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Research on methods of combining geogebra software and inventor for calculation of scissor car lift

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Abstract
Currently, the design calculation based on simulation software is widely applied. However, there are some problems that a simulation software cannot solve comprehensively. Some solutions are the combination of simulation software to solve each problem and combining the results obtained for the real problem. It not only helps to reduce the cost of experimentation but also achieves the best results due to the inherent strengths of each software.
Keywords: *Lifting bridge; car; garage; scissor; software; geogebra; inventor; software combination*

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I. INTRODUCTION

Nowadays, most of the street houses in Vietnam are tubular houses, so they lack a parking space or can only leave one and are very out of place. Some solutions that households often choose are to park their car outside the door or park it in public parking lots. This is very inconvenient and unsafe. In addition, households also want to take advantage of the facade for business, so a safe and convenient parking space is needed.

To solve this problem, the use of smart garage designs is a trend not only in Vietnam but also applied by many countries around the world, scissor car lift is a suitable choice because it not only optimizes the space used but also has high safety. The theoretical design calculation has become obsolete, but the trend of computational design by combining simulation software is both cost-effective and reliable.

II. OVERVIEW OF LIFTING EQUIPMENT FOR CAR

2.1 Overview of lifting equipment

Car-lifting equipment is a lifting machine used in maintenance and repair. Its main task is to raise the car to create a large space under the car for the mechanic to easily manipulate. Lifting equipment has many types with different capacities and lifting capacities. Some types use mechanical transmission, some use hydraulic transmission and mechanical-hydraulic mixture. Mechanical transmissions can be chain drives, nut drives, or a combination. But the common point is that they use the main source of driving force, which is electrical energy through an electric motor and through a gear transmission or chain drive, which can convert the rotation of the motor shaft into the rotation of the screw. The nut screw mechanism can convert the rotation of the screw into the reciprocating movement of the lifting frame i.e. the vehicle is raised and lowered. Or maybe through the hydraulic pump, it is possible to convert the rotation of the electric motor into energy in the form of potential energy, which is high oil pressure. This oil pressure is converted into reciprocating motion of the lifting frame by means of hydraulic cylinders and parallelogram mechanism.

2.2 Common types of lifts

a) 1-post lift

This type of lift is characterized by a simple structure, using hydraulic oil transmission. However, the stability is not high, the lifting weight is small, so it is only suitable for small vehicles such as 4-seater passenger cars.

Figure 1: Post lift

b) 2-post lift

The 2-post lift is similar to the 1-post lift but offers greater stability and a larger lifting weight.

Figure 2: Post lift with gate

c) 4-post lift

The 4-post lift allows lifting heavy vehicles and has high stability due to the large base area, but the working space is narrow and occupies a large area in the garage and workshop.

Figure 3: Post lift

d) Scissor lift

This type of lift allows lifting vehicles with large weight, high stability, and relatively open working space. There are several types that are highly mobile, able to move anywhere in the garage.

Figure 4: Scissor lift

III. RESEARCH RESULTS

The calculation results based on the software give the data similar to reality.

3.1. Construction goals, scissor lift input parameters

The method described here ignores the effect of dynamic loads. In fact, during operation every time the mechanism moves, starts or brakes, these loads appear. Their magnitude depends on the mass and the acceleration of the movement.

a) Structure diagram and input parameters

1: Car floor; 2: Cross structure; 3: Piston_cylinder; 4: oil pipe; 5: Damper; *6: Hydraulic pump; 7: Engine; 8: Safety valve; 9: Filters; 10: Oil tank*

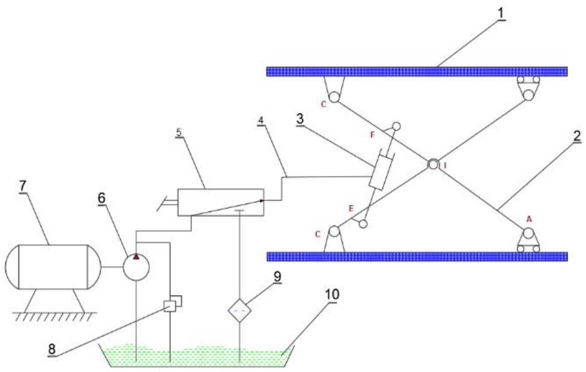


Figure 5: Structure diagram

b) Input parameters

Lifting equipment must be able to lift all 4-seater vehicles into the garage, so we choose the parameters of the vehicle with the largest size and weight in passenger cars, which is the Honda Civic or the pickup trucks.

Table 1: Dimensions of Honda Civic

Wheelbase	Length	Width	Height	Ground clearance	Unloaded weight	Deadweight tonnage
2700 mm	4630 mm	1799 mm	1416 mm	133 mm	1317 kg	1740 kg

From the above reference data, select the following input data:

- Lifting capacity: 2.5 tons
- Lifting height is 2m

From the actual height of a car from about 1.7m-1.9m to the roof, we will design higher than 1.9m (choose 2m). The height from the bottom floor to the roof (top floor) is completely lowered into the ground without the roof rising above the floor creating a flat surface that does not interfere with operation and creates more space.

- Lifting speed: 2m/min.

Usually, when the lifting speed is too large, it will lead to the unstable operation of the system, creating vibrations during the start of the lift. When the lifting speed is slow, it is safer to start the machine and the system will gradually increase the force until it stabilizes, but if the lifting speed is too slow, it will create a long time from start to finish. So when the user turns on the engine, they will have to wait a long time to get the car out of the garage, so we have to choose the appropriate lifting speed with the lifting speed of 2m/min = 3.33cm/s equivalent to the time 1 minute to complete the lifting. This time is neither too slow nor too fast.

- Working mode

Because the hydraulic system is used to raise and lower the car, the mechanism will work smoothly and safely without causing noise and the mechanism only lifts up and down little in a day, so the operation will be more stable.

3.2. Some calculation results

a) Geometric parameters:

From the preliminary calculation results by geometry and the required input parameters, we proceed to build the problem on geogebra to get preliminary:

- Position, size of stages
- Principle of motion transmission of the stages
- Provide a velocity graph to control the speed of the mechanical stages

Calculating the location of preliminary hydraulic placement by planar geometry. We have the location of the hydraulic layout diagram as shown:

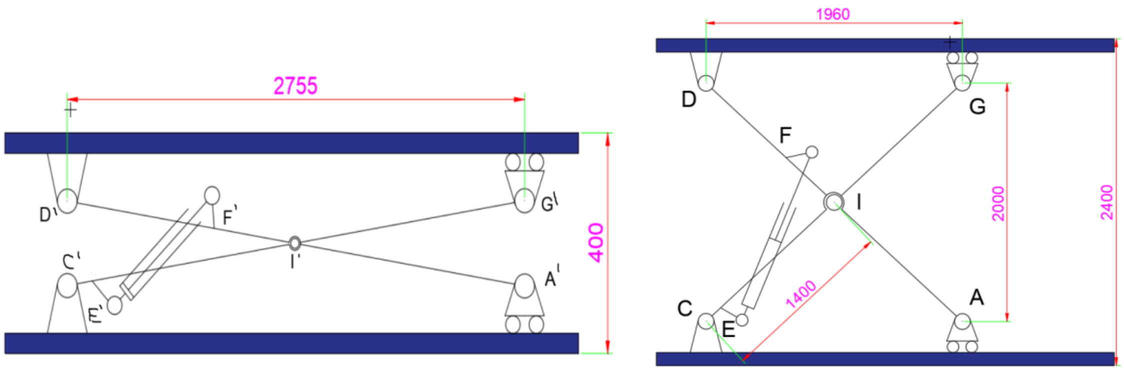


Figure 6: Structure diagram

Now we have to find the positions E,F , EF is the segment where the hydraulics rise to the highest position and E'F' is the segment where the hydraulics are located at the low position.

To find the position E, F we use algebraic problem to calculate.

Condition: $EF' \geq \frac{EF}{2}$

Table 2: Available dimensions table

IC	ID	I'C'	I'D	CD
1400mm	1400mm	1400mm	1400mm	2000

Table 3: Table of unknown dimensions and setting variables

IE	I'E'	IF	I'F'	EF	E'F'
x	X	Y	y	z	z'

From the problem condition we have relation: $E'F' \geq \frac{EF}{2} \Rightarrow z' \geq \frac{z}{2} \Rightarrow z \leq 2z'$. (1)

Having $Cos\widehat{CID} = \frac{CI^2+DI^2-CD^2}{2CI.DI} = \frac{1400^2+1400^2-2000^2}{2.1400.1400} = -\frac{1}{35}$

Length $EF = z = \sqrt{IE^2 + IF^2 - 2IE.IF.cos\widehat{EIF}}$

$$=> z = \sqrt{x^2 + y^2 - 2xy.-\frac{1}{35}} = \sqrt{x^2 + k^2x^2 + \frac{2kx^2}{35}} = x.\sqrt{k^2 + \frac{2k}{35} + 1}$$

At the lowest position we have: since DC' is the lowest position, we can choose DC'=170mm

Angle $Cos\widehat{C'I'D} = \frac{C'I'^2 + DI'^2 - DC'^2}{2C'I'.DI'} = \frac{1400^2 + 1400^2 - 170^2}{2.1400.1400}$

$$=> \widehat{C'I'D} = 7^0$$

$$E'F' = z' = \sqrt{I'E'^2 + I'F'^2 - 2I'F'.I'E'.Cos\widehat{C'I'D}}$$

$$=> z' = \sqrt{x^2 + y^2 - 2xy.cos7^0} = \sqrt{x^2 + k^2x^2 - 2kx^2.cos7^0}$$

$$=> z' = x\sqrt{k^2 - 2k.cos7^0 + 1}$$

From the problem condition we have

$$z \leq 2z'$$

$$=> x.\sqrt{k^2 + \frac{2k}{35} + 1} \leq 2x\sqrt{k^2 - 2k.cos7^0 + 1}$$

$$=> k^2 + \frac{2k}{35} + 1 \leq 4k^2 - 8k.cos7^0 + 4$$

$$=> 3k^2 - k\left(8cos7^0 + \frac{2}{35}\right) + 3$$

$$=> k \geq 2{,}2.$$

- Choose $k = 2{,}5\ ta\ có\ y = 2{,}5x.$

$$z = x.\sqrt{k^2 + \frac{2k}{35} + 1} = x\sqrt{2{,}5^2 + \frac{5}{35} + 1} = 2{,}7x$$

$$z' = x\sqrt{k^2 - 2k.cos7^0 + 1} = x\sqrt{2{,}5^2 - 5cos7^0 + 1} = 1.5x$$

- Choose x=500mm we have the following data sheet:

$IF = I'F' = x$	$IE = I'E' = y$	$EF = z$	$E'F' = z'$
$500mm$	$1250mm$	$1350mm$	$750mm$

b) Calculate the running distance of the roller on Geogebra software

- At the highest position, roller A runs to position DA=2000mm.
- At the lowest position, the roller moves segment A'.
- Therefore, the running distance of the roller is $t = DA' - DA$
- Calculate DA':

+ We have: $sin\widehat{I'DA'} = \frac{DC'}{2}.\frac{1}{I'D} = \frac{17}{280} => \widehat{I'DA'} = 3.5^0$

$$=> DA' = A'C.cos3.5^0 = 2795mm$$

$$=> t = DA' - DA = 2795 - 2000 = 795mm$$

We proceed to build the problem of position and motion on Geogebra software.

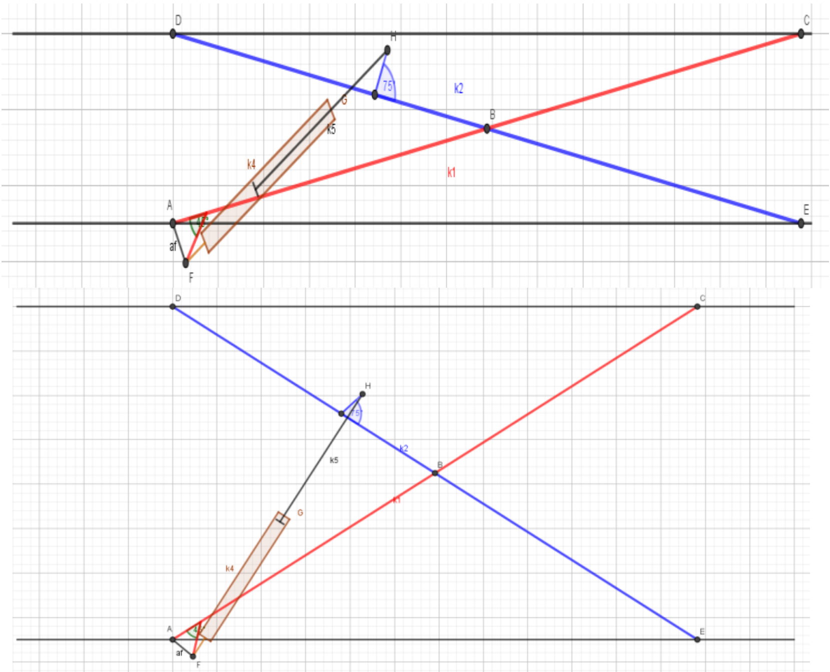


Figure 7: Lowest and highest position

c) Velocity problem:

To calculate the hydraulic speed, it is necessary to adjust for stage 1 to have a uniform reciprocating motion of about 2m/min.

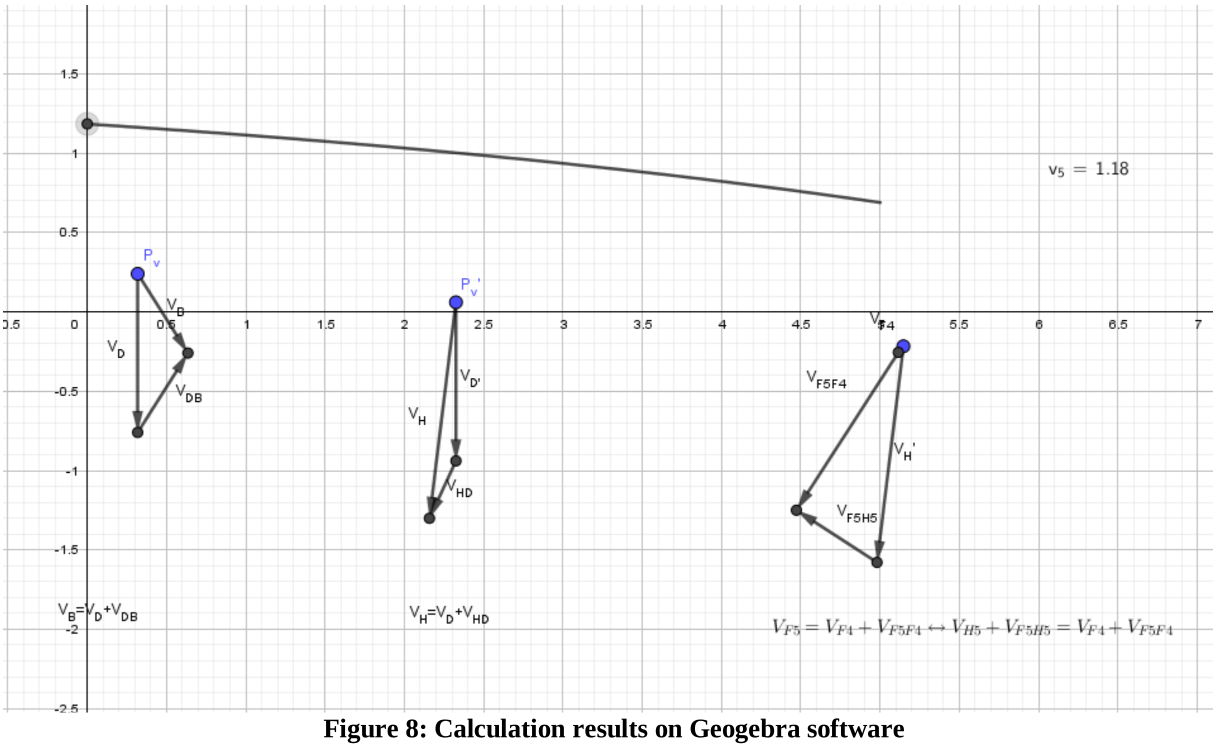


Figure 8: Calculation results on Geogebra software

The results show that the speed and size of the links ensure the set conditions.

d) Calculation of durability test for floor and lifting frame

With the dimensions of the actual vehicle mass, we choose the floor size and set the load:

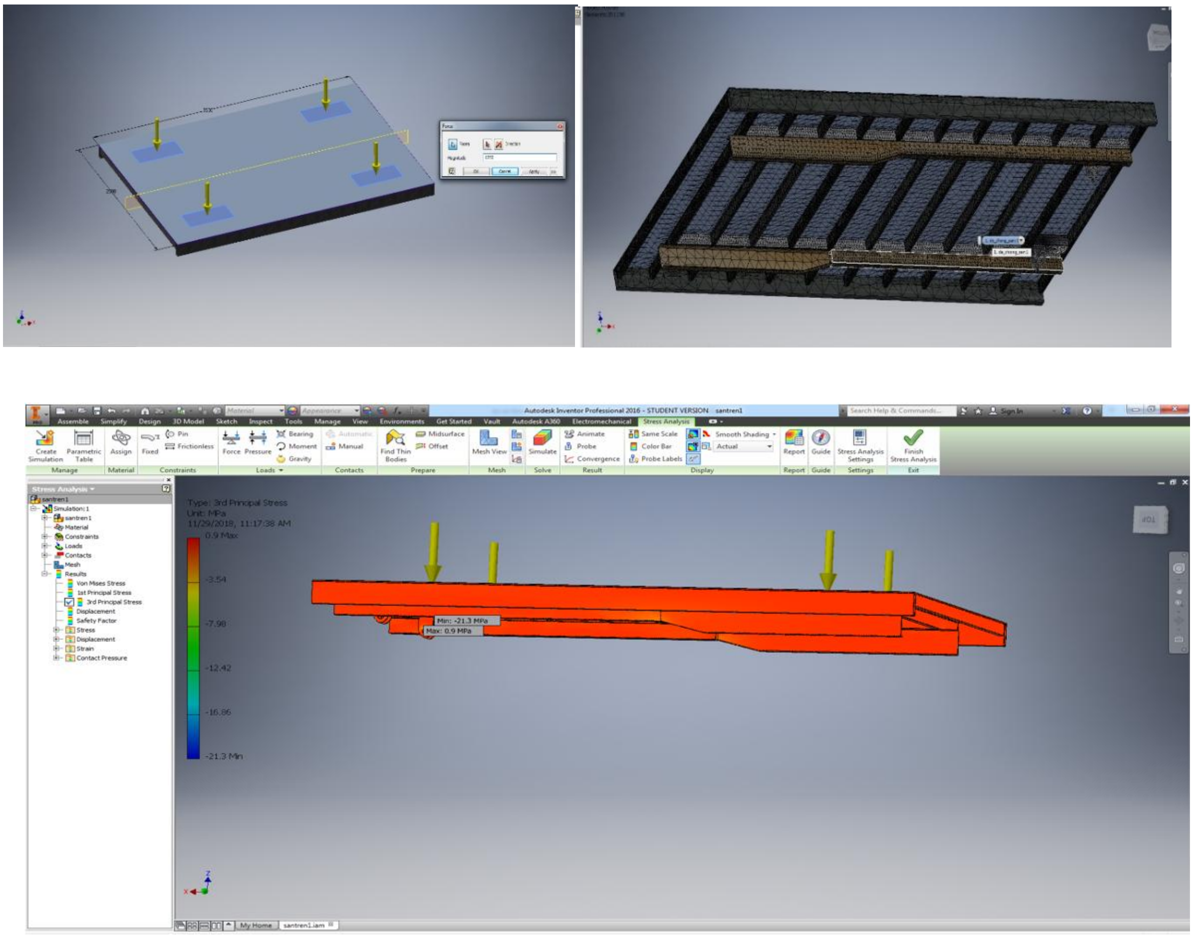


Figure 8: Meshing elements and applying force on Inventor software

From there we have the result table

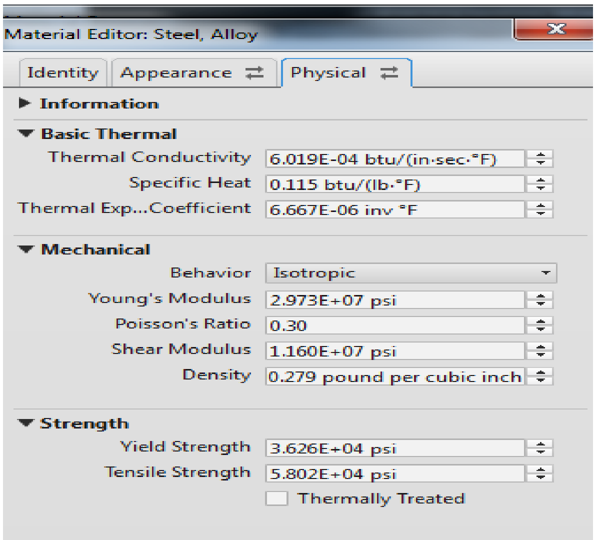


Figure 9: Result Table

The structure of the lifting bars consists of 4 bars of the same size and material, each bar is 2800mm length and has 3 holes on the bar to place the retaining pin. Because the bars are symmetrical when bearing forces, we only consider an X-shaped structure.

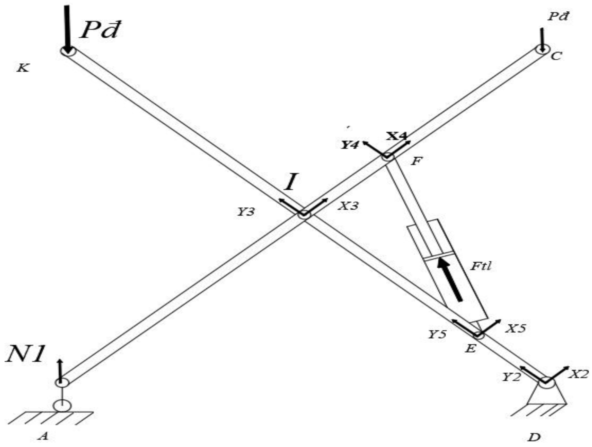


Figure 10: Cross sectional structure

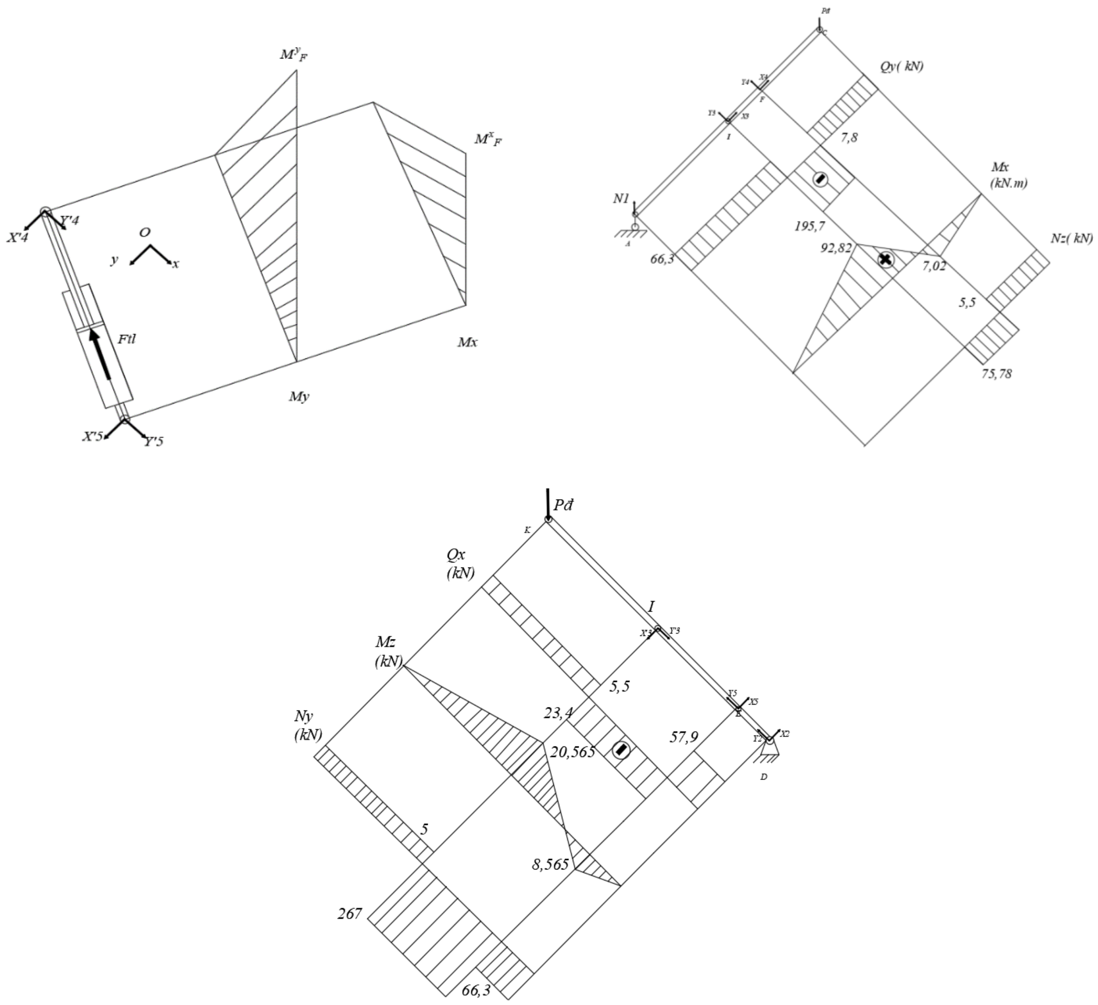


Figure 11: Torque diagram

We consider all cross-sections of the beams to be the same, so we will take the bar with the largest moment on the beam to choose, the rectangular cross-sectional area:

$$M^{x}_{max} = 92,82kN.m$$

$$\sigma_{max} = \frac{N_z^{max}}{F} + \frac{M_{max}^x}{Wx} \leq [\sigma] \qquad (2)$$

$$=> \frac{75,78.10^3}{bh} + \frac{92,82.10^3.6}{bh^2} \leq 6,7.10^6$$

choose b=0,08m=80mm

$$=> \frac{75,78}{h} + \frac{556,92}{h^2} \leq 563$$

$$=> h \geq 0,3m$$

Since beams are unchanged in cross-sectional dimensions

The cross-section is a solid rectangle:

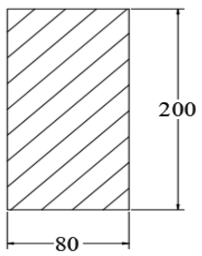
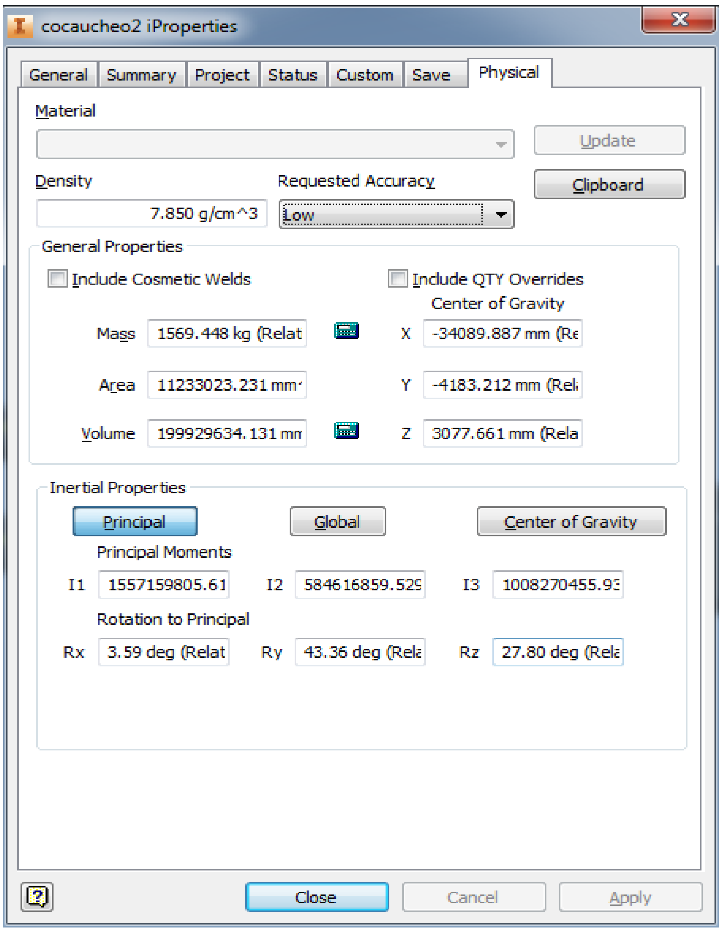


Figure 12: Cross section of lifting frame

Cross structure mass for further calculations and simulations for joints and racks



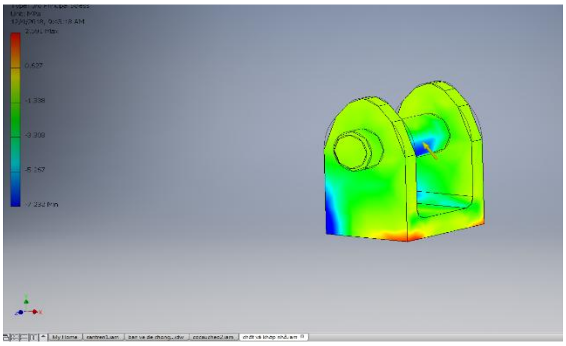
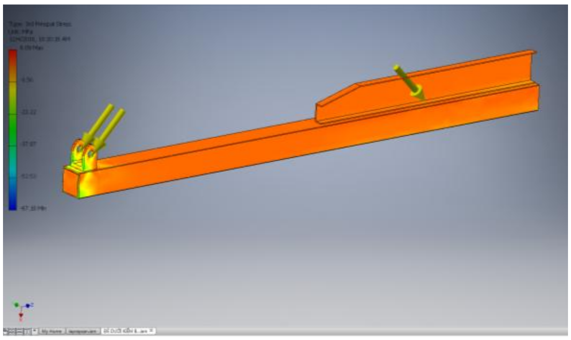



Figure 13: Simulation results of lower joint and support

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

a) With the above calculation results, we see that the structures ensure basic working conditions and ensure durable conditions.

b) The optimization problem to reduce material cost and volume has not been studied yet.

4.2. Recommendations

a) Continue to research methods using artificial intelligence (optimal for continuous variables) and improve them so that they can be applied to the optimization problem to reduce costs as well as volume and size.

b) The problem is considering special points and static loads, still unable to control oscillation shutdown time as well as specific oscillations and other dynamic loads. Notice to calculate these parameters to achieve more accurate results.

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