# Sustainable Analysis of Lightweight Lift System Design for Disable People Using Finite Element.

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*Abstract* - Lift is a kind of system in building to move people vertically. In Malaysia, most of the lifts in the buildings are available only five levels and above. Thus, the movements of disable people below than five levels are limited. There are the idea of the design and analysis of light weight and lift system for the use of disable people is developed. The aim of design is transporting a disable people using wheelchair from ground floor to first floor. Design concept of lift is based on rails, electric motor and gears. The structural and component model of lift is developed using the CAD software. The three-dimension solid model is then imported to the FEM software to analyze the sustainable of the lift system. Thus, stress and strain relation was figured to identify the behavior of elastic limit and the strength of structure to resist the application of forces acting without breaking.

## INTRODUCTION

By this era development, we cannot avoid and forget about the disabled people. They are also contributed in development of this country. Because of the human right, they also have the right to enjoy the facilities same like the normal people such as education, employment, proper housing, medical care, accessible transportation, a barrier-free environment, sports and recreation facilities and also a right to participate in all aspects of life. Disable people subjected for whom using wheelchair or more specifically people is difficult or impossible to walk due to the mental or physical illness, injury, or disability to move. In this research the design and analysis of light weight and lift system for the use of these disable people are developed. The objective of this study is to design and analysis the sustainable lift system. The function of lift is transporting a disable people using wheelchair from ground floor to the first floor.

*Type of Elevators*

Currently, there are two types of elevators, hydraulic and traction or roped. The hydraulic elevator consists of a cab attached to the top of a hydraulic jack similar to a jack used for a car lift in a service station. The hydraulic jack assembly normally extends below the lowest floor and is operated by a hydraulic pump and reservoir, both of which are usually located in a separate room adjacent to the elevator shaft. Hydraulic elevators are generally used in single-family residences [1]. The second type is the roped elevator. This is the system that is most commonly associated with elevators. The roped system consists of a cable that is connected to the top of the cab and is operated by an electric motor located in a penthouse above the elevator shaft [1] [2].

*Material Analysis*

Stress and strain analysis was about observation on the strength behavior of the material. Behavior of material represent on relationship between the applied loads and the response of the structure modeling of material plasticity for test Series P36 as shown in Fig. 1[3][4]. Thus, the graph is plotted in terms of stress and strain curve. The curve will always slope upwards and never reverse, as true stress is corrected for the decrease in cross-sectional area. The peak stress on the engineering stress-strain curve is known as the ultimate yield strength. After a period of necking, the material will rupture and the stored elastic energy is released as noise and heat. The stress on the material at the time of rupture is known as the breaking strength.

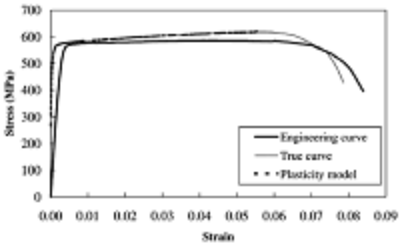



Fig. 1: The graph of Stress Versus Strain of the structure modeling of material plasticity for test Series P36.

## METHODOLOGY

The lift or elevator only limited for one disable passenger only, with maximum load of 1500N. The space of the platform is about 1m x 1m. It is able to place one disable passenger and wheelchair. It is also has a rack gear which is connected to the spur gear. The spur gear is connected to the break motor. The function of break motor is to control the spur gear to moving upward and downward. Design concept of lift is based on rails, electric motor and gears [5]. The structural and component model of lift will be developed using the CAD software. The three-dimension solid model is then imported to the FEM software to analyze the sustainable of the lift system.

The materials that had been choosing to make this lift are steel, carbon steel like C-45, alloy steel like EN 24 to construct spur gear and pinion gear. Meanwhile to construct the cab or platform with rail we use galvanizing steel and AISI 1005 steel. For every material discovered, material properties also need to be determined. These material properties are important to calculate the ultimate tensile strength, hardness, creep, bending strength and torsional strength [8].

The analysis was held based on the applying loads to the critical part as shown in the Fig. 2. The load on the platform structure is starting from the optimum value for the lift system which is 1500N. The load of 1500N represent the maximum capacity of the passenger attach on the platform. The stress and strain analysis is use to investigate about the sustainability of the critical parts involved in the lift system. This analysis also discuss about stress allowable in each of the critical parts.

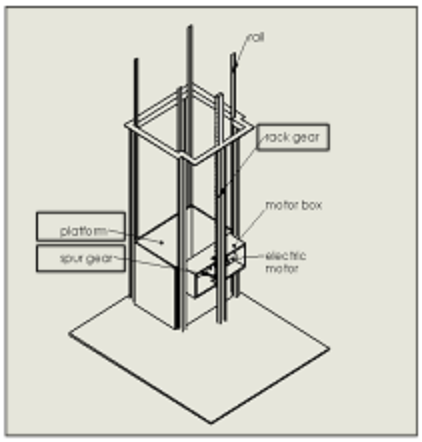
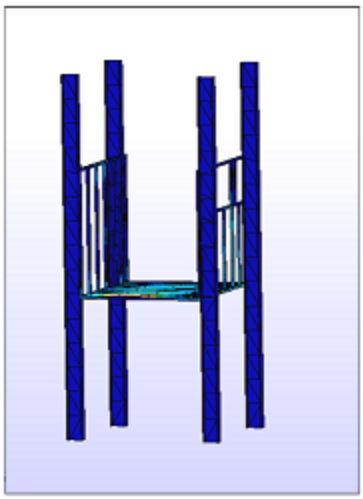



Fig. 2: Design of lift system. The critical parts of lift system which are platform and gears will be analyzed using FEM software.

This lift system was analyzed by using ALGOR software. This software was used to determine the stress and the strain value after considering its mesh, material properties, boundary condition and forces attach on the lift system. All the information involves in the analysis was based on the real condition of the lift system. Then, the result value was analyzed in the incremental value of force attach on the lift system.

## RESULT AND DISCUSSION OF THE ANALYSIS

In the analysis of the critical part, each critical part was analyzed using different value of forces. There were 10 different of forces acting on the reasonable area of parts. From Fig. 3 and 4 of the von misses stress and strain analysis show the effect of forces acting on the area. By using this method, it can define the sustainable part for the lift system.



(a)

Fig. 3: The von misses stress analysis for platform and I beam model.

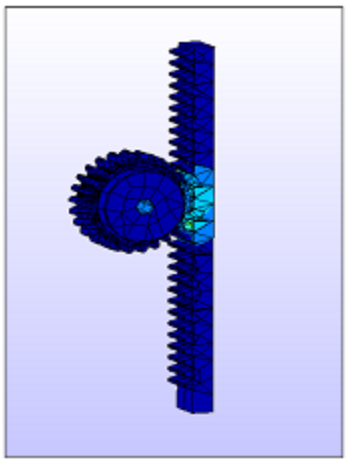


Fig. 4: The von misses stress analysis for spur and linear rack gears model.

The result of analysis data was collected and arranged to form of table for platform and I beam part shown in table 1 and spur and linear rack gears are shown in table 2. The load in the table was predicted base on the material properties of each of the part. From the table range loads for platform and beam are 2000N to 20000N and range loads for gears are 4000N to 12000N interval. The stress and strain analysis is about to determine the distribution of stresses and the deformation the assembly parts [6] [7]. First the data of von misses strain was collected to define as the deformation of the part per unit length. Then second the data of von misses stress was define as the forces acting on the parts per unit area.

Table 1: Results analysis data of the maximum von misses stress and strain of the platform and beam part.

| Results data for platform and I beam | | | |
|---|---|---|---|
| No. | Load (N) | Max. Strain (mm/mm) | Max. Stress ($N/mm^2$) |
| 1 | 2000 | 1.71E-04 | 2.64E+01 |
| 2 | 4000 | 3.41E-04 | 5.29E+01 |
| 3 | 6000 | 5.12E-04 | 7.95E+01 |
| 4 | 8000 | 6.82E-04 | 1.06E+02 |
| 5 | 10000 | 8.51E-04 | 1.32E+02 |
| 6 | 12000 | 1.02E-03 | 1.59E+02 |
| 7 | 14000 | 1.19E-03 | 1.85E+02 |
| 8 | 16000 | 1.36E-03 | 2.11E+02 |
| 9 | 18000 | 1.54E-03 | 2.38E+02 |
| 10 | 20000 | 1.71E-03 | 2.64E+02 |

Table 2: Results analysis data of the maximum von misses stress and strain of the spur and linear rack gears.

| Results data for spur and linear rack gears | | | |
|---|---|---|---|
| No. | Load (N) | Max. Strain (mm/mm) | Max. Stress ($N/mm^2$) |
| 1 | 4000 | 7.77E-05 | 1.20E+01 |
| 2 | 6000 | 1.16E-04 | 1.81E+01 |
| 3 | 8000 | 1.55E-04 | 2.41E+01 |
| 4 | 10000 | 1.94E-04 | 3.01E+01 |
| 5 | 20000 | 3.88E-04 | 6.02E+01 |
| 6 | 40000 | 7.78E-04 | 1.20E+02 |
| 7 | 60000 | 1.16E-03 | 1.81E+02 |
| 8 | 80000 | 1.55E-03 | 2.41E+02 |
| 9 | 100000 | 1.94E-03 | 3.01E+02 |
| 10 | 120000 | 2.33E-03 | 3.61E+02 |

When a load is applied to the particular part, deformation will be results. The deformation is elastic if it completely recovered immediately after load is removed. Purely elastic deformation is associated with stretching of the primary bonds in specimens. Stress is the force per unit area.

$$\sigma = F/A \quad (1)$$

Strain is elongation per unit length:

$$\varepsilon = \Delta L / L \quad (2)$$

By plotting the von misses stress verses the von misses strain as the increasing load applied to the part so as increased the yield a von misses stress-strain diagram. The graphs of both parts are representing yield strength of the material in the lift system. The theoretical measurement of stress when maximum force 1500N attached on the platform was 1.98E+1 $N/mm^2$. Whereby, the theoretical measurement of stress when maximum load 2440N attached on the rack gear was 0.732E+1 $N/mm^2$. Based on the theoretical show that maximum force attach on the platform and gears were not affected the stress and strain in the Fig. 5 and 6.

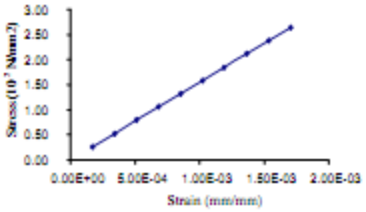



Fig. 5: The graph of the yield strength of the platform and I beam.

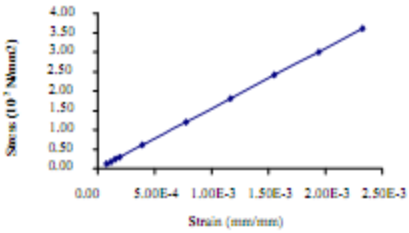



Fig. 6: The graph of the yield strength of the spur and linear rack gears.

Materials undergo strain when they are subject to stress. The relationship between stress and strain is different for different materials, and can be appreciated by plotting stress against strain. Yield strength ($\sigma_y$) is the stress at which strain change from elastic deformation to plastic deformation, causing it to deform permanently. The value of yield strength of platform analysis is 200 kN/mm. Then the yield strength for gears connection is 351 kN/mm. In this module, we assume that materials obey the first type of behavior, linear elastic. After the yield point, the specimens will undergo a period of strain hardening in which the stress increases again with increasing strain up to ultimate strength. If the specimens are unloaded at this point, stress- strain curve will be parallel to that portion of the curve between origin and the yield point. In the yield point the elongation the materials are permanent that mean the material was fails and unavailable for use.

## CONCLUSION

The stress and strain relation was figured. After increasing steadily, the load will observed to suddenly drop to slightly lower value, which is maintained for a certain period while the part keeps elongating. But in the graph analysis above show the increasing continually without dropping. According to further studied state that the result data given from analysis using software hardly defined the value of load drop to the lower value. So, the value of the yield strength was identified in the material properties of the software report. Based on yield strength, the lift structure can resist the force applied and effort to bring disable people.

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