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Design of frame for a wall mounted indoor swing

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ABSTRACT

All The back and forth motion of the swing is good for children under the age of five years as it teaches them how to get along with others. But nowadays, due to the shortage of time & also rush at the gardens, children are not able to play swings. Some indoor swings are available but they are having some drawbacks. This paper presents the design of a frame of a wall mounted swing. It consists of a cantilever beam, two support members, and other parts. The cantilever beam is designed considering the bending stresses developed in it. This beam will be used for hanging the chains of swing. The deflection of the beam in a horizontal plane during swinging action is restricted by two supporting members on each side of the beam. All welded joints in this frame are also designed.

Keywords: *Wall mounted swing, Cantilever beam, Bending stress, Welded joint.*

1. INTRODUCTION

Due to the shortage of time, many times children can't be taken to gardens for playing swing & other equipment. Also during the rainy seasons, the gardens are closed. This leads to more use of games related to mobiles & computers. Disadvantages of these games are involvement in unwanted things, sleepless nights and fatigue, reduced time with family, nostalgia, eyesight issues, and isolation.

Swinging is actually a therapy component of Sensory Integration. Sensory experiences include touch, movement, body awareness, sight, sound and the pull of gravity. The process of the brain organizing and interpreting this information is called sensory integration. Sensory integration provides a crucial foundation for later, more complex learning and behavior.

Currently, the indoor swing arrangements are available as shown in Figure 1.

a) Partially wall mounted

b) Door frame mounted

c) Floor hanging

Figure 1 Indoor swing arrangements available in the market

But these arrangements are either consuming much space. Also, these arrangements create obstructions in the path of travel. Some of these are having only one hanging point which leads to rotation of the swing through 360° about the vertical axis.
Hence the need is felt of developing a wall mounted swing.

2. PROPOSED STRUCTURE OF WALL MOUNTED INDOOR SWING

The proposed wall mounted swing is as shown in Figure 2. The frame is fixed to the wall. The swinging action is parallel to the plane of the wall.

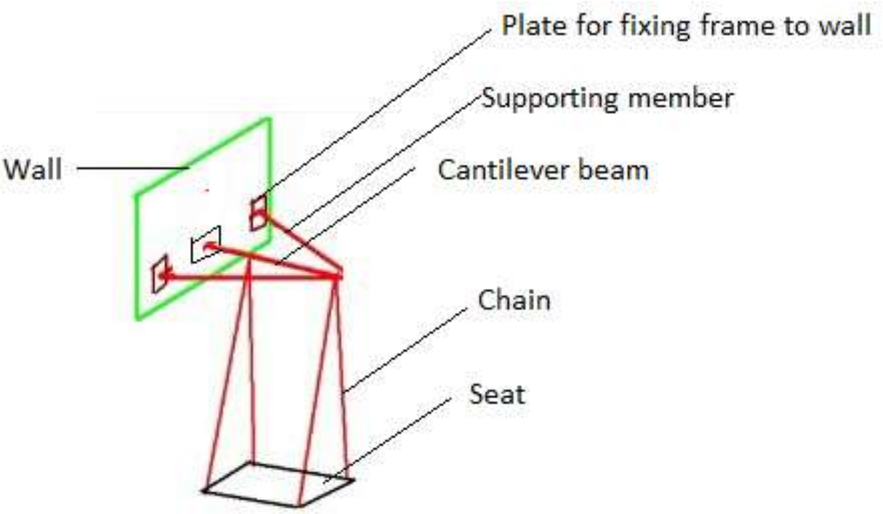

Figure 2 Proposed wall mounted indoor swing

3. DESIGN OF FRAME

Let the maximum weight of child be 50 kg for designing this swing.

3.1 Design of cantilever beam: The left end of the beam is fixed to the wall. The two points at which the chains are hanged are the loading points. Thus, it is a case of a cantilever beam with two point loads.
Point load = 50x9.81/2 = 245.25 N

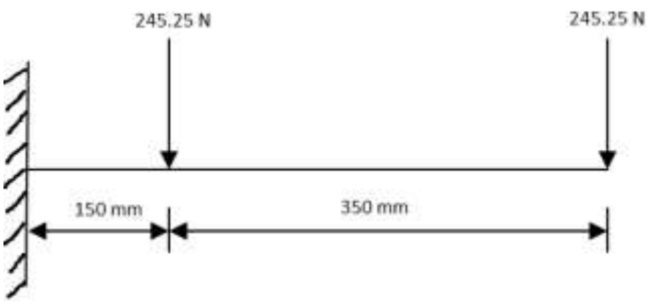

Figure 3 Cantilever beam of swing

Shear Force Diagram: For the design of the cantilever beam, shear forces are determined at various sections. The shear force diagram is shown in Figure 4.

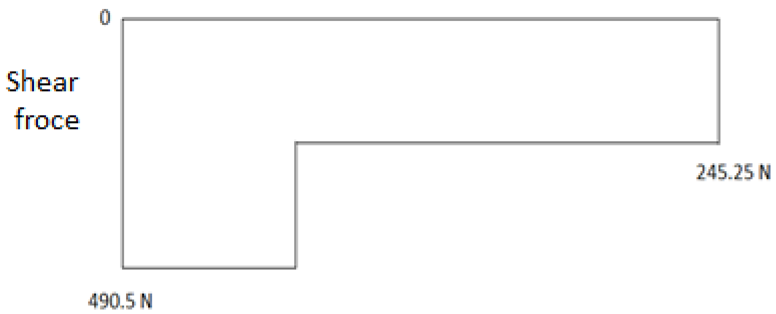

Figure 4 Shear Force Diagram

The maximum shear force occurs at the fixed end of the cantilever beam. The maximum shear force is 490.5 N.

Bending Moment Diagram: In addition to the shear forces, bending moments are also calculated at various sections.

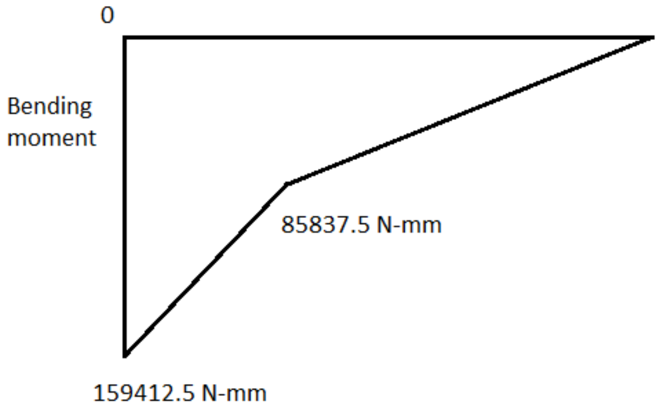

Figure 5 Bending moment diagram

The maximum bending moment occurs at the fixed end of the cantilever beam.

Calculation of bending stress:

Bending stress is given by

Where
σ_b = Bending stress, y_{max} = Distance of beam's neutral axis to the extreme fiber
I_c = Centroidal moment of inertia of beam's cross-section
M = Maximum bending moment
Let the cantilever beam, y_{max} = 25 mm.
Let the material of the cantilever beam be mild steel.
Yield stress of mild steel = 250 N/mm^2
Considering a Factor of Safety = 4,
Allowable bending stress = 250/4 = 62.5 N/mm^2
Hence,

I_c = 63765 mm^4
An angle of 50 x 50 x 3 mm having I_c = 69000 mm^4 (slightly larger than the calculated value) is finalized for the cantilever beam.

Check for shear failure at the fixed end of a cantilever beam:
Max. Shear Stress =
Cross section area of angle is 295 mm^2 …………(Ref. 3)
Max. Shear Stress = = 1.66 N/mm^2
Allowable Shear stress for mild steel = 0.5 x (Yield stress/ Factor of Safety)
= 0.5 x (250/4) = 31.25 N/mm^2
Actual shear stress is also very less than the allowable shear stress of the mild steel.

Check for deflection of the beam at the free end:

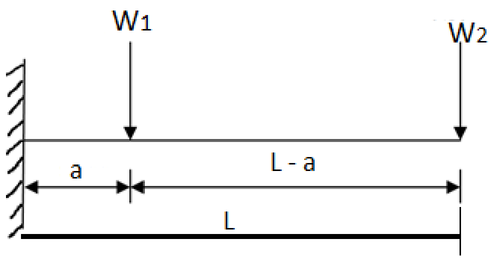

Figure 6 loading of the cantilever beam

Deflection of beam at the free end = δ = …………(Ref. 3)
But here $W_1 = W_2$ = W ……(say)
δ =
=
= 0.79 mm

This deflection is very much smaller & hence is having no effect on the performance of swing. Also, the above load will actually be shared by the supporting members on the two sides of the cantilever beam. Hence the actual deflection will be still smaller than the above-calculated value.

3.2 Design of weld joint at the fixed end

Figure 7 shows various terms related to weld zone.

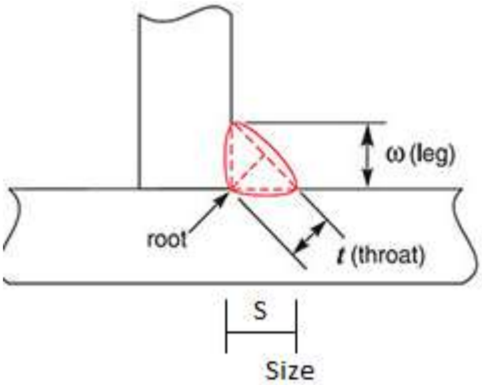

Figure 7 Weld nomenclature

Figure 8 shows the cantilever beam welded to plate.
For simplicity & safety also, considering the whole load as if acting at the free of the cantilever beam,

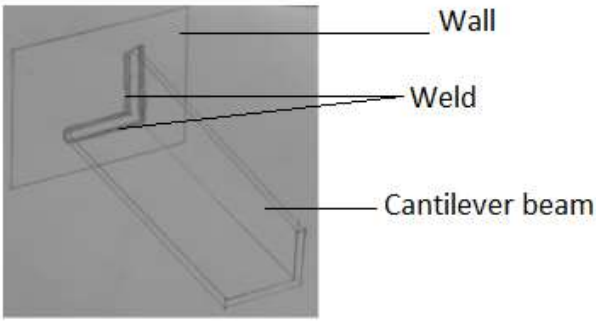

Figure 8 Weld joint at the fixed end of the cantilever beam

Area at the throat = [(50 +50) + (47+47)] x 0.707 S = 137.158 S mm^2
Direct Shear stress = =
Bending moment = Load x Eccentricity = P x e = 490.5 x 500 = 245250 N-mm
Section Modulus of the weld through the throat = Z =
0.707 S = 1367.927 S
Bending stress = f_b = = N/mm^2
Max. Shear Stress = $f_{s\ (max)}$ = …………………………………(Ref. 2)
= = 89.71 N/mm^2
= 89.71 /S
Hence, 89.71 /S = 31.25
S = 2.87 mm
Say S = 3 mm

3.3 Design of welded joint to provide a hanging arrangement for chains

Let two 'U' shaped bent rods be welded at the bottom side of the cantilever beam.

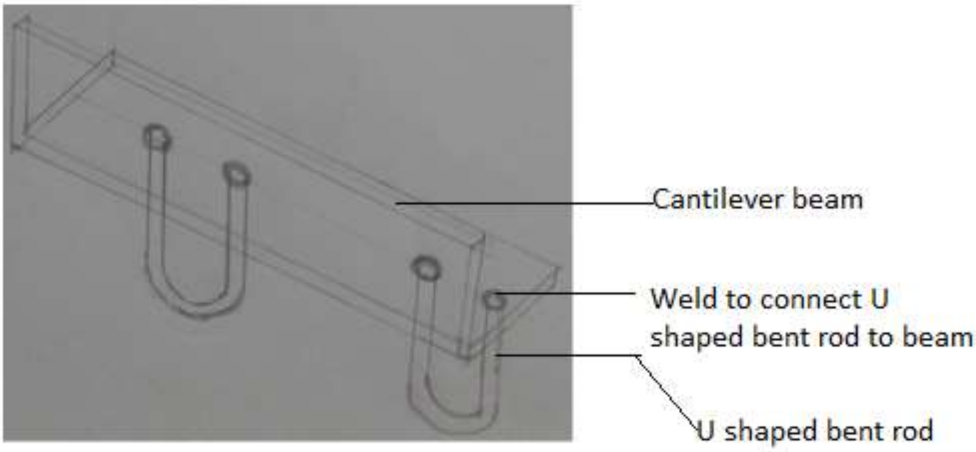

Figure 9 Weld joints at the bottom of the cantilever beam

Let the rod be of diameter 6 mm.
Throat area = 0.707 S x π x d = 0.707 S x π x 6 = 13.32 S
Shear stress = Load / area = (245.25/2) / (13.32 S) = 9.2 /S N/mm^2
Allowable Shear Stress = 31.25 N/mm^2
Hence, 31.25 = 9.2/ S
S = 0.294 mm
Say S= 1 mm
Hence weld size should be 4 mm.

3.4 Dimensions of holes in the frame for fixing it to wall

Let 5 mm thick plate is welded at the ends of the cantilever beam & two supporting members to fix this frame to the wall.

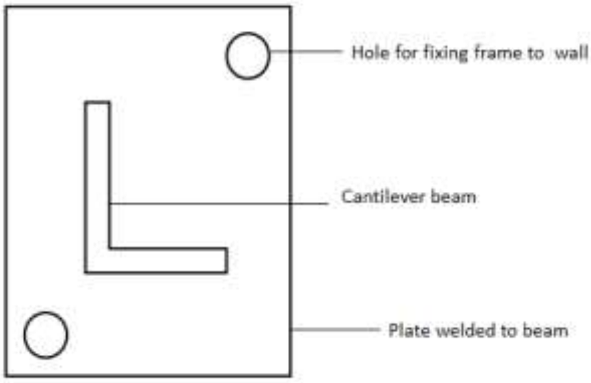

Figure 10 Arrangement of holes for fixing the frame to the wall

Let Total Number of nails to be used six (two at each plate)
Max. Load = 490.5 N
The allowable Shear strength of mild steel = 31.25 N/mm^2
Load on one nail = 490.5 /6 = 81.75 N
Hence cross-sectional area of one nail = 81.75 /31.25 =2.616 mm^2
Considering the dynamic conditions during swinging action, let us take a nail of diameter 6 mm giving an area of cross section = 28.26 mm^2

3.5 Design of supporting members:

The supporting members are actually meant for avoiding the deflection of the cantilever beam during swinging action. Both the supporting members will be in compressive loads.

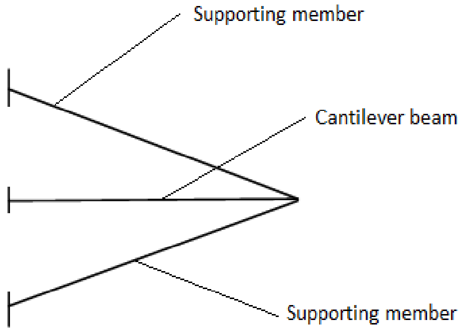

Figure 11 Cantilever beam with supporting members

During swinging the deflection (in the horizontal plane) of the cantilever beam will be stopped by the supporting members. The same angular section which is used for cantilever beam can be used for the supporting members safely. The supporting members will also help in reducing the deflection of the free end of the cantilever beam.

4. CONCLUSIONS

The designed wall mounted swing will be useful for indoor applications. The drawbacks of the existing indoor swings are taken into account while designing this swing. Hence it is better than the existing indoor swings.

5. ACKNOWLEDGEMENT

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