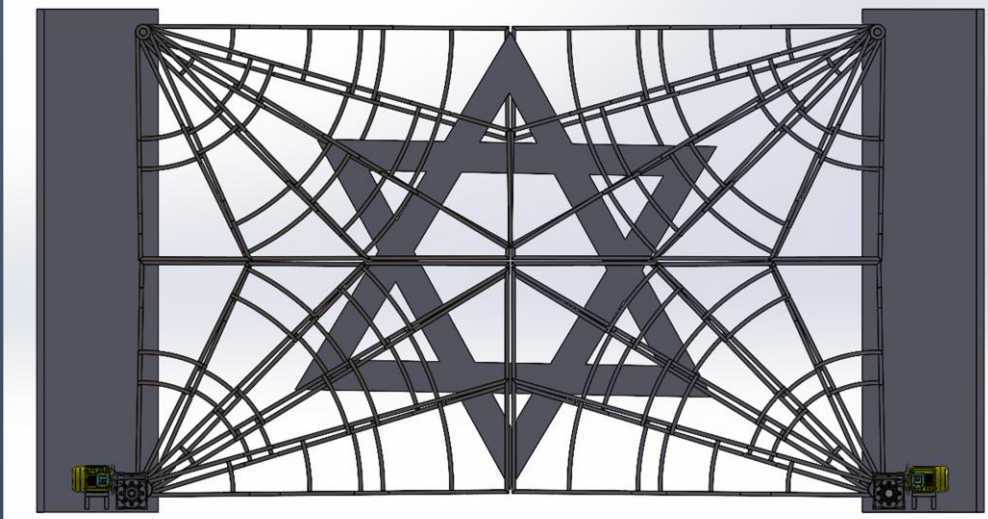
2024

Design of Automatic Fin Gate



ABSTRACT

This report presents the design of an automatic gate and the mechanisms integrated into it. The design focuses on minimizing the space occupied by the gate, maintaining weight balance, improving aesthetics, and ensuring mechanical efficiency. The report primarily emphasizes the gate's structural and mechanical design while also providing methods to enhance its strength, efficiency, and ease of operation.

Contents

DESIGN

Structural design

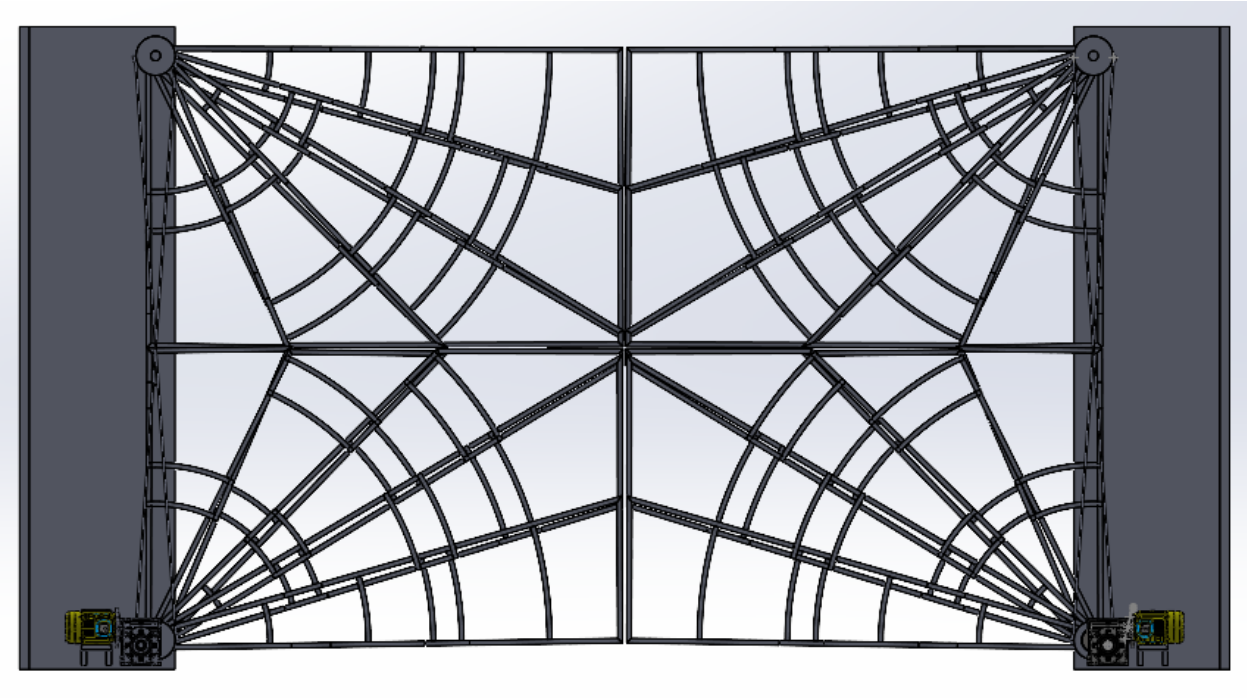


Fig: Structural design

This gate is made up of four wings and is symmetrical about both horizontally and vertically. Here the upper portion is connected to lower in such a way that the weight of each other is cancelled out for the purpose of rotation during opening and closing action. This will be explained later. Further only a single part among the four is explained.

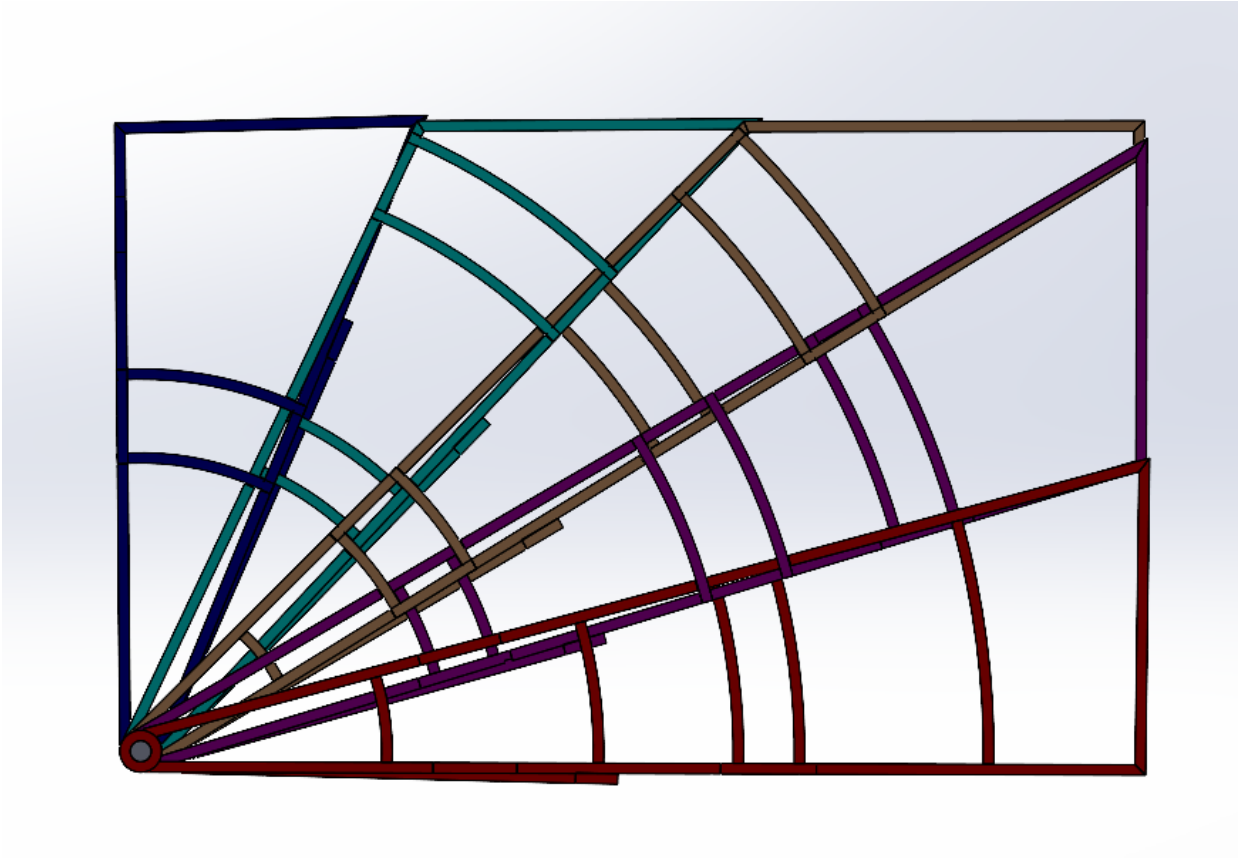


Fig: Single functional part

The single part is made up of five panels made up of square tubes. They rotate about a single shaft and are interconnected by an interlocking mechanism which takes no extra space.

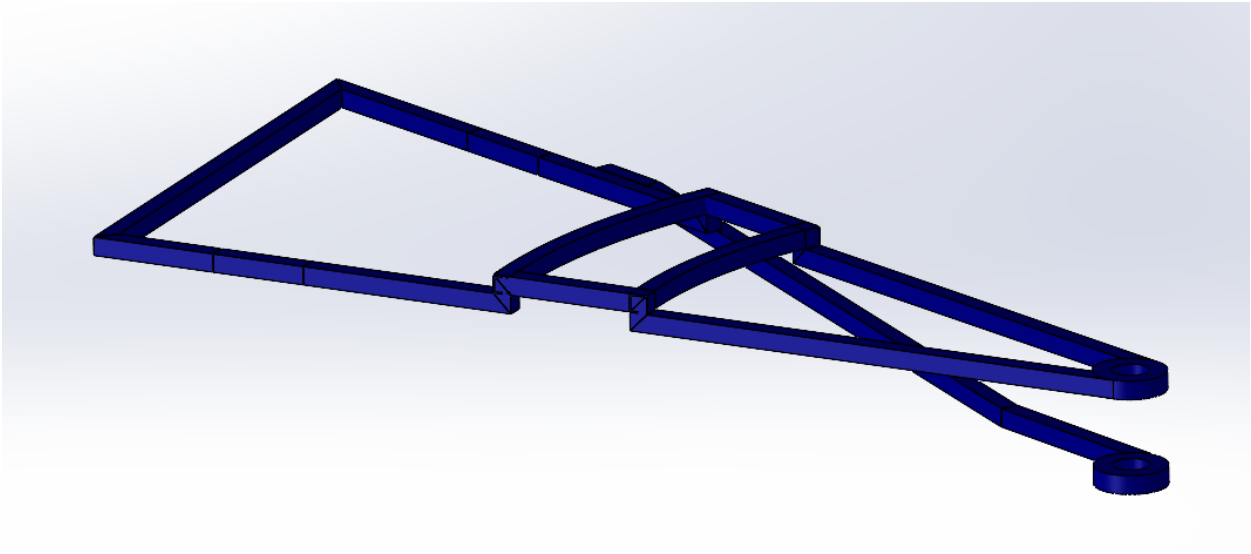


Fig: panel 1

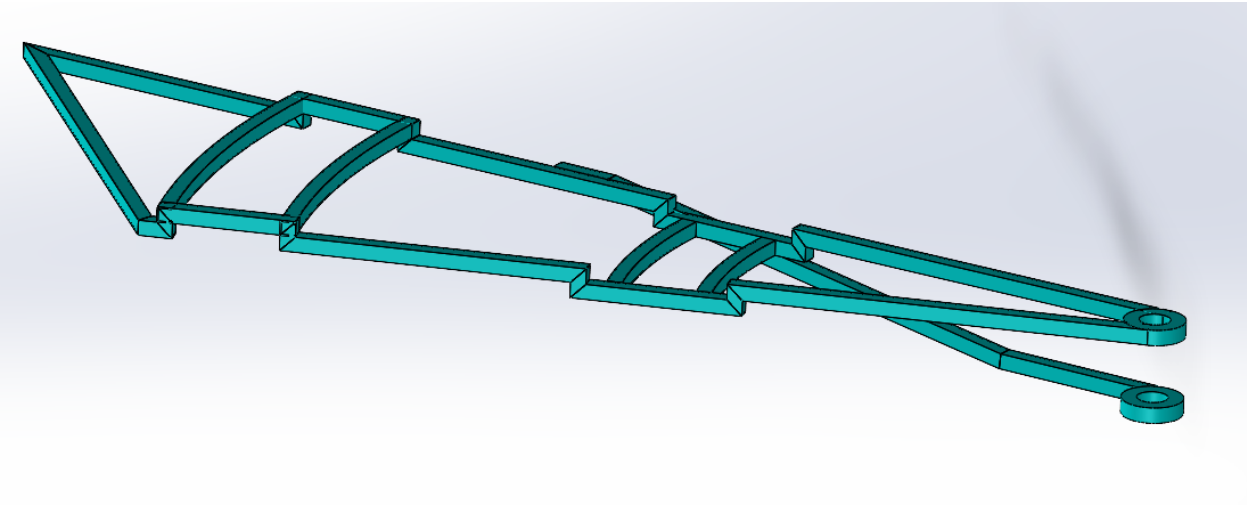


Fig: Panel 2

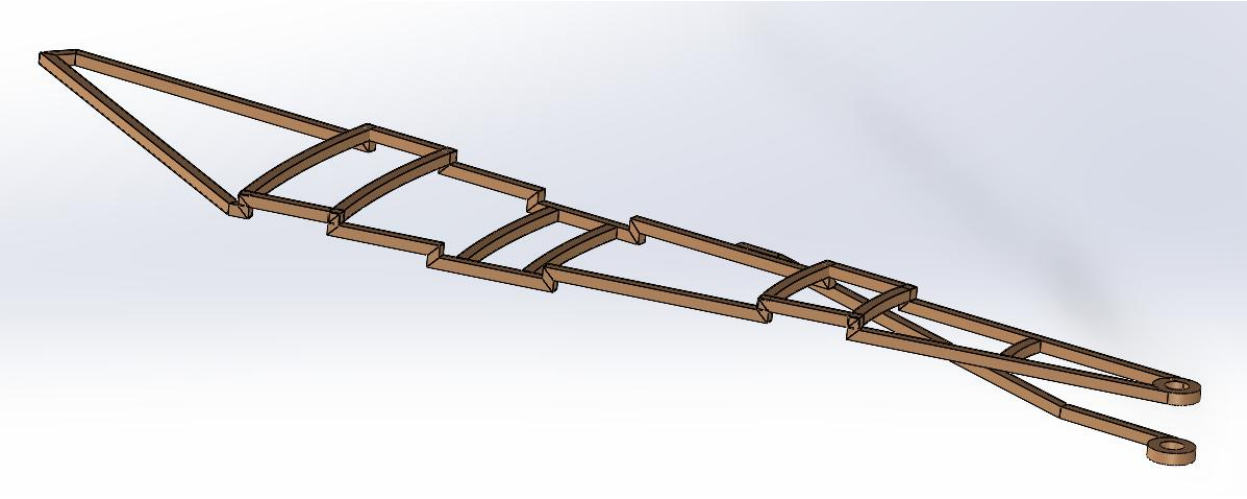


Fig: Panel 3

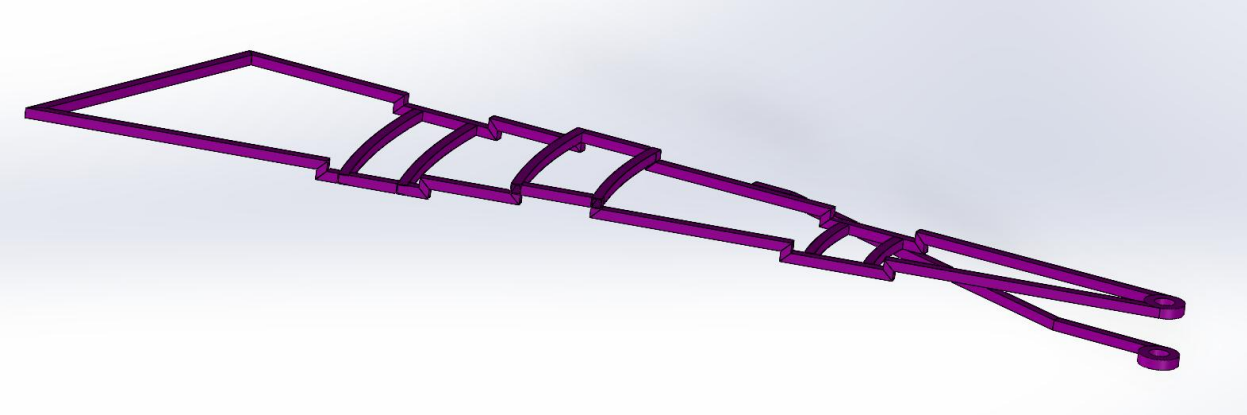


Fig: Panel 4

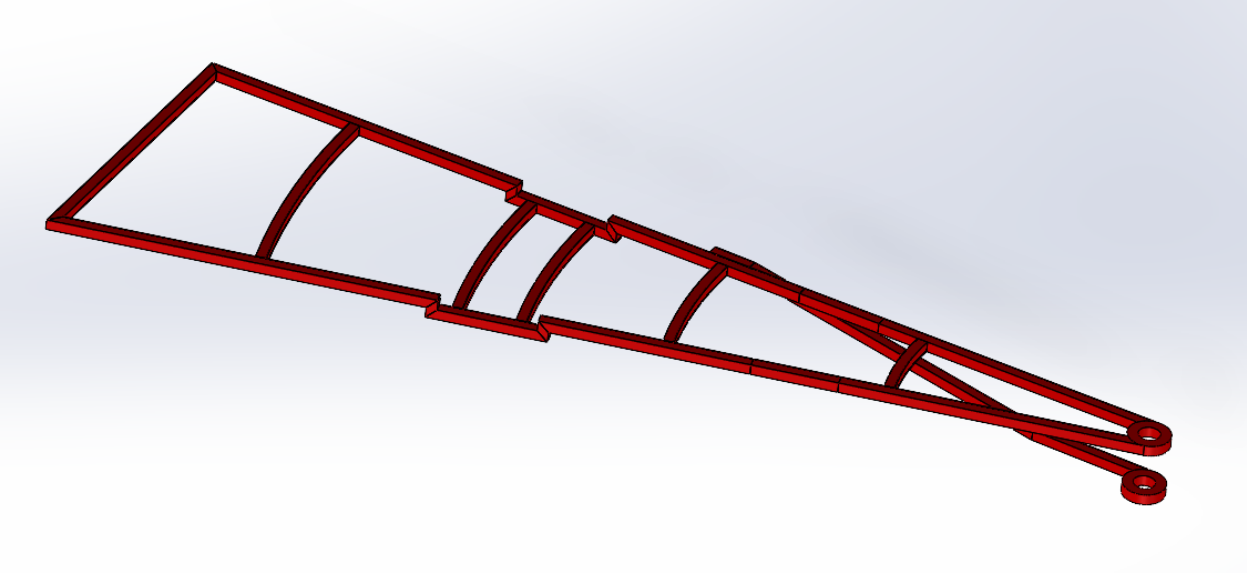
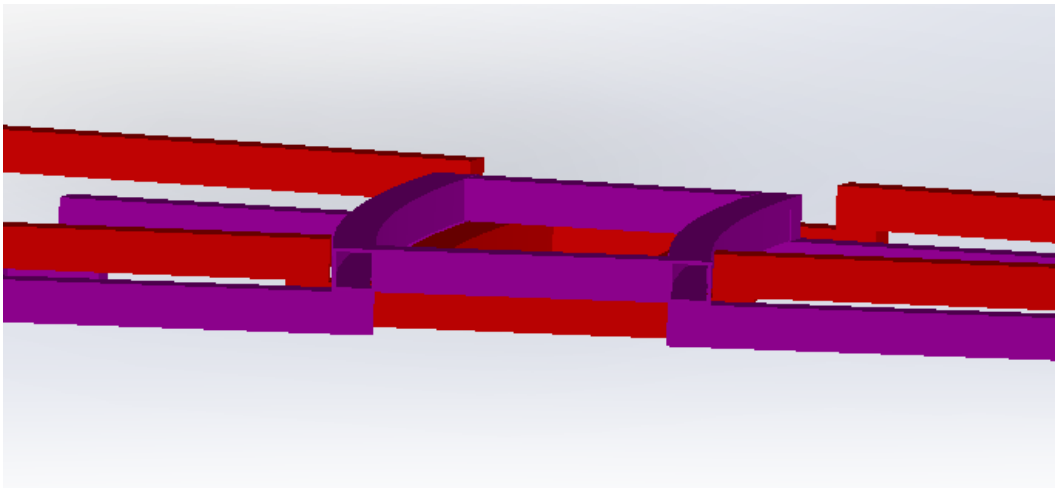


Fig: Panel 5

Every panels rotate about a shaft and are supported by two bushes that are 13cm apart. These bushes assure lateral rigidity of the panel. Corresponding panels are interlocked so it can further increase the strength of gate. Different mechanisms between the panels are explained below.

Interlocking mechanism.

This mechanism interlocks two panels. This provides support without increasing thickness of the gate. At the interlocking section the tube is bent such that it leaves its plane and goes along the plane of another panel, whereas the tube of another panel is bent to cover the former panel, this creates a crisscross which interlocks the panels without additional space. It is demonstrated below:



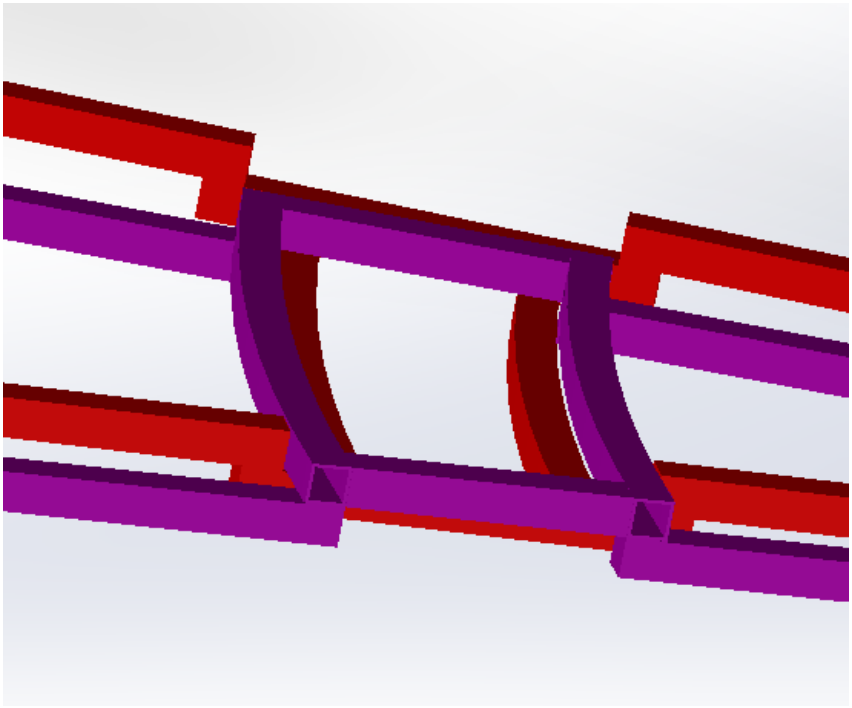


Fig: Interlocking mechanism

Linkage Mechanism

Linkage mechanism is adopted in order to assure smooth transition during opening and closing action. It connects all the panels together and create uniform motion among the panels.

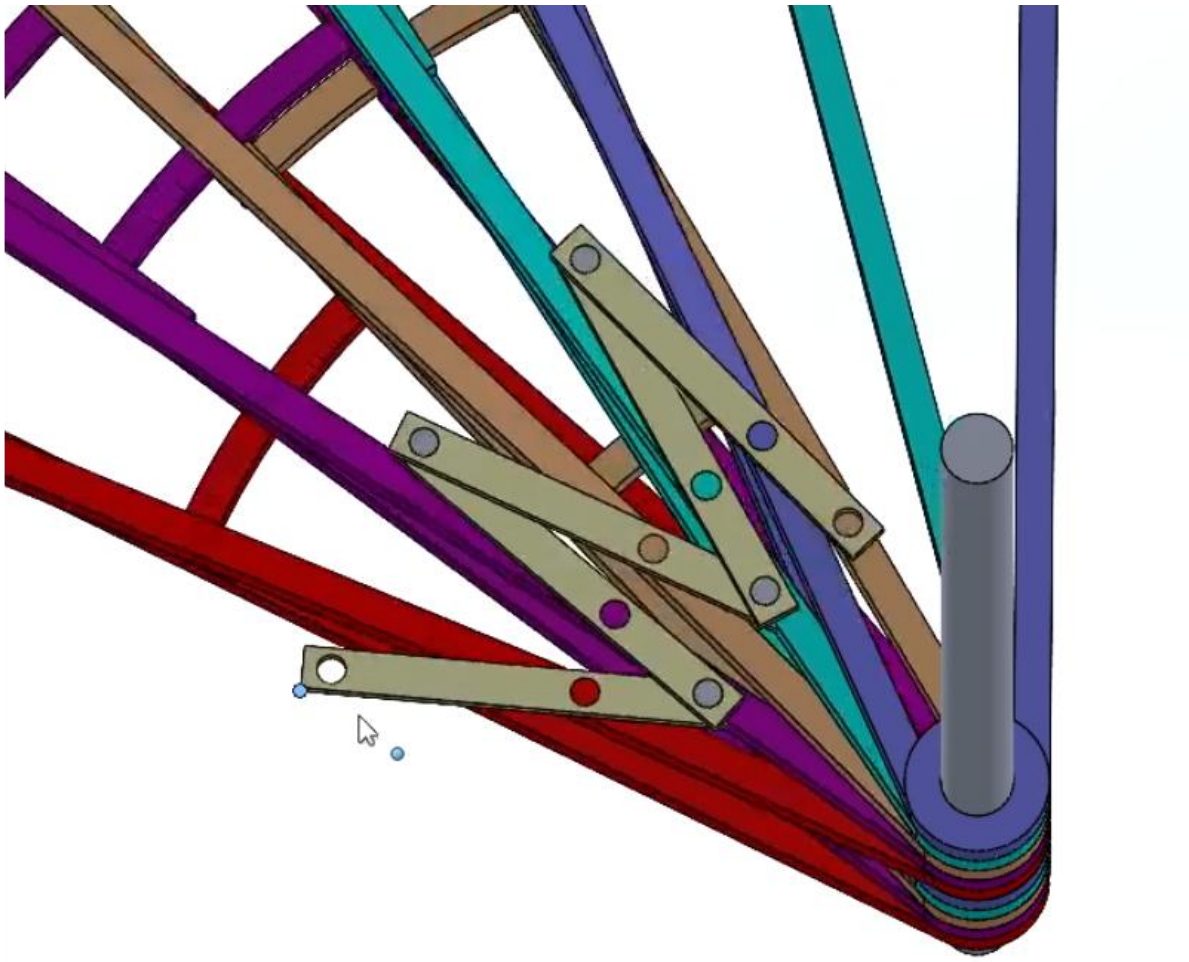


Fig: Linkage Mechanism

Two hinged mechanism

The two hinged mechanism increased lateral rigidity as compared to single hinged. It is designed such that it consumes no extra space in overall assembly as compared to single hinged except around the shaft. There are five bushes of and corresponding panels between the hinges but during the opening and closing motion none of the hinge mechanism creates issue.

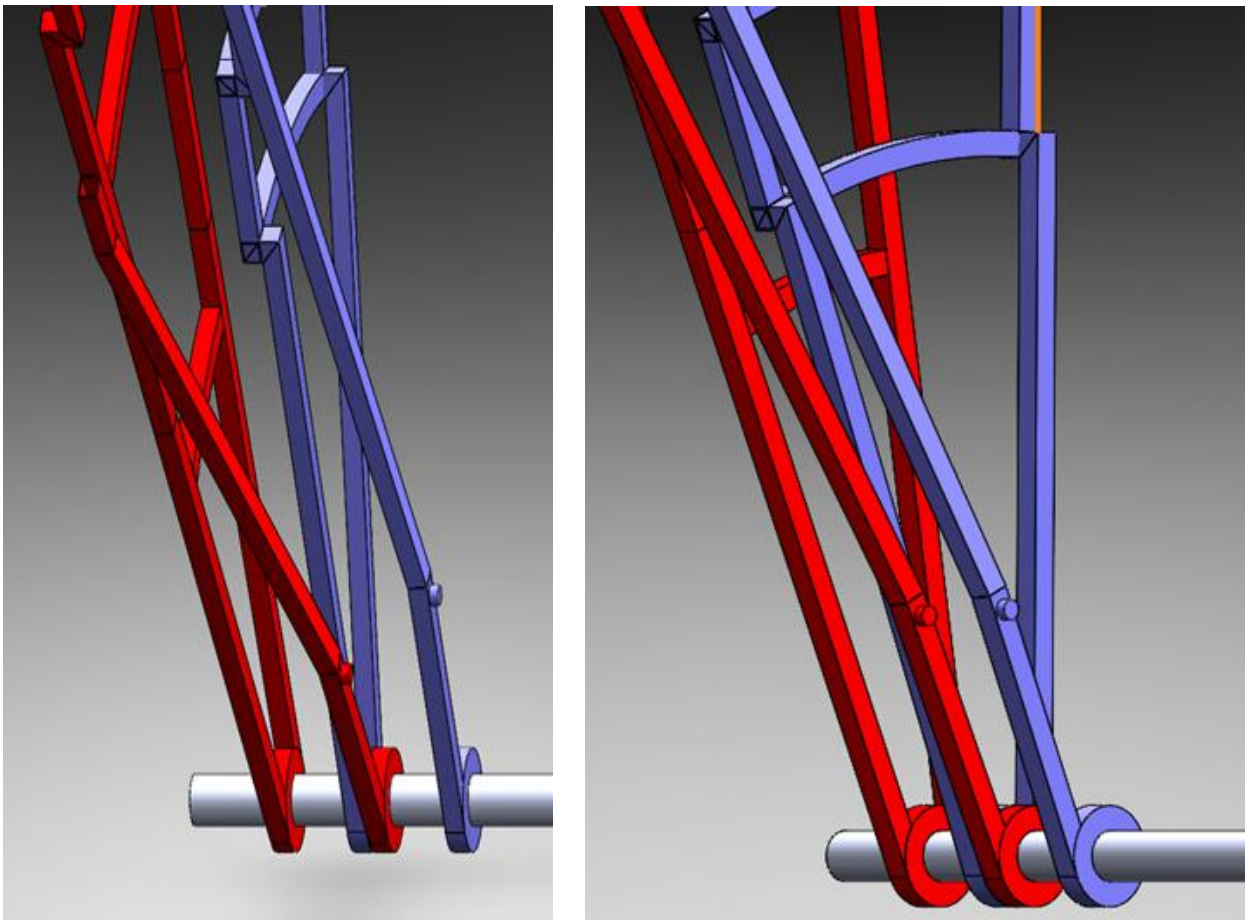


Fig: Interaction between two panels

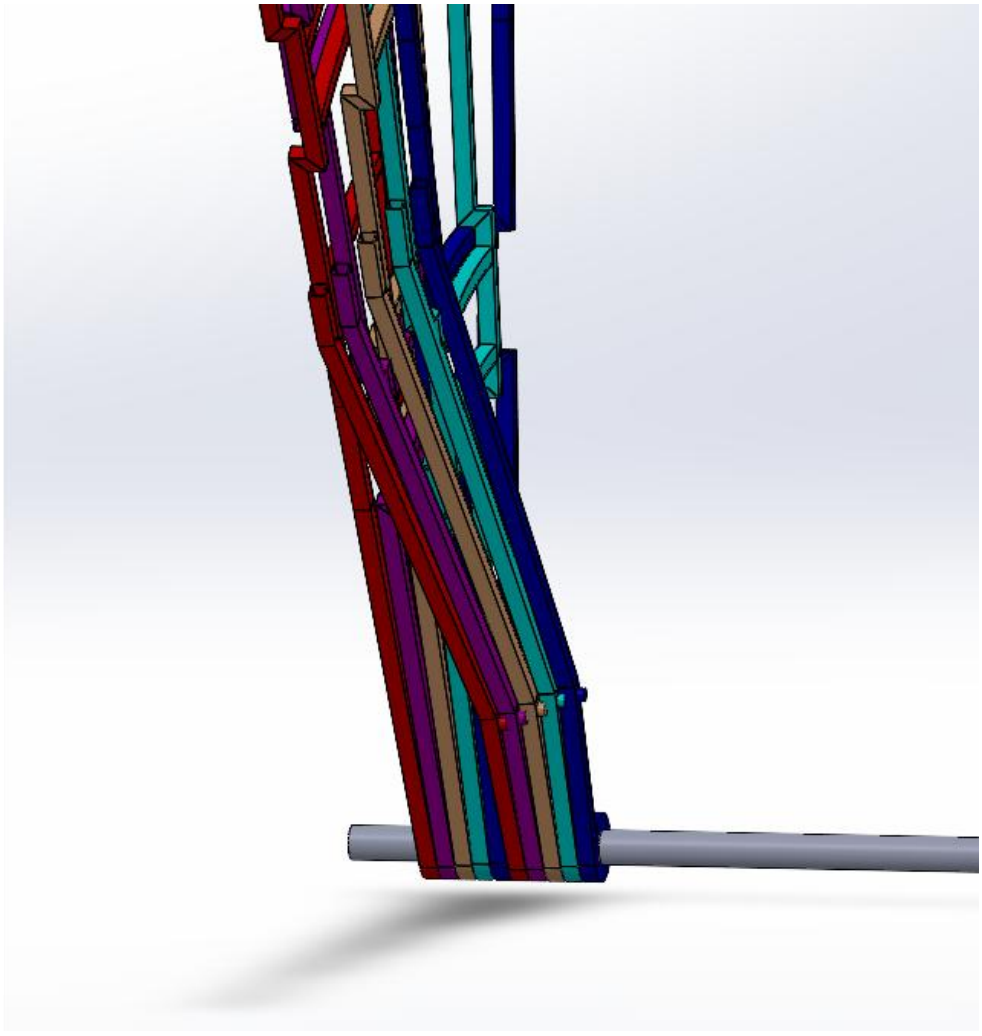


Fig: Interaction between five panels (1)

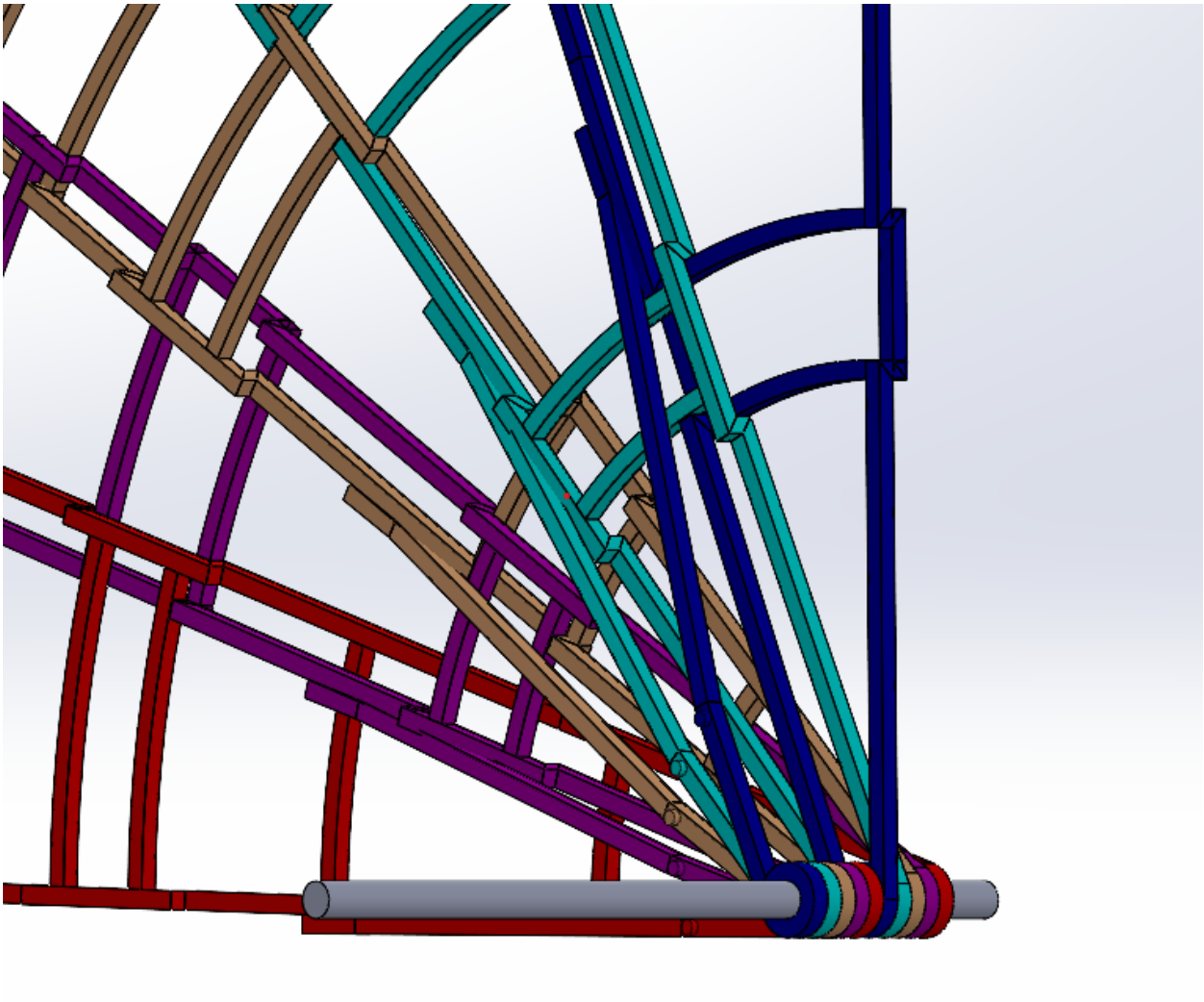


Fig: Interaction between five panels (2)

Weight balance mechanism

The motion of panels are in vertical direction. So, we need to apply force to overcome the change in center of gravity during opening and closing actions. Our gate has a mirror image about mid horizontal plane in terms of structure and motions too. So, this weight balance mechanism completely eradicates the necessity to apply that force. So force required is only to overcome the friction between the parts. Which can be further reduced by the use of simple rollers which is shown later.

The weight balance mechanism has a chain pulley assembly connected to the fifth panel of both the upper and lower fins. Rest of the mechanisms are linked by the linkage mechanism. We can also use pulley with ropes fixed since they have to rotate only 90 degrees.

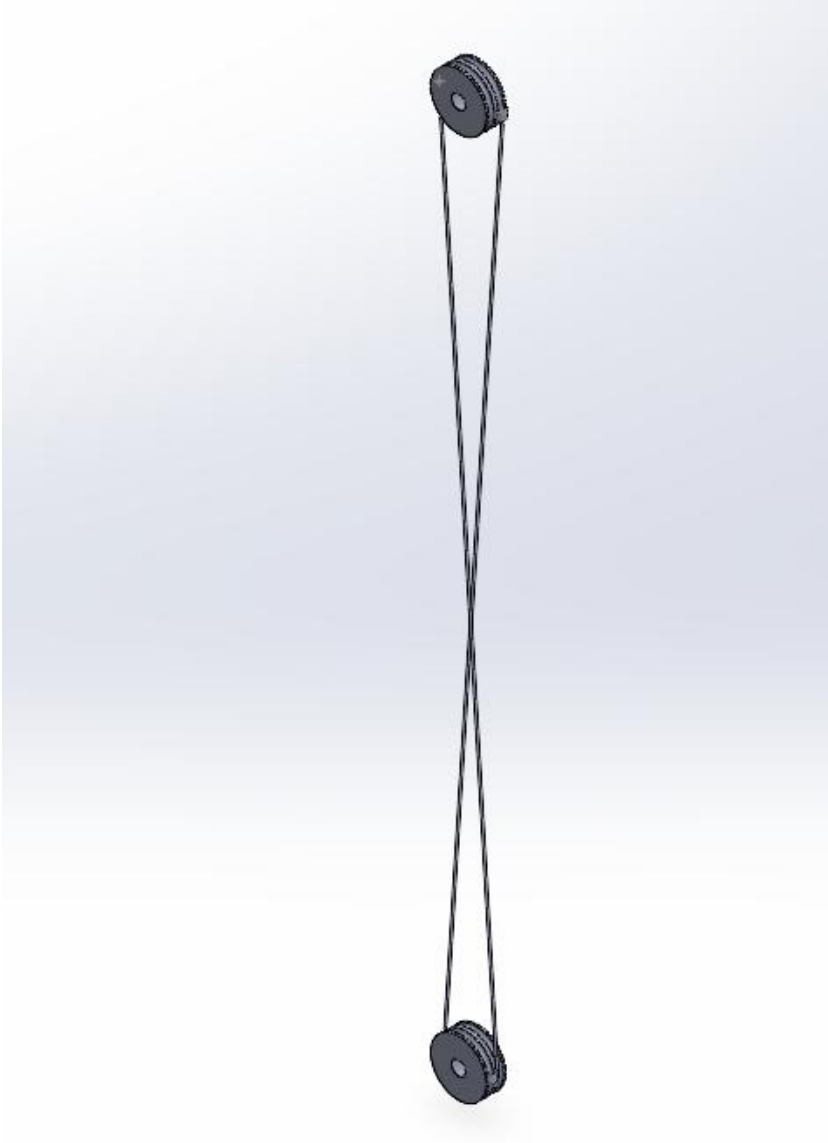


Fig: Weight balance mechanism

Opening and Closing Action

The gate can be driven by single or two actuators. The actuator can be motor, linear actuator, hydraulic or pneumatic. During the opening of gates, all the panels fold into the pillar of the gate such that they are aligned vertically. To hold them in that position a simple lock can be used which is controlled electronically. During closing of gates, the panels unfold and come to the closed position. The linkage mechanism makes these transition uniform and smooth.

Fig: Gates in open position

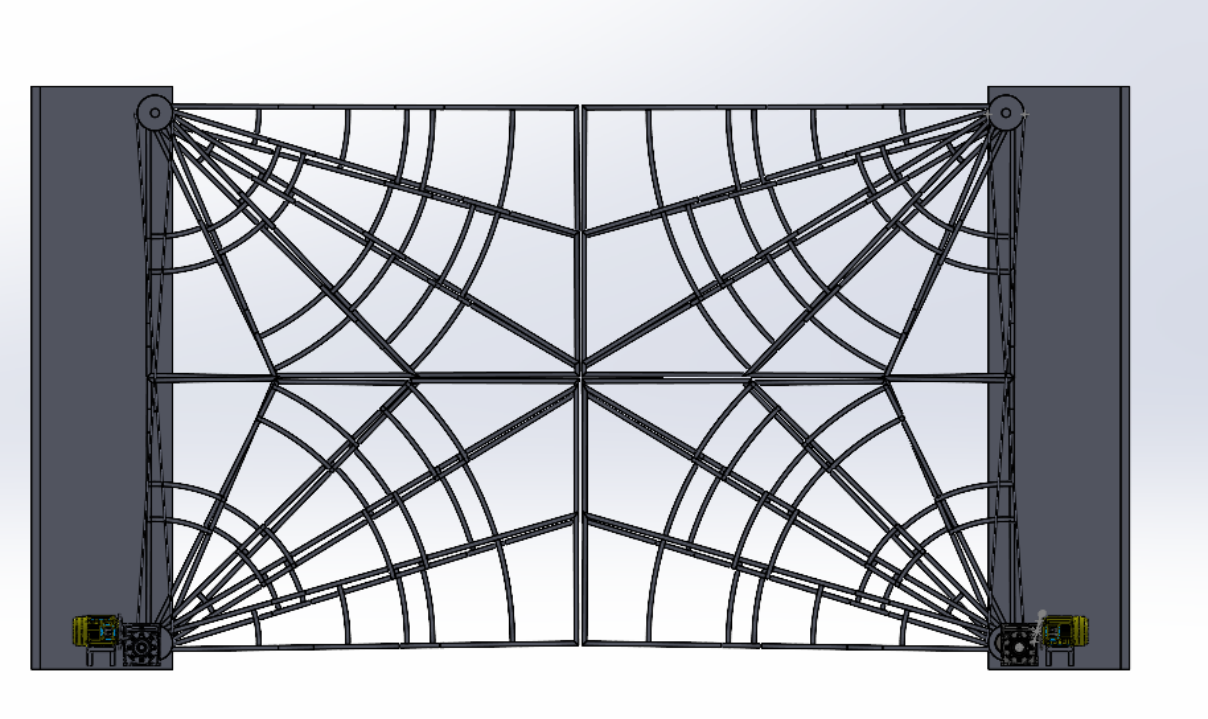


Fig: Gates in closed position

Aesthetic design:

The above design is just structural design. We can add different patterns using plane sheet. We can cover all the panels to make it opaque. We can create different transition animations, different designs. Some designs are demonstrated below.

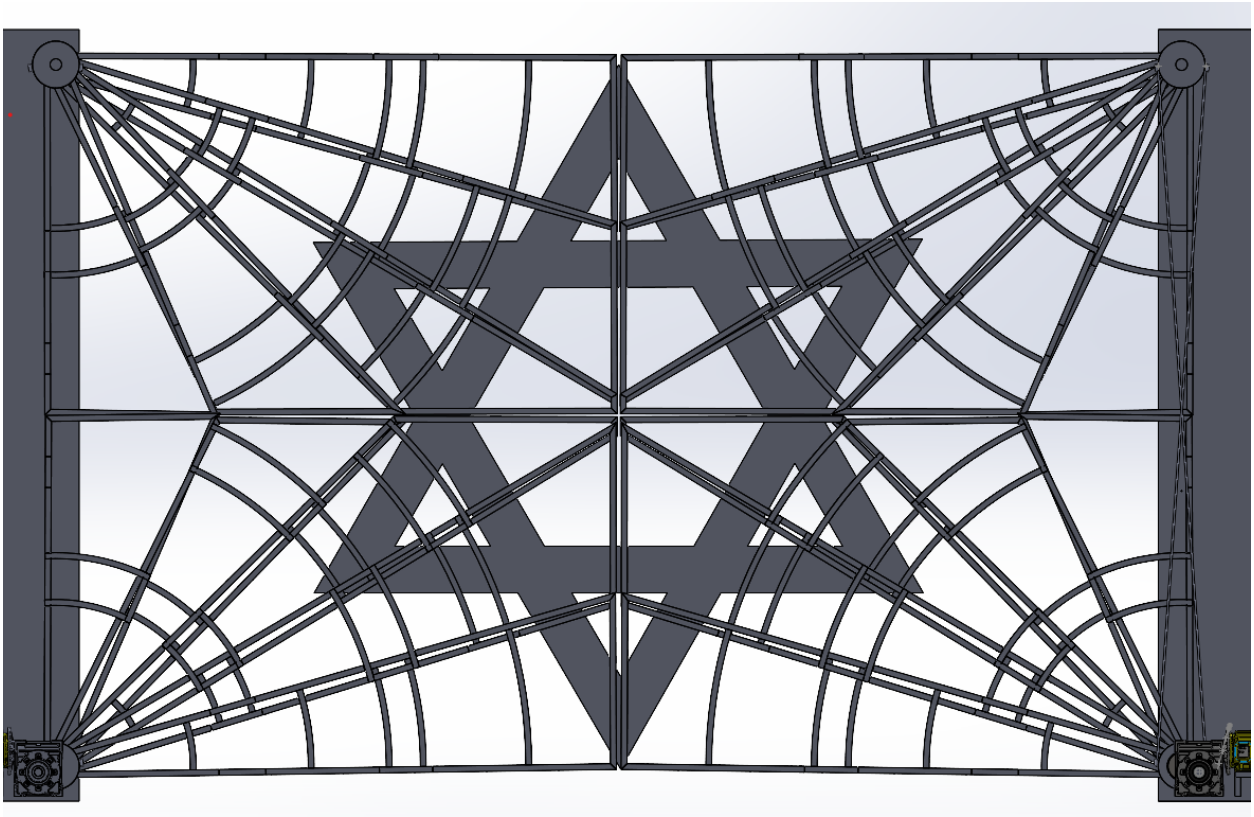


Fig: Gate design with logo.

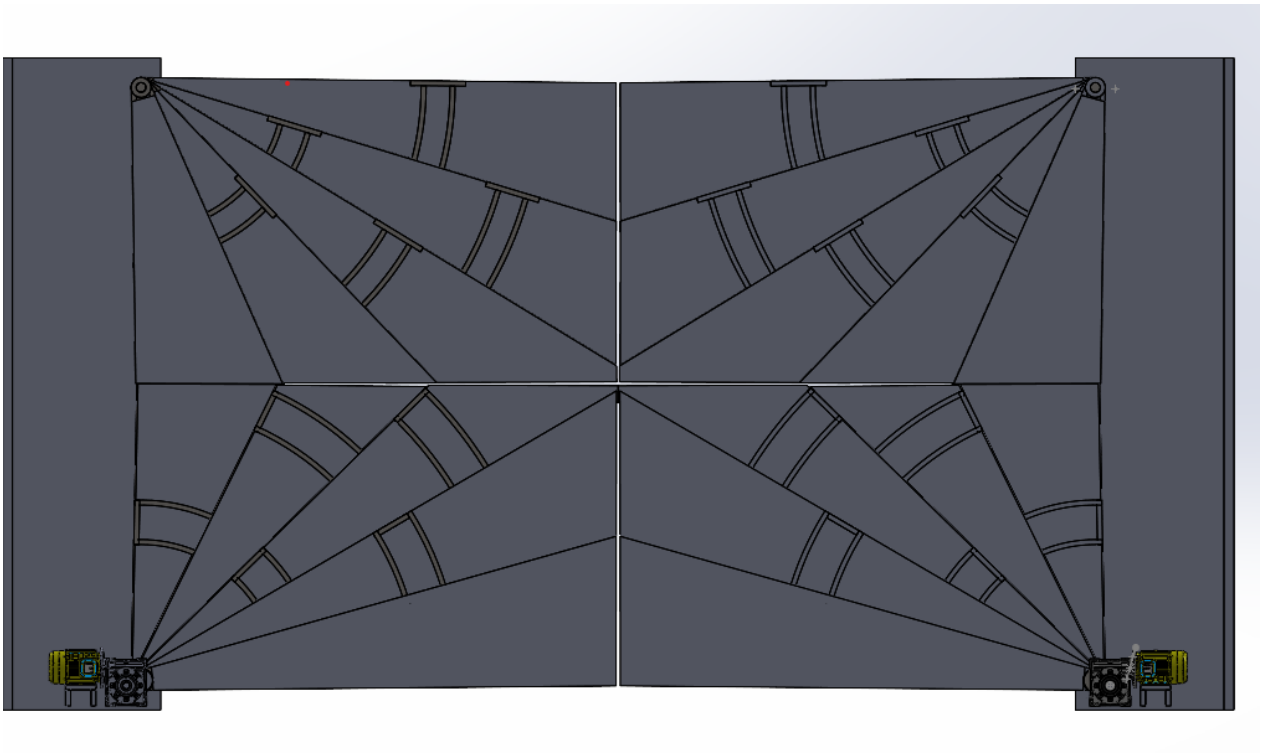


Fig: Opaque gate

Transmission system:

The gate can be powered by a linear actuator or a motor. Linear actuator can be directly fitted to the fifth panel and motor can be connected to bush of the fifth panel. I have designed a worm gear assembly for reduction, if necessary gear box can also be used. The capacity of motor required depends on material used, finishing of parts and alignment since the motor has to overcome the friction among the parts.

Motor disengagement

In case of power cutoff, the gate must be handled manually, for that purpose we have designed a motor engagement and disengagement mechanism. The motor is placed above a sliding rack and a threaded shaft to fix the position of motor.

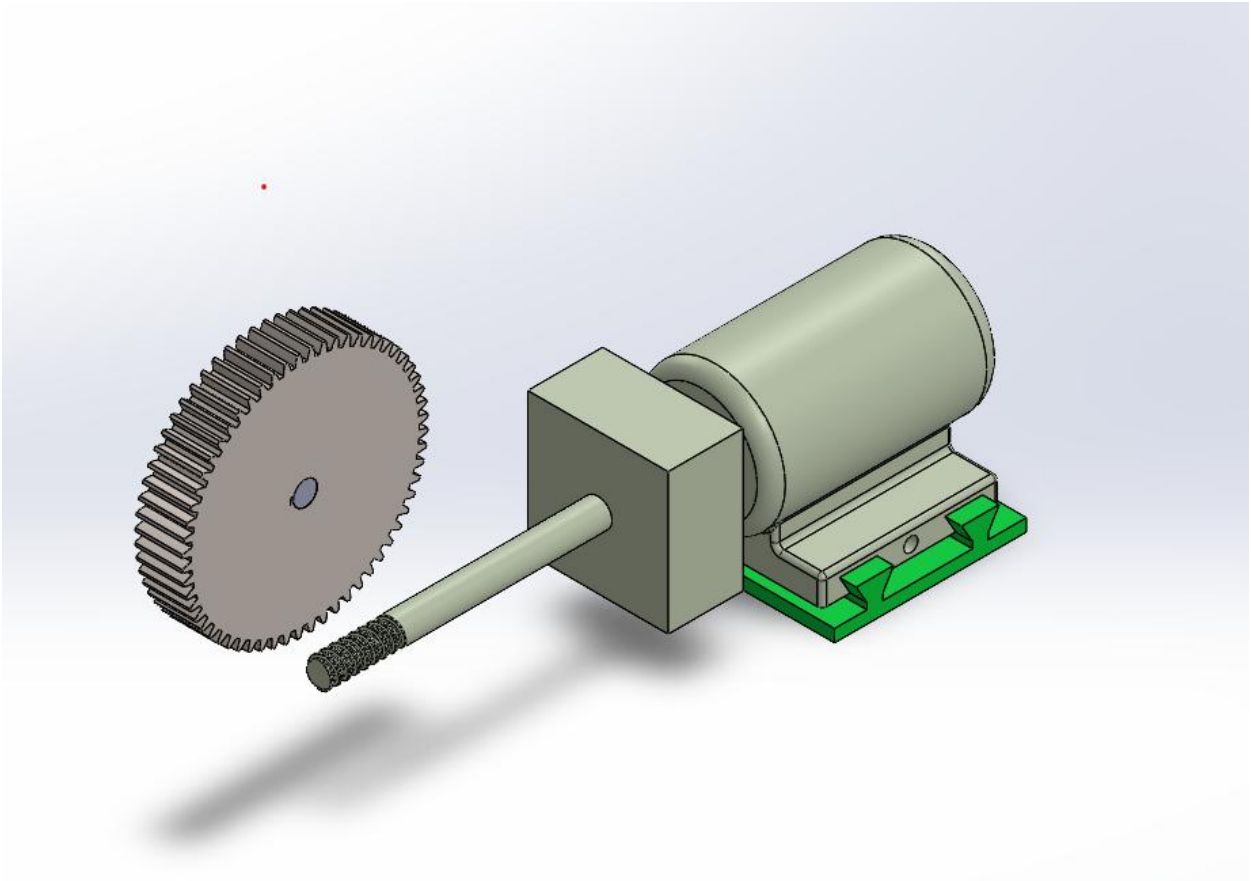


Fig: Disengaged motor with worm gear

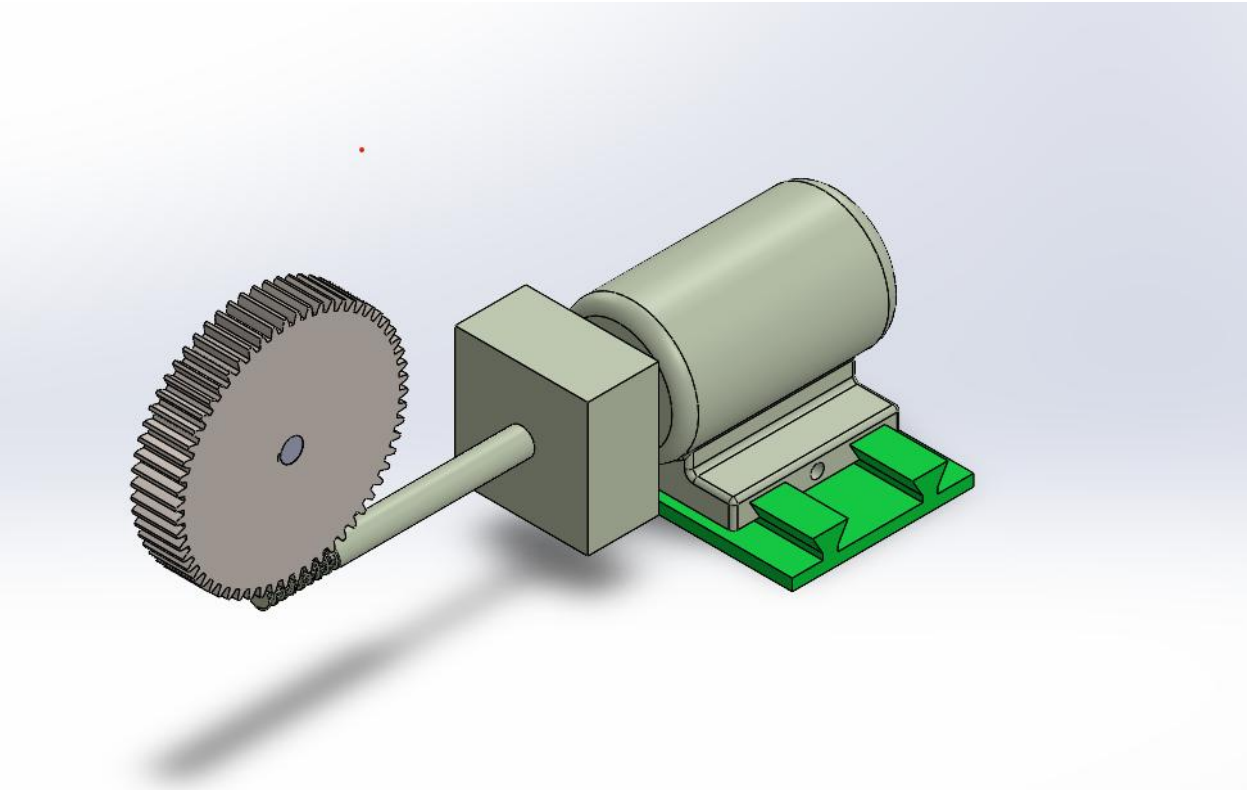


Fig Engaged motor with worm gear

Design Alternatives:

I have not analyzed the strength and efficiency of gate, doing further calculations or experiments, following steps can be used in case required:

Steps to increase robustness:

If necessary, robustness of the gate can be increased by implementing the following methods:

- Using stronger square tubes:

I have designed the gate with 1-inch square tubes of 2mm thickness. To increase robustness, larger square tubes with a thicker profile can be used, such as 2-inch square tubes with 2.6mm thickness. Although this increases the gate's thickness by 10 inches, it significantly enhances robustness.

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- Increasing density of tubes:

  Doing analysis, we can increase the number of tubes in a single panel. This increases robustness without increasing thickness of the gate. For example we can add a tube at the mid of the panel.

- Increasing distances between the bushes.

  Stability can be enhanced by increasing the distance between two bushes on the same panel.

- Increasing number of supports:

  Now I have used single support from secondary bushes, we can increase the supports for better stability.

- Increasing intersection area in the interlocking part.
  We can increase total intersection area to increase strength and make it rigid.

Steps to increase efficiency.

I have not yet calculated the friction between the parts. If the friction proves to be excessive, we can incorporate rollers between the panels as demonstrated below. Depending on the analysis, either single or multiple rollers can be used to reduce friction and ensure smooth operation.

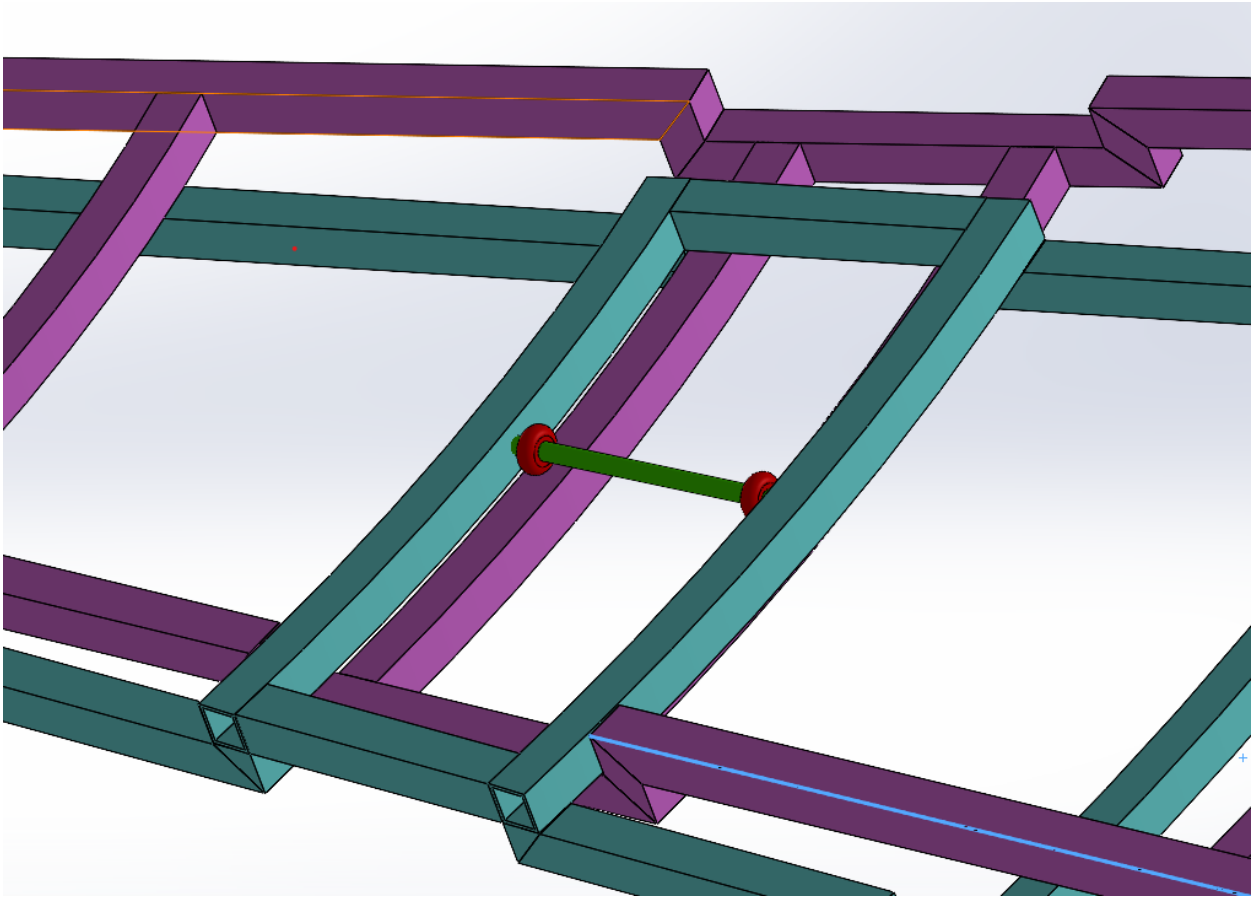

Fig: Roller between panels.

Steps for manufacturing and maintenance simplicity:

If necessary, we can simplify the manufacturing and maintenance processes by taking the following actions:

- Use of nut bolt for joints:

  Utilizing nut and bolt joints makes maintenance easier. These fasteners are easy to install and facilitate straightforward replacement, enhancing the overall efficiency of assembly.
- Alternative to interlocking mechanism:

Interlocking mechanism can be a bit difficult to manufacture so, we can use simple locking mechanism. But this can increase thickness of gate and make it less compact.

Electronics and Electrical components:

The motor selection should be made after thoroughly analyzing the gate. It is advisable to design the structural gate first or even fabricate and then calculate the required torque. Based on this analysis, an appropriate motor can be chosen, followed by determining the necessary gear reduction.

The electronics of this gate are similar to those of other electronic gates, so this aspect has not been discussed.

Cost:

I have analyzed only the approximate cost of design of gate.

Cost of MS tubes.

With 1 inch 2mm square tube, it costs about NRs 50,000.

With 2 inch 3.2 mm square tube it costs NRs 150,000.

Any intermediate sized tube can be used and cost can be calculated.

Estimating the cost of motor, gear assembly to be NRs 30000-40000 and of electronics and sensors to be NRs 20000. Material cost can range from NRs100,000 to 250.000.

Different views of gate

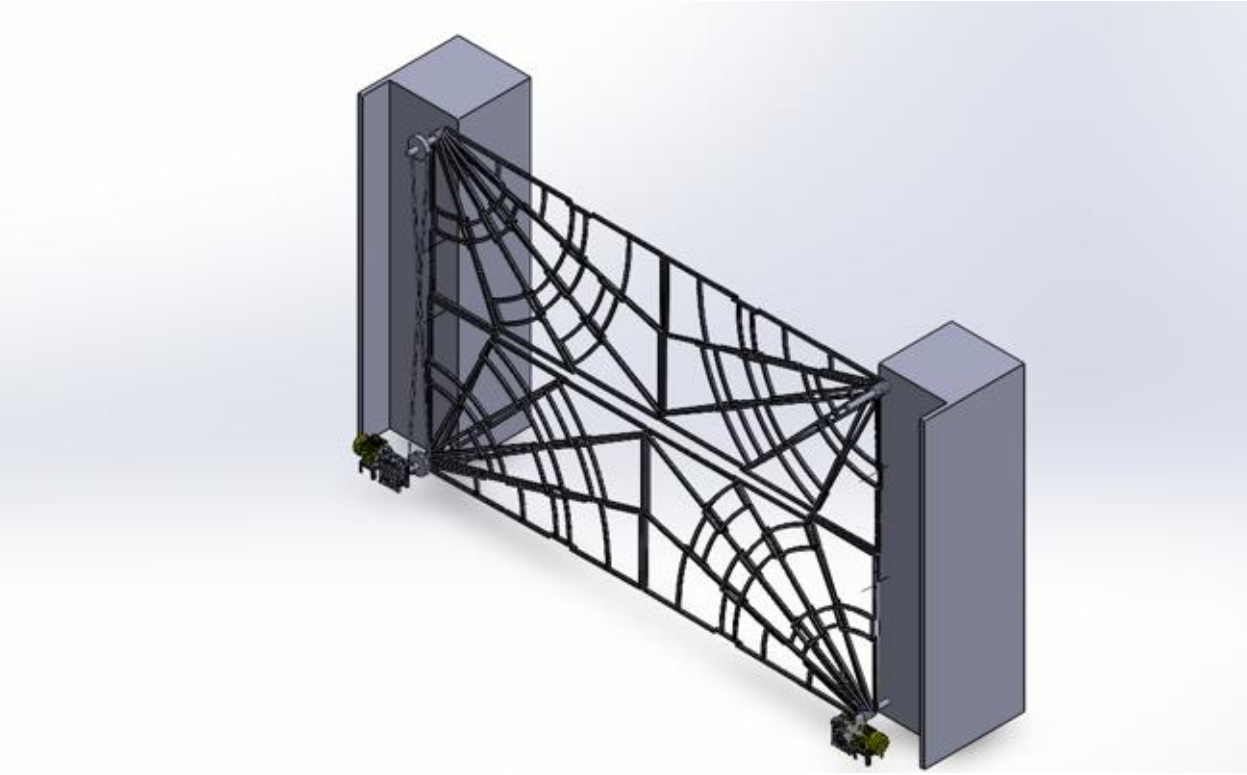

Fig: Isometric View

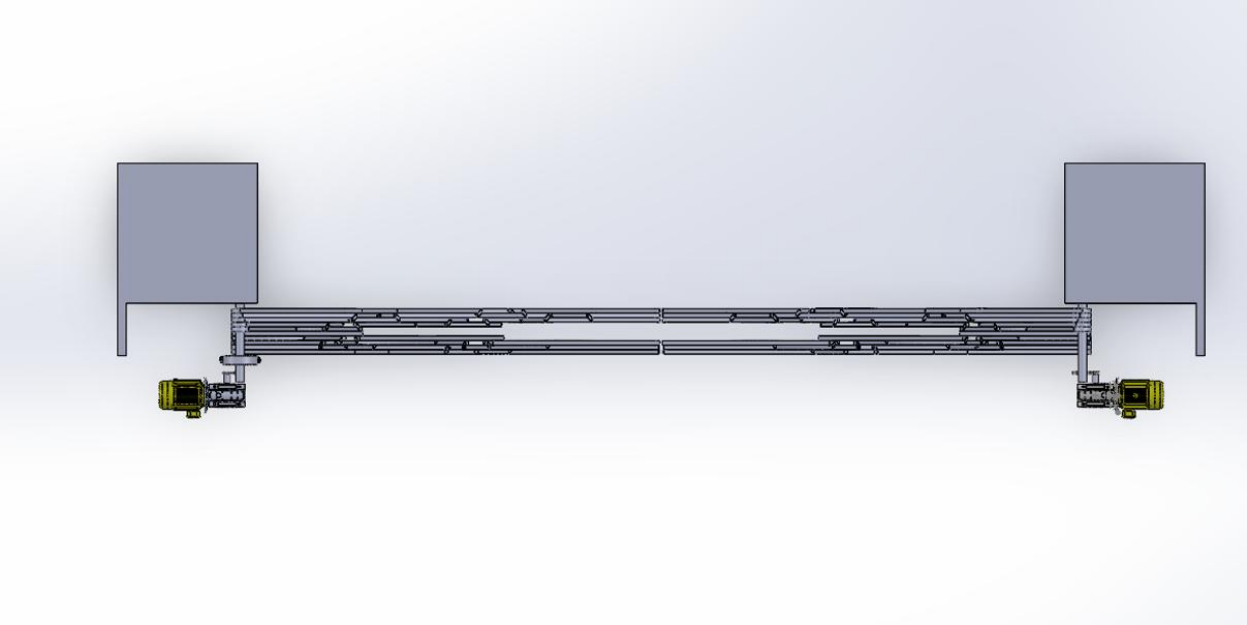

Fig: Top View

Conclusion:

In conclusion, an automatic gate with single-plane motion has been designed with various structural and mechanical alternatives to ensure optimal suitability. This gate is ideal for locations where minimal trajectory is desired, offering an elegant and seamless aesthetic transition. Its unique design not only enhances visual appeal but also provides functional superiority, making it a standout choice for modern architectural applications.