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Product Development Hand Rail Assisting Walking Cane for Physically Aid

Bankapalli Vamsi, MD Affan, Kancharana Sohith, Sasubilli Rakesh Rao
vamsibankapalli@gmail.com, affankdp@gmail.com, sohithkancharana@gmail.com, Rakeshrao.nitt@gmail.com
Dept. of Production Engineering
National institute of Technology, Tiruchirappalli, India

Abstract- **One of the basic problems of the user with conventional walking cane is overcoming the balancing problems in congested areas (i.e. Non-spacious regions such as bathrooms, offices, Indian middle class houses, etc.). Even though many research studies have been reported in different fields to increase the independence of users, the question of overcoming these problems always remains a topic of discussion for many researchers. Our project mainly concentrates on the difficulties encountered during walking and to lay for a support to hold on something in non-spacious regions. This idea is truly based on capital involvement to buy different kind of things many a times. Ending up with one tool that can solve our basic needs is better concern. Some time was spent on the project to fix the metrology regarding the dimension, and having a tough sketch the CAD models is done Autodesk fusion 360 and Dassault CATIA software. This structure and mechanism will analyze in Ansys software. All the design parameters of the product were based on the standard design of the walking cane in India. The major part of the project focuses on the proposed design concept and concludes by discussing the physical working model of the proposed design.**

Keywords - **Walking cane, Autodesk fusion 360, Dassault catia, Ansys**

I. INTRODUCTION

One-fifth of the estimated global population i.e. between 110 million and 190 million people, experience significant disabilities. Disabilities of various parts such as eye, ear, hand, leg, etc. Imbalance is one of the disabilities which are caused due to various reasons such as infections of your ear, head injury, poor blood circulation, low blood pressure, chemical imbalance in your brain and certain medications. Osteoarthritis is one such imbalance problem. It is the most common form of arthritis, affecting millions of people worldwide. It occurs when the protective cartilage that cushions the ends of your bones wears down over time. Although osteoarthritis can damage any joint, the disorder most commonly affects joints in your hands, knees, hips and spine. [1] Osteoarthritis symptoms can usually be managed, although the damage to joints can't be reversed.

Staying active, maintaining a healthy weight and some treatments might slow progression of the disease and help improve pain and joint function. Over 18% of the global population has moderate, severe or extreme difficulty with walking especially due to Osteoarthritis. As the population continues to grow and age, this result number is set to keep rising. Current walking aids and the systems for distributing them are inefficient and unsustainable so increasing attention is being given to the design of simpler and cheaper walking aids which can be adapted easily and are readily available.

1. Walking aid
A walking aid is an assistive device designed to facilitate walking by improving people's stability, balance and upright body posture which can provide them with the confidence and ability to live more independently. [2] A person's weight can be redistributed through a walking aid to reduce pressure, and thus pain, from their lower limbs. Without a walking aid the user may feel more pain, may not be able to walk, or might walk with an unstable gait. Timely access to suitable walking aids is extremely important, particularly for young people, as it can increase the likelihood of them attending school and being able to join in social activities with their peers which can change the trajectory of the rest of their lives. Walking aids come in many shapes and sizes and some have become collector's items. People with disabilities may use some kinds of walking sticks as a crutch.

2. Types of walking aids Some Interviews [2] with physiotherapists and observations of patients at a Neuro Rehab Centre were conducted by a researchers - F. Nickpour and C. O'Sullivan are helped provide a better understanding of why different features were required for each type of walking aid and established that most patients "get through a few different pieces of equipment" during the course of rehabilitation. Table 1 shows the three basic types of walking aid which are available with a range of

variable features which enable them to facilitate walking across a broader spectrum of user requirements. [3].

Table 1 The three basic types of walking aid which are available with a range of variable features.

Type	Feature
Cane	The cane or walking stick is the simplest form of walking aid. It is held in the hand and transmits loads to the floor through a shaft. The load which can be applied through a cane is transmitted through the user's hands and wrists and limited by these.
Crutches	A crutch also transmits loads to the ground through a shaft, but has two points of contact with the arm, at the hand and either below the elbow or below the armpit. This allows significantly greater loads to be exerted through a crutch in comparison with a cane.
Walkers	A walker (also known as a Zimmer frame) is the most stable walking aid and consists of a freestanding metal framework with three or more points of contact which the user places in front of them and then grips during movement. The points of contact may be either fixed rubber ferrules as with crutches and canes, or wheels, or a combination of both. Wheeled walkers are also known as rollators. Many of these walkers also come with an inbuilt seat so that the user may rest during use and with metal pouches to carry personal belongings.

Since, we are working on design of walking cane, our primary motive is to concentrate on different types of walking canes. Many research studies have been reported in different bio-mechanical designing fields to increase the independence of users, the question of overcoming these problems always remains a topic of discussion for many researchers. Day by day, many innovations had been implemented to alter the design of walking cane by considering ergonomics of users.

3. Different types of walking canes There are many different types of canes available, with each providing various benefits. The following are some of the main types of canes on the market today as well as their functions and features. [4]

3.1 Single point canes Single point canes have a single support point at its end and are the most common type of walking cane. 1.3.2. Multi point canes Quad canes, tripod canes and other multiple-point canes, on the other hand, have several points that touch the ground and are stand-alone to provide more stable support for individuals who require more assistance with balancing. Of all cane types, quad canes (also known as 4-prong canes) offer the highest level of support.

3.2 Folding Canes folding canes are designed to fold and become compact enough to store easily in a handbag. Most collapsible canes are height adjustable and this type of cane may be ideal for those who want the option of being able to conveniently store their canes when not in use.

3.3. Seat Canes Seat canes are sturdy medical-grade walking canes with seats that can be unfolded whenever the user needs to take a break and sit down.

4. Type of handles when choosing a cane, it is important to consider what type of handle is most suited for your needs. In order to determine this, you'll need to factor in two things: 1. the shape of the handle and 2. the type of grip the handle is designed with. The images of various cane handles are shown in table 2.

4.1. Crook Cane type The rounded handle of this standard cane allows users plenty of space to find the most comfortable position for use, as well as making it easy to hook over the arm or other places, which is especially convenient when opening doors. Other common names for the crook handle cane include shepherd's crook walking stick and tourist handle cane.

4.2. T-Handle cane type These are also known as straight-handle canes, these canes are ideal for users who have weakness in their hand, as they are designed to reduce stress and hand fatigue. 1.4.3. Fritz cane type Fritz handle canes are similar to T-handle canes, but the extra curve is designed to provide better comfort for users and remove pressure to the hand and fingers, making it an ideal choice for users who suffer from arthritis. Many people prefer the fritz cane for its classic, distinguished style. When comparing the different types of handles available, the fritz handles cane ranks highest for both popularity and comfort.

4.4. Offset Cane- type Offset handle canes are shaped like a question mark, with the area just under the handle jutting out slightly. This helps distribute the user's weight over the cane shaft (or the body of the cane), making them more comfortable for use. Although offset handles are not unique to quad canes, nearly all quad canes available today are designed with this type of handle.

4.5. Cane bottom - types although the tip of your walking cane may seem small and insignificant, cane tips that have become worn or torn are dangerous. Fortunately, it is easy and inexpensive to replace this part of your cane, so be sure to do it regularly for your safety or that of your loved one. When selecting replacement cane tips, the first thing you'll need to know is the measurements of the bottom of

your cane and find a cane tip size to match. This will usually be somewhere between 0.5" and 1", including 5/8", ¾" and 7/8". Once Type: Feature: Cane The cane or walking stick is the simplest form of walking aid. It is held in the hand and transmits loads to the floor through a shaft. The load which can be applied through a cane is transmitted through the user's hands and wrists and limited by these. Crutches A crutch also transmits loads to the ground through a shaft, but has two points of contact with the arm, at the hand and either below the elbow or below the armpit. This allows significantly greater loads to be exerted through a crutch in comparison with a cane. Walkers A walker (also known as a Zimmer frame) is the most stable walking aid and consists of a freestanding metal framework with three or more points of contact which the user places in front of them and then grips during movement.

The points of contact may be either fixed rubber ferrules as with crutches and canes, or wheels, or a combination of both. Wheeled walkers are also known as rollators. Many of these walkers also come with an inbuilt seat so that the user may rest during use and with metal pouches to carry personal belongings. you know which of the above measurements you need, the next step will be to choose the type of cane tip you prefer.

4.5. Rubber cane tips - The most common cane tip type is the basic, rubber cane tip which provides great traction and often includes a steel insert for increased durability.

5. Quad tips another type of cane tip available is the tripod or quad cane tip, which is attached to a single tip on the cane but ends with three or four prongs. This design offers increased traction, stability and weight capacity, and allows the walking cane to stand upright on its own. Some cane users prefer using these self standing cane tips instead of the bulkier quad cane.

5.1. Hand grips- The next thing to consider is the type of grip the handle of your cane should have. The table 3 shows the different types of hand grips and their features.

Table 2 The four basic types of walking cane handles

Cane type	Diagram
Crook cane type	
T-Handle cane type	
Fritz cane type	
Offset cane type	

Table 3 The different types of hand grips and their features.

Grip type	Benefit
Foam grips	Soft and comfortable
Gel grips	Reduce hand stress and fatigue
Large grips	Ideal for arthritis and joint pains
Orthopedic grips	Designed to fit the hand

5.2. Suction cups A suction cup, also known as a sucker, is a device or object that uses the negative fluid pressure of air or water to adhere to nonporous surfaces, creating a partial vacuum. The working face of the suction cup is made of elastic, flexible material and has a curved surface. When the center of the suction cup is pressed against a flat, nonporous surface, the volume of the space between the suction cup and the flat surface is reduced, which causes the air or water between the cup and the surface to be expelled past the rim of the circular cup.

The cavity which develops between the cup and the flat surface has little to no air or water in it because most of the fluid has already been forced out of the inside of the cup, causing a lack of pressure. The pressure difference between the atmosphere on the outside of the cup and the low-pressure cavity on the inside of the cup keeps the cup adhered to the surface.

5.3. Mechanism Of Suction Cups When the user ceases to apply physical pressure to the outside of the cup, the elastic substance of which the cup is made tends to resume its original, curved shape.

The length of time for which the suction effect can be maintained depends mainly on how long it takes for air or water to leak back into the cavity between the cup and the surface, equalizing the pressure with the surrounding atmosphere. This depends on the porosity and flatness of the surface and the properties of the cup's rim. The force required to detach an ideal suction cup by pulling it directly away from the surface is given by the formula:

$$F = AP$$

Where, F is the force, A is the area of the surface covered by the cup, P is the pressure outside the cup (typically atmospheric pressure)

5.4. Flat Suction Cups Flat suction cups are particularly suited for handling workpieces with flat or slightly curved surface. Flat suction cups can be evacuated quickly due to their flat shape and low inner volume, therefore they can grip the workpiece in a very short time and can withstand the forces which result from fast movement of the object during handling. 1.7.3. Bellow suction cups Bellows suction cups are used when it is necessary to compensate for varying workpiece heights, to handle parts with uneven

surfaces or fragile parts. The bellows make this suction cup especially flexible and adaptable.

6. Telescopic Pole mechanism telescoping in mechanics describes the movement of one part sliding out from another, lengthening an object from its rest state. In modern equipment this can be achieved by a hydraulics, but pulleys and spring based locking systems are generally used for simpler designs. In our project, we are focused on set of three single acting telescopic pole mechanisms. Single acting telescopic cylinders are the simplest and most common design. As with a single acting rod style cylinder, the single acting telescopic cylinder is extended using external forces. This external retraction force is usually gravity acting on the weight of the load. This external weight must obviously be sufficient to overcome the friction and mechanical losses within the machine design even after the work portion of the machine cycle has been accomplished. We were used a spring based hole-shaft locking system in our design.

II. DESIGN METHODOLOGY

We focused on User-centered approach and design thinking process to implement our idea. The Usercentered design (UCD) process outlines the phases throughout a design and development life-cycle all while focusing on gaining a deep understanding of who will be using the product. And also on the other we approached design thinking process also to implement our idea. Design thinking process is a non-linear approach which is an iterative process [8] that we used to understand users, challenge assumptions, redefine problems and created innovative solution. In the figure 1 and 2 as shown below, we listed our methodological approach.

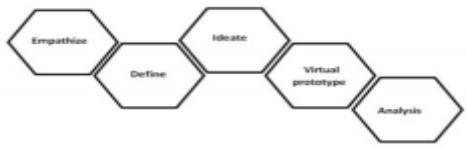

Fig.1 Our methodological design approach - 1.

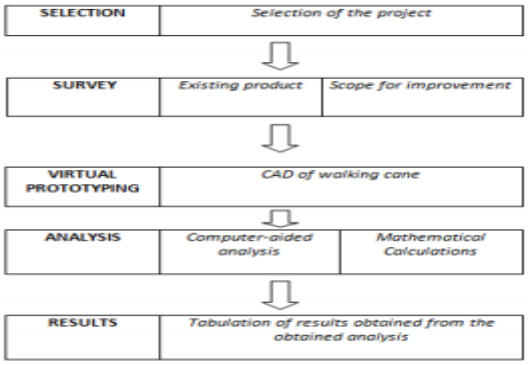

Fig:2 , Our methodological design approach – 2.

III. PROPOSED DESIGN

Our designs' overview and characteristics which is based on our methodology as mentioned in unit 2 are listed below

1. System architecture - To overcome certain limitations of existing devices, the proposed system had to attain some requirements, such as the arrangement of suction type hand rails in the middle part of cane. This design have a capability of assist the physically aid people by providing a balance through cane design and also with suction hand rail (fig 4). The entire height of the cane is divided as three parts (fig 3) which will connect by means of telescopic pole mechanism with a hole-shaft based spring locking system (1.8.). the handle of cane, which is a 1 DOF system will move 90° with respect to cane axis YY' (fig 5) as per our requirement. The rotational plane of the handle is XY (+'ve) plane direction. The handle is connected to the top tube of telescopic pole using a tight fit spring based hinge. For the trapped air dispersion and relaxation inside a suction cup a rubber pipe and sliding switch are also attached to the middle part of telescopic pole. All the tubes with telescopic pole will have 1 DOF along YY' axis. The quad tips will attach to the bottom telescopic pole for ground grip. (fig 3).

2. System working As per the 3.1., the system consists three telescopic poles which will use to modify the overall cane design into hand rail. These three poles are moving along YY' axis as shown in figure below.

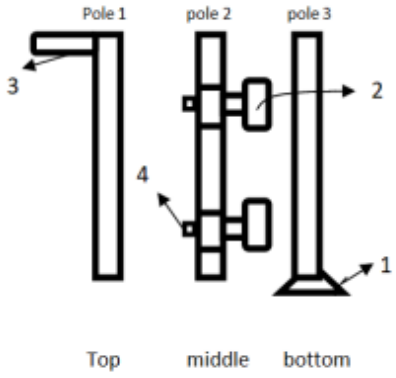

Fig:3 , Telescopic poles | top, middle and bottom | with parts specification

The assembly of three poles by means telescopic mechanism as shown in figure 3. When the user is in open space and doing regular works such as walking, the entire cane will help him/her to assist. The usage of suction hand rail, the design which will obtain by closing all poles together as single pole by means of telescopic mechanism (fig-4). The modified hand rail design will use when the user is in congested areas or in bathroom as well. These handrails will give a support to him/her during assisting

regulars. The description of individual parts is mentioned below:

- The quad gripper used to provide grip between ground and cane. The entire weight of the person and cane is concentrated at the gripper - ground junction.
- The suction cup which is used for hand rail purpose. These suction cups attached to any type of surfaces irrespective of roughness or slipperiness or wetness.
- The handle design will play a major for every walking cane, because people with Osteoarthritis may be had finger/wrist arthritis. So, selection of ergonomically handle bar will add an advantage to them to reduce loads on their joints. The orthopedic model – palm grip handle is used in this design for better ergonomics.
- It is the button kind type which will used to disperse or relax the trapped air inside the suction during hand rail assist model.

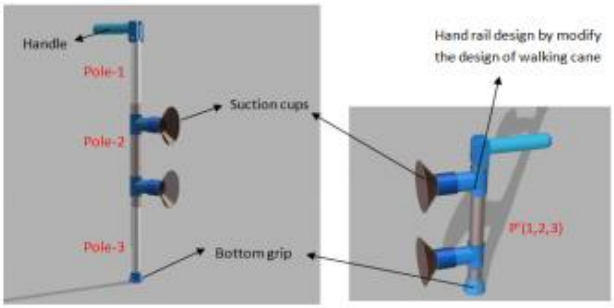

Fig:4 , Virtual design of our idea a) walking cane b) Hand rail (by folding of all poles)

As shown in figure 4, There are three poles named p(1), p(2) and p(3) are connected which looked as a conventional walking cane, when all the poles are stretched separately (fig 4). User can use this stick as a hand rail by closing p(1) and p(3) inside a p(2) by means of telescopic mechanism. Let the resultant pole of the design is p'(1,2,3).

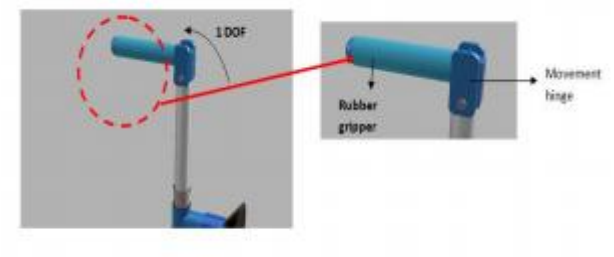

Fig:5 , Handle design

The handle consist a rubber foam grip is for better ergonomics and hand grip. This handle is attached to spring type hinge design, which will move 90° as shown in figure 5. 3.2. Working The working of the rehabilitant is very simple, as shown in figure 6, The user can avail the walking cane by stretching all poles. If the user is wanted to use this device as hand rail, he can move the poles p(1) and p(3) into p(2) to get the resultant p'(1,2,3). The DOF system of p(1) along –'ve Y-axis and p(3) along +'ve Y-axis. The handle will move along positive XY plane.

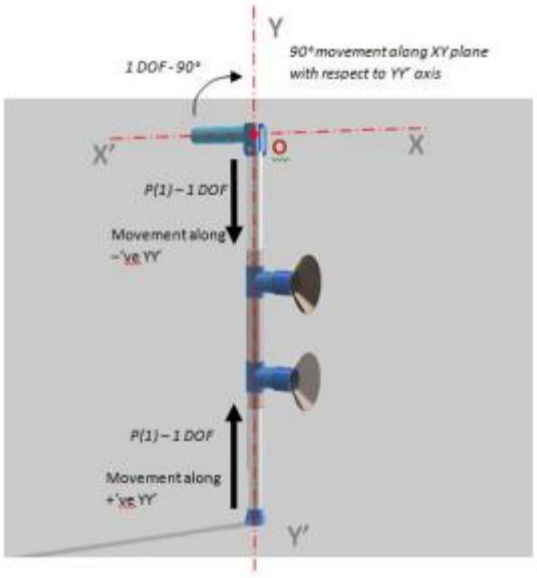

Fig:6 , Poles movement

The neoprene rubber type suctions cups were used in this virtual prototype. These suction cups will attach to any type of surface easily. As shown in figure 7.

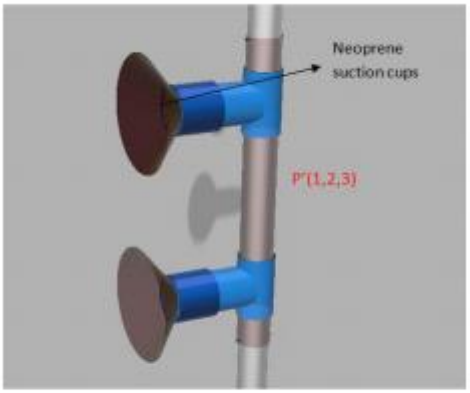

Fig:7 , Hand rail design

IV. RESULTS AND OBSERVATIONS

The user can use the p(2) as handle of the handrail, and will avail this design's for support on walls.

1. Human centric experience- Human-centered design (HCD) is an approach to problem solving, commonly used in design and management frameworks that develops solutions to problems by involving the human perspective in all steps of the problem-solving process. Human involvement typically takes place in observing the problem within context, brainstorming, conceptualizing, developing, and implementing the solution. The user in the figure 8, is using a walking cane, when all the poles are stretched by means telescopic mechanism. Accessible toilets, showers and bathrooms at least in public and commercial buildings must be fixed with handrails to the wall. So, according to our proposed design seem to make sense as temporary items in particular cases in private and domestic facilities. A walking cane which will converted as simple temporary handrails by means of telescopic mechanism.

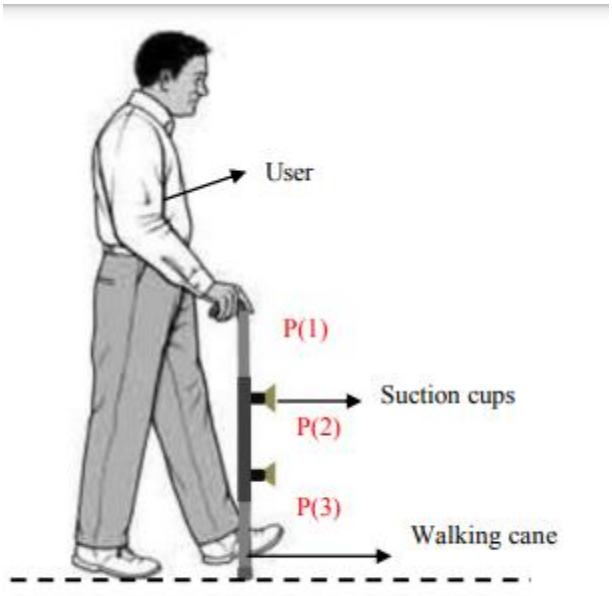

Fig:8 , Human experience with our cane

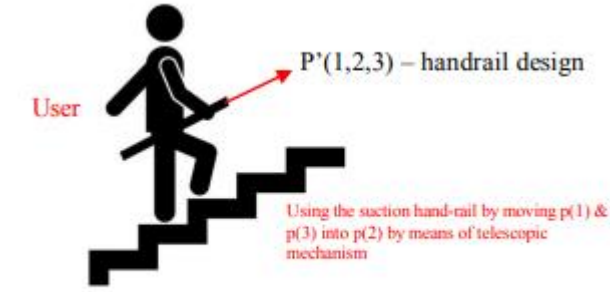

Fig:9 , Application of the hand rail

As shown in figure 9, the user is using the handrail of walking cane while stair ascending. There are other many applications such as using these handrails in bathrooms, public spaces, congested areas etc, for good support.

2. Computerized analysis The computerized analysis of stress, strain, displacement, safety factor and reaction force were analyzed. The result of the analysis was shown below.

3. Bottom rubber gripper Material Neoprene Mesh: tetrahedron meshes Analysis type: Static stress analysis.

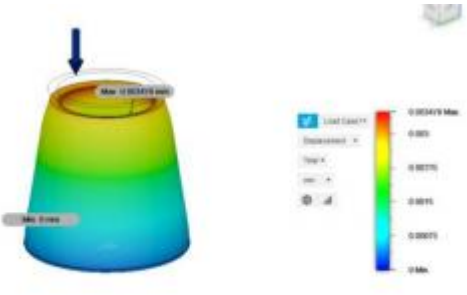

Fig:10 , Displacement analysis (mm) of bottom rubber gripper

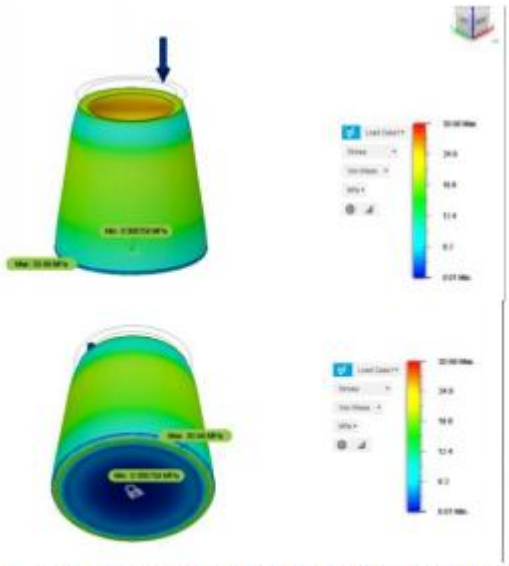

Fig:10 , Stress analysis (Mpa) of bottom rubber gripper Von mises

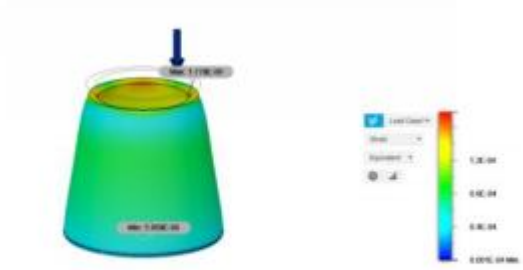

Fig:11 , Strain analysis of rubber gripper

Safety factor: minimum – 6.76 and maximum – 15

4. Buckling analysis of p (3) Material- Aluminum alloy Mesh: Tetrahedron mesh Analysis type buckling stress analysis.

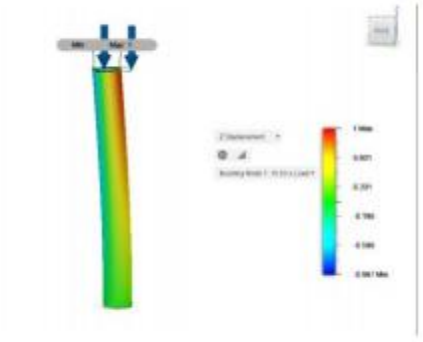

Fig:12 , Buckling load analysis of p(3) Z-direction

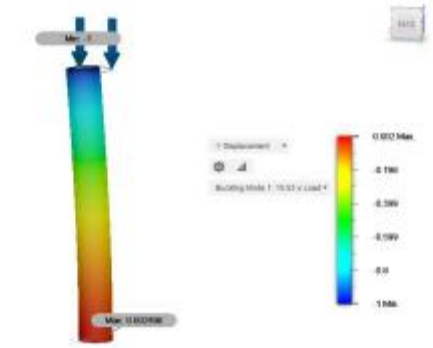

Fig:13 , Buckling load analysis of p(3) Y-direction

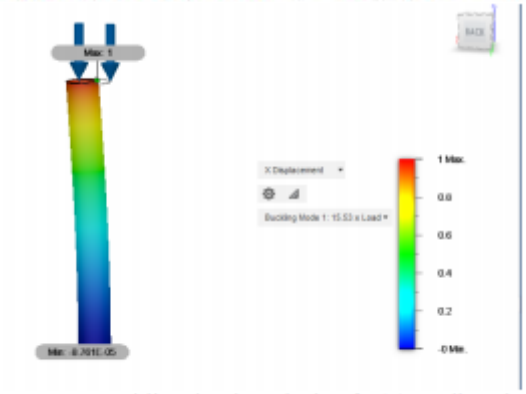

Fig:14 , Buckling load analysis of p(3) X-direction

4. Buckling load analysis of walking cane without a gripper, suction and handle Material: Aluminum alloy Mesh: Tetrahedron mesh Analysis type buckling stress analysis

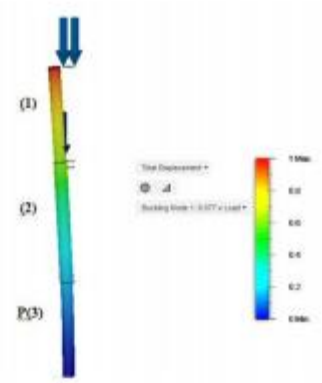

Fig.15 , Buckling load analysis of walking cane on two modes.

5. Literature on cane bio-mechanics There are many factors involved in prescribing the appropriate ambulatory assistive device. The patient's upper body strength, balance and coordination, overall physical strength and endurance, level of impairment, cognitive function, vision and living environment must be taken into account. [9] The patient's upper body strength should be evaluated to determine whether one or both of the upper extremities would be needed to bear weight or achieve balance. If only one upper extremity is needed then a cane would be the proper device, while those needing two upper extremities would benefit from a walker or a pair of crutches. Also the degree or amount of the patient's weight needed to be borne by the device would aid the Physiotherapist in choosing the appropriate device. [10]

5. Gait analysis Most people in need of canes have pain or injuries (like in the case of an antalgic gait due to hip osteoarthritis) that make them avoid weight bearing on the affected side or limb and decrease the stance phase on that limb in an attempt to unload the mechanical stress on the painful hip joint as shown in figure 16. A cane can increase stability during the single-limb support phase. Therefore, a sound knowledge of the normal gait pattern and cadence is of utmost importance in evaluating and understanding the limitations of the patient with abnormal gait patterns and in prescribing the appropriate ambulatory assistive device. [11].

Fig:16 , Increase of angle of equilibrium (about threefold) by using sticks (A) or crutches (B) with its ends far apart (orange arrow). [11]

In measuring a cane height, the cane is placed approximately 6 inches (15.24cm) from the lateral border of the toes.The patient should be wearing appropriate, comfortable shoes during measurement. These are the various ways to determine the appropriate cane length.

- Elbow Angle: The patient should stand erect and hold the cane with the elbow flexed at 20 to 30 degrees. The angle of elbow flexion is measured using a goniometer. There should be 20 to 30 degrees of elbow flexion in the elbow while holding the cane approximately 15 cm (6“) from the lateral border of the toes, This degree of flexion allows efficient elbow movement while walking with the cane, and allows the arm to shorten and lengthen during different phases of the gait cycle, and provides a shock absorption mechanism.
- The floor to the greater trochanter, The patient should stand erect and the distance from the floor to the greater trochanter measured to give the length of the cane. That means the top of the cane is at the same level of the greater trochanter when the patient is standing upright with the arms hanging loosely by the side as shown below.
- The distal wrist crease to the floor, The patient should stand erect with arms hanging loosely by the side and the distance from the distal wrist crease to the floor measured to get the cane length.
- Use a formula.

Length of cane = height of the individual (meters) x 0.45 + 0.87 m. (L = H x 0.45 + 0.87 m).

V. CONCLUSIONS

We are the team of four members developed, investigated and validated under the mentor that the virtual design and analysis of this type of walking cane with suction hand rail will best suitable for future real time prototyping. .

Acknowledgements- We are grateful to our guide Dr. C. Sathiya Narayanan, associate professor, department of production engineering for his guidance, constant support and encouragement in completing the work.

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