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An Adjustable Step Stool for Stunted People

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Abstract: The most typical problem for stunted people is that they have trouble finding work and have low self-esteem. However, present market tools for stunted persons have a fixed height, are pricey, and the size is difficult to use. As a result, the goal of this research and development project is to develop assist equipment that can change the height of stunted persons up to 30 cm, allowing them to work or gain a slight height, allowing them to execute their jobs properly and successfully. Furthermore, the instruments can endure a specific weight of 150kg or less. The height and weight restrictions were calculated using the average height and weight of Malaysians. The screw mechanism and hollow square leg design have been used to create an adjustable step stool. In addition, a study was performed to establish the tools' stress, strain, displacement, and Factor of Safety. The value collected from the analysis was recorded in order to pick the optimal parameter that should be employed in tool design. The conclusion of the entire design study showed that the von misses stress (9.322×10^1 MPa) was lower than the yield stress (2.206×10^2 N/mm^2 MPa). Furthermore, the tool's safety factor is 2.2, indicating that it is suitable for human use. Finally, a prototype of this design was successfully constructed to demonstrate the screw mechanism with the hollow square leg design.

Keywords: Stunting. Step stool.

1. Introduction

Standard deviations (SD) below the reference median of the WHO reference population in terms of height-for-age was defined as stunted (− 2 SD) or severely stunted (− 3 SD) [1]. Malaysia also was not free to the problem of stunted growth. Malaysia indicates an increase in the number of stunting in children under five years of age which is from 17.2% (2006) to 20.7% (2016)[2]. In Malaysia, the problem of stunted people is becoming more serious, and it is vital to pay attention to the challenges that they are currently facing. As we all know, stunted people will always battle with their height in everyday life. When it comes to their height, however, they lack a specific instrument to assist them in overcoming their difficulties. This condition can cause problems at work and have a detrimental impact on the health of those who are stunted. In addition to prevention of musculoskeletal strain, a recent simulation study found the use of a step stool (23 cm in height) was associated with improved compression depth [3].

There are a number of gadgets that can help people acquire height, but none of them were created with stunted persons in mind. Apart from that, youngsters and the elderly regularly used the existing

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equipment to provide some height support while conducting household tasks at home. The current design has a variety of flaws due to material, size, and height constraints. The height of the existing step stool is set and cannot be modified to satisfy the height requirements of those who are short. Furthermore, the step stool was small, making it difficult to stand on for extended periods of time without risking injury, particularly while working. Different materials have been used for different types of step stools, including aluminium, wood, and tubular steel. The current product's material was also too light, making standing on it uncomfortable for users and potentially leading to high maintenance expenses. The purpose of this research is to create a product that will help stunted people acquire weight. These step stools are designed to help stunted people handle them more easily, allowing them to get more work prospects and live a normal life. The goal of this step stool's creation is to enhance public awareness and assist people in thinking about their situation or challenges, particularly at work and in school.

2. Mechanism and Methodology

2.1 Stunted Height

The mean height for all races is 159.6cm [4]. This value was significant and was set as a recommendation for the adjustable step stool's maximum height. This value was chosen to meet the minimum height requirement for stunted persons, which is 135.6 cm, hence the maximum height adjustment for the step stool was 30 cm.

2.2 Mechanism

The screw mechanism was suitable for adjusting the step stool's height. In order to improve the product's stability and safety, the screw and scissor mechanics were integrated. A screw jack raises or lowers a heavy load using a tiny force delivered in the horizontal plane [5]. The traditional screw jack (also known as the scissors jack) is still widely used due to its numerous advantages, including long life, strength, packaging, mobility, and cost, with the most notable being its self-locking feature, which means that when the rotational force on the screw is removed, it will remain motionless where it was left and will not rotate backwards, regardless of the load it is supporting [6].

2.3 Design Analysis

Process design study was performed utilising software analysis by simulating external loads on solid work to build a step stool that can endure 150 kg. There are four designs of adjustable legs: hollow circle, hollow square, solid circle, and solid square, all of which have been studied using static analysis to determine which leg performs best. The static analysis was performed on the key part of the step stool, the leg, as well as the step stool frame, to determine the results of stress, strain, displacement, and factor safety.

3. Results and Discussion

This section discusses the representation and performance of step stool to withstand load 150 kg with maximum adjustment height 30cm.

3.1 Leg static analysis

Table 1 shows the summary of the result for the leg analysis. The example of analysis; stress, strain, displacement, and factor safety are shown in Tables 2 until 5. Based from Table 1, the solid circle leg step stool has the highest maximum stress with 3.175×10^3 N/mm^2 (MPa), while the solid square has the lowest maximum stress with 4.095×10^2 N/mm^2 (MPa) (MPa). This stress value gives a comparable outcome to these four characteristics, all of which are prone to plastic deformation. Based on the journal, materials are said to start yielding when the von misses stress reaches a value known as yield strength [7]. This statement shows that the material for parameter tend to yield when the load of 150kg is apply at the top of the leg. This is because of the value of maximum stress which is higher or bigger than value of yield strength, 2.206×10^2 N/mm^2 (MPa).

The result of strain analysis shows the highest value on solid circle parameter which is 8.218x10^{-3} while the lowest value of strain of Solid Square is 1.128x 10^{-3}. Based from the previous study, mentioned that the strain is defined as the ratio of the added length of an object to the original length [8]. The word strain relates to the relative change in the dimension or shape of the object where a pressure is applied, the minimum strain analysis determines the minimum deflection that occur when stress is apply on the step stool leg which is good to ensure the step stool leg not fracture when it been use.

The displacement result of the different four parameter shows the highest displacement value on Solid Square (6.599x 10^{-1} mm) compared to others result. The same concept as a strain analysis, the value shows that the displacement that occur when load (150kg) is apply on the top of the leg is not good compare to the hollow square which has smallest displacement (1.192 mm). As we know, the small displacement is better than big displacement to avoid any failure or safety risk in the future. Moreover, previous study also mentioned that the least resultant displacement from the design analysis provided optimum service life of material [9].

3.2 Full static analysis

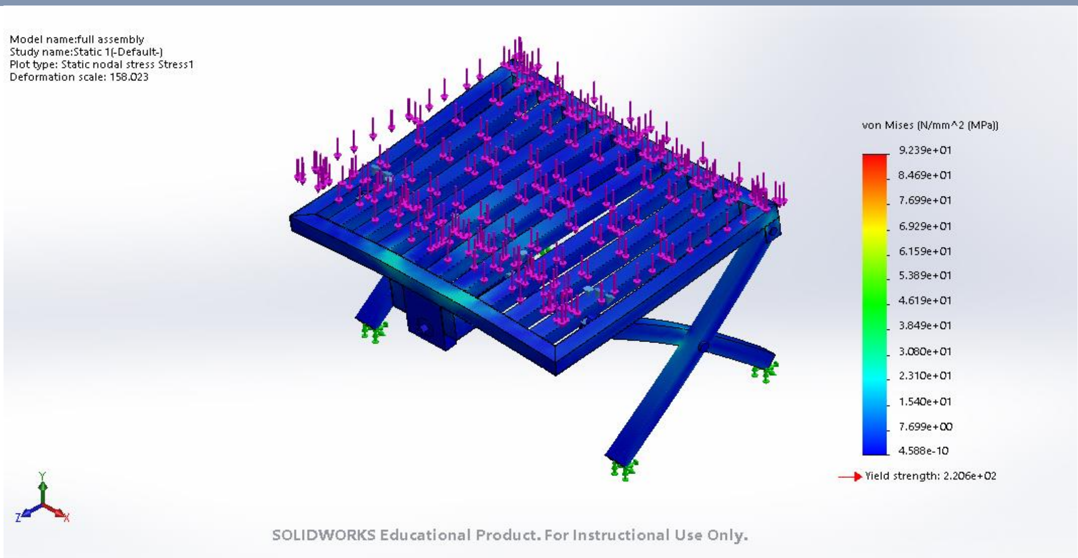
Table 1: Result summary of leg analysis

Parameter	Hollow square		Solid Square		Hollow circle		Solid circle	
	Max	Min	Max	Min	Max	Min	Max	Min
Von Misses Stress N/mm^2 (MPa)	9.322 x10^2	4.588 x10^{-1}	4.095 x10^2	2.961 x10^{-5}	2.054 x10^3	1.086 x10^{-1}	3.175 x10^3	3.205 10^{-1}
Strain	1.550 x10^{-3}	4.185 x10^{-7}	1.128 x10^{-3}	2.465 x10^{-10}	5.846 x10^{-3}	1.761 x10^{-6}	8.218 x10^{-3}	2.254 x10^{-6}
Resultant force displacement (mm)	1.192	0.000	6.599	0.000	2.478	0.000	1.674	0.000
Weight (Kg)	1.65		3.84		1.33		3.05	

Table 2: Von Misses Stress

Name	Type	Min	Max
Stress1	VON: von Mises Stress	4.588x10^{-1} N/mm^2 (MPa) Node: 149851	9.322 x10^2 N/mm^2 (MPa) Node: 131162

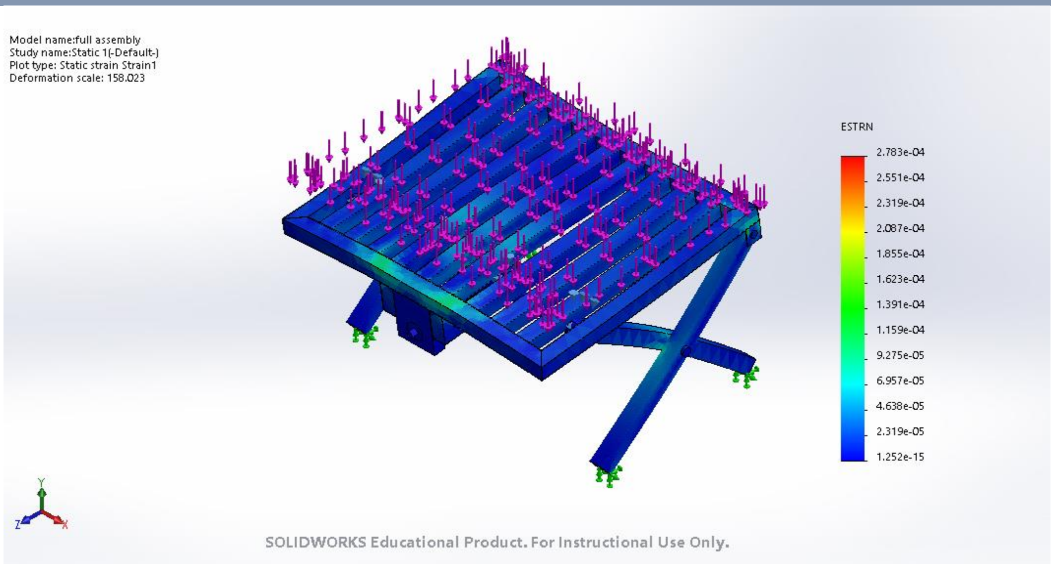
Name	Type	Min	Max



Full assembly-Static 1-Stress-Stress1

Table 3: Strain Result Analysis

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	4.185 x10-7 Element: 77093	1.550 x10-3 Element: 68412

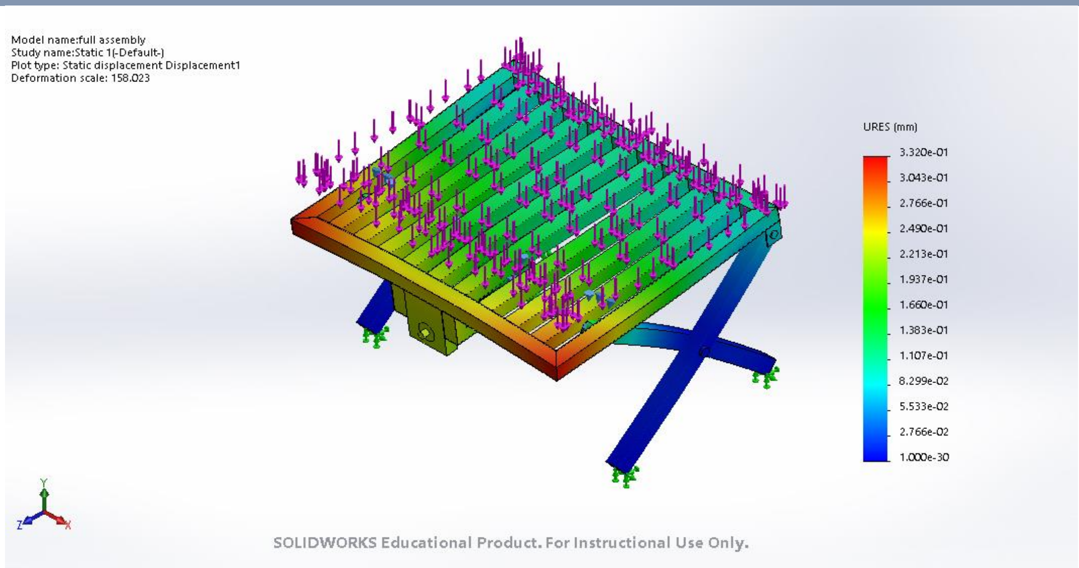


Full assembly-Static 1-Strain-Strain1

Table 4: Resultant Displacement

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000 mm Node: 124928	1.192 mm Node: 108788

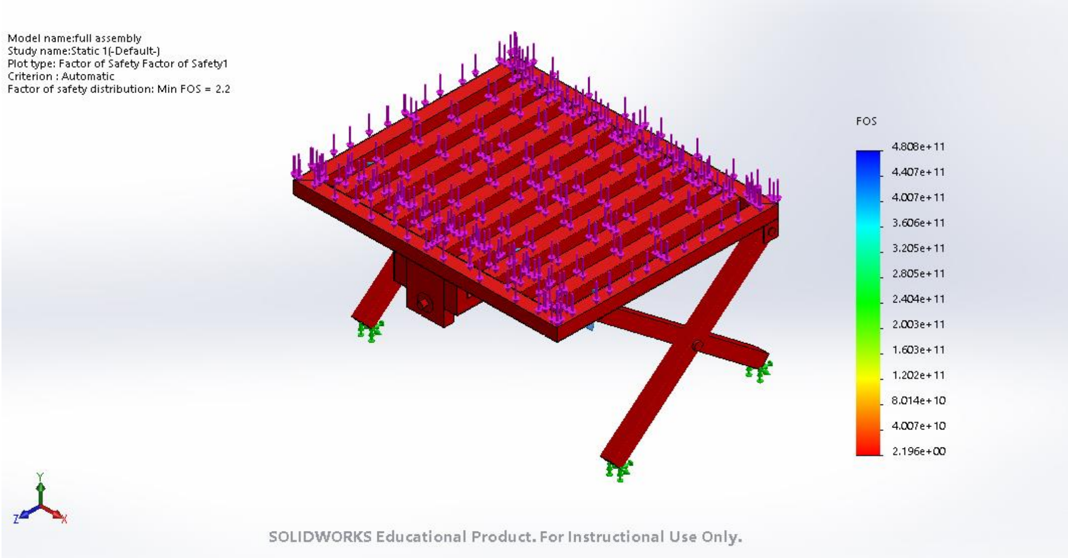
Name	Type	Min	Max



Full assembly-Static 1-Displacement-Displacement1

Table 5: Factor of Safety

Name	Type	Min	Max
Factor of Safety1	Automatic	2.196 Node: 124914	4.808×10^{11} Node: 149851



Full assembly-Static 1-Factor of Safety-Factor of Safety1

3.3 Mass product and leg static analysis

Based on the data that been gathered by the analysis, the most suitable design that can be used in the project is the hollow square design. This is because the design has the highest value of stress and it can withstand the load of 1471.5N without failure. The design also has considerable value of strain which is only 1.550 $x10^3$ which is very small value to performing a deformation process when subjected to 1471.5N of load. The displacement of the hollow square design is small which 1.192 mm is so that the project will not be tilted when people with 1471.5N weight step on the step stool. For the weight of the leg design, the hollow square is considerable lightweight due to its weight is only 1.65 Kg compare to the solid square design which is 3.84 Kg.

3.4 Full static analysis

After selecting the design of the leg based on the critical point static analysis, the selected leg design (Hollow Square) was assembled to the full design of the project to proceeding to the static analysis for full design. The complete design that been assembled is consist of frame, screw mechanism and leg shows total mass of the product is 10.76 Kg based on SolidWorks2019.Based on the result of the static analysis that been conducted below, the maximum stress that the product can withstand is 9.322×10^1 N/mm^2 (MPa) which is low than the yield strength 2.206×10^2 MPa which the material will not fail. This is because the material will yield or fails when it Von-misses stress is at a critical value which is known as the yield strength [10]. The result show that the maximum strain happens to the product during having a load of 1471.5N is 2.783×10^{-4} which is the small value and the product will not go to deform. This is because strain (or strain rate) and stress are intimately related during deformation by material rheology, as idealized by constitutive equations that depend on material properties and deformation conditions [11]. This relationship between stress and strain shows that small value of stress will result small value of strain. The maximum displacement of the project after a load of 1471.5N applied to the design is 0.332 mm which is also very small value for displacement which cause the product is not tilted when the load is applied to it. This is because, Areas of high stresses, high resultant displacement and high equivalent strain indicates unsafe zones which are prone to the highest level of deformation and vice versa[12][13]. Finally, the minimum value of the factor of safety is 2.2 satisfied the requirement of safety factor to higher than 1 which is if the Factor of safety is equal to 1 condition in Finite Element means that the shear strength at failure is reached and the modelled slope is failing[14].

Conclusion

Finally, the screw mechanism and hollow square leg design have been used to create an adjustable step stool that is suited for loads under 150kg and can be adjusted up to 30 cm in height. Apart from increasing the height of stunted individuals by 30 cm, the size of this product was also adequate for stunted people to stand on for a long time and can sustain the weight of 150kg. Regardless, this concept is still in its early stages, and more research, such as a better patent or material selection, is required to improve it.

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