N4 LAUNCHPAD DESIGN AND FABRICATION

DESIGN

Design considerations

1. Structural integrity – the launchpad should withstand the forces/ thrust generated by the rocket during liftoff.
    a. Requirements and options:
        i. Strong and rigid structural members – consider the material and the cross-sections and the suitable length.
        ii. Stable base – consider the most stable base shape whether the square or triangle base.
        iii. Assembly technique – consider single launch rail support or telescopic joining of the rail support.
        iv. Fastening – Use of bolts. Consider the appropriate bolts to use.
2. Rocket alignment – use Open Rocket to find the vertical angle offset for optimum stability during lift off. Practical method of loading the rocket onto the launchpad.
    a. Requirements and options
        i. Easy rocket loading – release system for loading of rocket onto the launchpad.
3. Rocket launchpad height – the launch rail required length of 5m. This requires launch support of 4m and an overhang of 1m.
4. Portability – Easy setup and portability.
    a. Requirements and options
        i. Telescopic assembly for launch rail support
        ii. Detachable base.
5. Fabrication – The launchpad design should allow for fabrication using standard materials and locally available fabrication methods.

EXPECTED LOADING

1. Thrust generated by the rocket and weight of the rocket (Actual load)
2. Horizontal component of actual load – acts on the rail support beam.

DESIGN CALCULATIONS

The mean thrust of the motor is 3kN. Using a safety factor of 2:

The design load is given by;

$$L_d = SF \times L_a$$

where:

L_d is design load

SF is safety factor

L_a is actual load

resulting to design load of 6kN.

The horizontal component of the design load is given by

$$F_h = L_d \times \sin \alpha$$

where:

F_h is horizontal component of design load

α is rocket tilt angle of 5°

resulting to 523N.

The launch rail assumes a cantilever fixed at different point and made of hollow square tubes. The design load shall be used to calculate the base dimensions and base member sizing. The horizontal component force shall be used to size the rail support beams and their cross section.

The rail support is a cantilever beam with point load and fixed at base of the launchpad.

Taking:

- Length of beam (L) = 4 m = 4000 mm
- Point load (F_h) = 523 N
- Material: Mild steel Yield strength (σ_y) = 250 MPa, E = 200 GPa
- Hollow square section: $I = \frac{B^4-(B-2t)^4}{12}$

  Where:

  - I is moment of inertia
  - B is the side of square tube in mm
  - t is thickness of tube in mm

a) Maximum bending moment (M_{max})

$$M_{max} = F_h \times L = 2{,}092{,}000\ Nmm$$

b) Section modulus (S)

$$\sigma_{max} = \frac{|M_{max}|c}{I} \leq \sigma_y$$

Since: $S = \frac{I}{C}$ then $\sigma_{max} = \frac{|M_{max}|}{S}$:

$$S = \frac{|M_{max}|}{\sigma_{max}} = \frac{2{,}092{,}000}{250} = 8368 \text{ mm}^3$$

c) Cross section dimensions *(B)*

$$I = \frac{B^4-(B-2t)^4}{12}$$

Taking thickness as 3 mm:

$$S = \frac{B^4-(B-2t)^4}{12} = 8368 \text{ mm}^3$$

Expanding the equation using binomial expansion and solving for *B* as 50mm.

d) Check for maximum deflection

Maximum deflection is given by:

$$\delta = \frac{FL^3}{3EI}$$

The moment of inertia *I* for the 70mm hollow square cross section is given as:

$$I = \frac{B^4-(B-2t)^4}{12}$$

resulting to 208,492 mm^4.

Substituting the values in the equation:

$$\delta = \frac{FL^3}{3EI}$$

the maximum deflection was found to be 268 mm. This deflection is huge and exceeds the maximum allowable deflection.

WAY FORWARD

Options to explore:

- Using a support reinforcement on one of the sides of the beam.
- Use truss instead of single telescopic bar.

SIMULATIONS

The maximum displacement is 47.9252 mm, which could impact structural integrity.