \eta\ total}$ so that P = $\frac{1000kg\ x(1-0.45)x60m/m}{6120\ X\ 0.87(\frac{G}{L})}$ = 6.19 kw,while driving efficiency is total $\eta\ \left(\frac{G}{L}\right)$ = 0.95 x 0.85 x 0.97 = 0.74 ≅ 0.87

5. Rope calculation

The calculation of the rope used in the elevator design with a capacity of 1000kgs, 60 Mpm is type = 6x37 = 222+1c, and Dmin/d = 25, while the maximum pulling force of the rope is $S_w = \frac{2610\frac{kg}{5}}{3.0,95.0,97}$ = 188.82 kg so that the cross-sectional area of the rope $F_{(222)} = \frac{188,82}{\frac{\frac{16000kg}{cm^2}}{8,80} - \frac{1}{25}.36.000} = \frac{188,82}{1818,18-1440} = 0.499cm^2 =$ 0,5cm². For wire diameter $\emptyset = \sqrt{\frac{4.0,5cm^2}{3.14x222}} = \sqrt{\frac{2\ cm^2}{697,08}}$ = 0.054 cm . For the rope diameter used (d) = 14.2 mm, weight per meter = 0.670 kg, actual fracture strength = 10200 kg/mm2, 12.07 mm ≈ 13 mm (rounded up) then the rope used is Ø 14.2 mm. The actual tensile strength of the rope $= \frac{S}{F_{222}} \frac{188,82\ kg}{0.5\ cm^2} =$ $377,64\frac{kg}{cm^2}$ = 3.8 kg/mm². The breaking strength of the steel rope is $P_{222} = F.\sigma_b =$ $0.5\ cm^2.\frac{16000kg}{cm^2}$ = 8000 kg, and the allowable tensile stress of the rope is obtained $S_b = \frac{P_{222}}{K} = \frac{8000\ kg}{8,80}$ = 909.1 kg.

The allowable tensile stress of the rope is obtained Smax = 909.1 kg while from the previous calculation it is obtained that the tensile stress that occurs in the rope is S = 188.82 kg, so it can be concluded that the rope is safe against tensile loads.

Average number of duty cycles per month = 1000, while f actor price m is $\frac{D_{min}}{d}$ = m. σ. NB. C. C1. C2 or 25 = m x 2.42 kg/mm² x 4 x 0.93 x 0.97 x 1 so m : 25/13.71 = 1.82.

Then the number of repeated bending winding cycles that occur before the rope breaks (z) with the interpolation formula: $y = x + \left[\frac{b-a}{c-a}\right] x\ (z-x) = 280 + \left[\frac{1,82-1,74}{1,87-1,74}\right] x$ $(310-280)$ = 298.459. The number of cycles of repeated bending allowed can be calculated from the equation: $Z_1 = \frac{Z}{\phi} = \frac{298.459}{2,5}$ = 119.383,6 times of bending, so that the life of the rope can be calculated from the following equation: $N = \frac{Z_1}{a.Z_2.\beta} = \frac{119.383,6}{1000.4.0,5} =$ 59,6918 months or 4.97 years.

Design of an Elevator with a Capacity of 630 kg, 105 Mpm

1. Calculation of the carrying capacity of the elevator design with a capacity of 630 kgs, 105 Mpm

The carrying capacity of an elevator can be calculated using the formula: Capacity (Q) = 8 people x 73 kg/person = 584 kg, while the weight of the cage (G cage) = 300 + 100F, where F is the area of the cage with the formula length x width then, Gs = 300+125(1.1 mx 1.6 m) x kg/m2 = 476 kg. By obtaining the weight of the cage, the counterweight (Gcw) is = Cage Weight + 0.45 Capacity = 476 kg + 0.45(630) = 759.5 kg. Then the total weight (Qtotal) = Gs + Q transport + Gcw = 1819.5 kg (Car/Cabin).

2. Motor power calculation

The driver that will be used in the 630 kgs, 105 Mpm elevator design is Nst = $\frac{Q+Gs-Gcw)}{75.\eta total}$(Hp) or $P = \frac{Q\left(1-\frac{O}{B}\right)xV}{6120\ X\ \eta\ total}$ so that $P = \frac{630\ kg\ x(1-0.45)x105 m/m}{6120\ X\ 0.87(\frac{G}{L})} = 6.83$ kw, while driving efficiency is $\eta\ total\frac{G}{L} = 0.95\ x0.85\ x0.97 = 0.74\ \cong 0.87$.

3. Rope calculation

The calculation of the rope used in the elevator design with a capacity of 1000kgs, 60 Mpm is type = 6x37 = 222+1c, and Dmin/d = 25, while the maximum pulling force of the rope is $S_w = \frac{1819{,}5\frac{kg}{5}}{3.0{,}95.0{,}97}$ =131.63 kg so that the cross-sectional area of the rope $F_{(222)} = \frac{131{,}63}{\frac{\frac{16000kg}{cm^2}}{9{,}50} - \frac{1}{25}.36.000} = \frac{131{,}63}{1684{,}21-1440} = 0.539cm^2 =$ $0.54\ cm^2$. Then the K used is 9.50 (SNI 03-6573-2001). For wire diameter $\emptyset = \sqrt{\frac{4.0{,}54cm^2}{3.14x222}} = \sqrt{\frac{2{,}16\ cm^2}{697{,}08}} = 0.0556$ cm or 0.57 mm. For the diameter of the rope used (d) = $1.5\ \times 0.57\ \times \sqrt{222} = 12.74$ mm. Based on the standardization of steel rope with a diameter of 12.74, the weight per meter = 0.670 kg, the actual fracture strength = 10200 kg/mm2 or 12.74 mm ≈ 13 mm (rounded up) then the rope used is Ø 14.2 mm. The actual tensile strength of the rope $= \frac{S}{F_{222}} = \frac{131{,}63\ kg}{0.54\ cm^2} = 241{,}90\frac{kg}{cm^2} = 2.42\ kg/mm^2$. The breaking strength of steel rope is $P_{222} = F.\sigma_b = 0.54\ cm^2.\frac{16000kg}{cm^2} = 8640$ kg, and the allowable tensile stress of the rope is obtained $S_b = \frac{P_{222}}{K} = \frac{8640\ kg}{9{,}50} = 909.5$ kg.

The allowable tensile stress of the rope is obtained Smax = 909.5 kg, while from the previous calculation it is obtained that the tensile stress that occurs in the rope is S = 131.63 kg, so it can be concluded that the rope is safe against tensile loads.

Average number of duty cycles per month = 1000, while f actor price m is $\frac{D_{min}}{d} = m.\sigma.NB.C.C1.C2$ or 25 = m x 2.42 kg/mm² x 4 x 0.93 x 0.97 x 1 so m : 25/8.73 = 2.86. Then the number of repeated bending winding cycles that occur before the rope breaks (z) with the interpolation formula: $y = x + \left[\frac{b-a}{c-a}\right]x\ (z-x) = 550 + \left[\frac{2{,}86-2{,}77}{2.94-2{,}77}\right]x$ $(600-550) = 576.470{,}58$. The number of cycles of repeated bending allowed can be calculated from the equation: $Z_1 = \frac{Z}{\phi} = \frac{576.470{,}58}{2{,}5} = 230.588{,}23$ bending times, so that the life of the rope can be calculated from the following equation: $N = \frac{Z_1}{a.Z_2.\beta} = \frac{230.588{,}23}{1000.4.0{,}5} = 115.29 = 115.3$ months.

From these calculations, it is found that the age of the rope is 115.3 months or 9.61

years. So then the steel rope is replaced before 9.6 years (life < 9.6 years) of service life even though the visual condition of the steel rope looks good, this is caused by factors that affect the strength of the rope, for example, the working condition of the rope due to friction, possibly some the rope is already broken along the fiber layer or steel rope range [10].

Engine Room/Top Traction Design

The design of the engine room/top traction is the most important room, where all the elevator operation processes take place as a whole [11]. In the engine room there are several elevator propulsion devices including the Control System or Control Panel (Control Cabinet), Geared Machine or Driving Machine, Primary Velocity Transducer/Encoder and governor. In the Indonesian national standard, the engine room height is at least 2 meters, so if you look at the engine room data in a 6-story building which is under construction, it is 2.5 m so that it can be categorized according to applicable standards [12].

Overhead and Pitdepth

Overhead design is something that a designer needs to pay attention to, especially the distance between the last floor and the roof of the hoistway/base of the engine room, where the amount depends on the speed of the lift [13]. For 60 mpm, it's usually around 4.45 m and for speeds of 105 mpm the top-end overhead height is at least 4.85 m [14]. While the pit depth design is the distance from the first floor to the bottom of the hoistway. The depth of the lower end pit R/L is at least 1.55 m for a lift at 60 mpm and for a speed of 105 mpm in a lower end pit of 2 m [14]. In the design that has been planned for an elevator capacity of 1000 kg, the overhead size is 4.5 m and the pit depth used is 1.5 m, but what is of concern to the researchers is that to achieve SNI RTT which requires a speed of 1.75 m/s and is sufficient with a capacity of 630. kg then the required overhead is 4.85 m and a pit depth of 2 m. So if the elevator used is 1.75 m/m speed, the distance between the last floor to the roof of the hoistway/base of the engine room must be added to a minimum height of 0.35 m from the previous plan data to comply with Indonesian national standards and the depth of the pit must be increased. about 0.5 m from the previous plan data in order to comply with applicable standards.

Car/Cabin

The elevator cabin operates in the sliding room and treads on the rails on both sides, on the right and left there is a sliding guide that functions to guide or climb the rail [15]. In the analysis of the design of the elevator car/cabin, the researcher's attention in determining the car/cabin on the 6-story building is that everyone who will use the elevator feels comfortable. Where the cabin/car elevator that is intended for the public and people with disabilities must have a mirror that can reflect the image of everyone who is in the elevator. The use of this mirror itself is to anticipate all crimes that may occur while in the elevator car/cabin. The mirror layout can be designed on the door or left-right side or along with the cabin.

CONCLUSION

From the results of the recalculation on the design analysis of the elevator top traction 1000 kgs 60 MPpm car 1600 x 1400 hoistway 2430 x 2240 x 2350 in a 6-level Harmoni building, it can be concluded that the appropriate elevator needs are: The required speed is 105 Mpm or 1.75 m/s, the elevator top traction design 1000 kgs 60 Mpm car 1600 x 1400 hoistway 2430 x 2240 x 2350 in a 6-level Harmoni building does not meet the RTT (round trip time) according to the SNI interval (30-40) the suggested category is an agency office building so that it uses power (P) = 6.19 kW. However, if the elevator has a capacity of 1000 kg, the speed is changed to 1.75 m/s to meet the RTT according to the SNI interval (30-40) for the suggested category of agency office buildings so that the required power is P = 10.94 kW.

The need for an elevator that may be used as an alternative is an Elevator with a capacity of 630 kg with a speed of 1.75 m/s or 105(Mpm). The alternative elevator capacity of 630 kg with a speed of 105 Mpm (1.75 m/s) meets the RTT according to the SNI interval (30-40) for the suggested category of the agency office building so that the required power (P) = 6.83 kW is approximately 0.64 kW of an elevator with a capacity of 1000kg with a speed of 1 m/s and is smaller about 4.11 kW from a speed of 1.75 m/s with a capacity of 1000 kg so that the power required is more efficient. By using a capacity of 630 kg with a speed of 1.75 m/s, you can save about 10-20% on the cost of purchasing an elevator. In terms of the life of the rope used, the service life is longer at a capacity of 630 kg compared to a capacity of 1000 kg with the size of the rope used is 14.2 mm according to the standard.

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