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MOTORIZED WHEELCHAIR PROJECT

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Abstract. *This Project seeks to construct a wheelchair controlled by its occupant and with predisposition to motorization. As project factors for a prototype construction, was considered the materials that would be used, the fabrication process involved, construction methods, suspension system, mechanical resistance, comfort and conductor's autonomy, considering that the wheelchair can be seen as a bodypart of the person that uses it, due the strong dependence of these people to that assisted technology. The project was developed with the assistance of the professors and students, being part of a discipline known as Mobility and Accessibility Engineering.*

Keywords: *Wheelchair; Construction; Fabrication Process*

1. INTRODUCTION

The physical disability is characterized by the total or partial mobility loss, being that loss, in most cases, resultant of accidents or brain injury. In these days, one of the most alarming data is the big number of people with physical or brain damage. The ONU says that are a little more than 650 millions of people who have disability all around the world. The number represents about 10% of total world population. In Brazil, that percentage represents about 15 and 18 millions of people. In countries where the life expectation is above 70 years, the people expend about 8 years of their lives in a physical incapability situation.

The disability causes a reduction, limitation or non existent conditions of environment perception, or mobility and edification use. For the people who have some kind of disability and need a wheelchair as a locomotion way, the accessibility difficulties found in Brazil are notable. People with disability or amputation, need to have some kind of assisted technology, and with that technology, be an integrant part of the society. The dependence makes the assisted technology an essential field to be developed, bringing more comfort, security, mobility and practicality to the people who need to use it.

Research shows that the most part of studied physical disability are paraplegia, paraparesis and physical paralysis. That kind of paralysis are, most commonly congenital, but the research shows a consider number of paralysis resultant of firearms. The most part of the wheelchair users ask for improvements like, better comfort, motorization and accessible prices (COELHO, 2010).

The wheelchairs are the most utilized way of socialization and transport used for the people, which congenital or acquired, are found with some kind of motion disability.

Basically are two kinds of wheelchairs, the electrical and manual. The manual kind, have a lot of variations, as the assistant driven, bimanual driven with rear or lateral wheels.

The motorized wheelchairs can be used by users with no strength or dexterity in your arms, or old users that have lost the capability to move your arms. The number of people who need motorized wheelchair are growing every year. A query to the Regional Center of Prevention, Rehabilitation and Social Inclusion (CERPRIS), in Juazeiro – BA, shows that the requirement of motorized wheelchair with low cost became evident.

The common market wheelchair, have a high price, and that price are inaccessible by a big part of the local population. A short research in the national market shows that are few brands of motorized wheelchairs, and its cost are about 5.000,00 and 8.200,00 "Reais" (FILHO, 2010).

At this moment, was found the necessity to create, linking the University and the CERPRIS, a project that looks to assist the local population, producing wheelchairs, motorized and manuals, searching for a low construction price.

With the discipline of Mobility and Accessibility Engineering, the students could learn a little more about the social and structural problems that the person with physical disability is subjected.

Lectures with professionals from various areas, as medical, architects, engineers and teachers, allowed the students to obtain knowledge to consider every kind of disability when the construction process of the wheelchair was initiated.

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2. METHODS AND MATERIALS

The work was initiated 2 years ago, the project was developed for different students and, came suffering some changes in the course of time. This changes were based on wheelchair upgrades, seeking the best work method to be developed by the students.

The year of 2011, can be consider as the most productive year of the project. The student group of 2011 developed the final project of the wheelchair. With the lectures, the group could learn a little more about the difficulties faced by the people with some kind of disability, mostly the people of the Vale do São Francisco.

As main objective, the discipline looks to develop two models of wheelchair, being one motorized and the other manual. The discipline doesn't want to make the cheaper wheelchair, comparing with the models available on the market, but looks to elaborate a wheelchair with low cost, that meets the needs of the disabled people.

One of the important factor that made this project to come true, was the social impact caused on the Vale do São Francisco. With the money provided by the Universidade Federal do Vale do São Francisco, now, the project, with the students' help, 10 motorized and 10 manual wheelchair will be constructed until the final of December. The constructed wheelchair will be donated for the CERPRIS, an institution that helps disabled people.

The project, also will upgrade the CERPRIS's information system and a study will be made, trying to bring to Vale do São Francisco region, solutions that can help to upgrade the accessibility ways available on the streets.

On the mechanical project of all components of the wheelchair, was used the software SolidWorks, to modeling and confectioning all mechanical draws with high level of detail.

The selected tubes for the wheelchair structure are made of steel SAE 1020, with diameter of 1", and thickness of 0,9mm, metalon with rectangular profile (20x30mm) for the base of the set engine/reduction, and a flat plate with thickness of 0,2mm.

The suggested dumpers are usually used on bicycles, the dumper used are demonstrated in the picture (1). The dumper used on the project is considered as ideal to reduce the vibrations provided by the irregular terrain and to provide a better mobility of the wheelchair. This is one of the most critical points related to the project and construction, because it depends of the kind of disability, minimal vibrations can cause a discomfort and to prejudice the treatment of the patient (GRASSI, 2010).

Figure 1. Bicycle dumper

Looking to reduce even more the vibrations, Nylon supports will be used in conjunction with the attachment points of the dumpers.

The rear wheels will be adaptations of the wheels used on bicycles. The usual dimensions are 26" diameter, and known as "AERO" wheels. That is a new wheel line, being easily found on local market. These wheels have a high level of hardness and it's very light.

A motor/reduction conjunct GPB-MR4 will be used to help with the wheelchair locomotion, that engine costs approximately R$ 570,00.

The front wheels will have 8" diameter, being small than the rear wheels. It's made of a hard material, having the capability to not be locked on gritty and bumpy terrains (COELHO,2010), making the turns more easy to be made by the user.

For the alimentation system will be used 2 batteries (Moura Intelligent Battery 60 AH/MI-60CD).

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Figure 2. Wheelchair parts; 1- Rear wheel; 2- Front wheel; 3- Back suport; 4- Bottom; 5- Batteries; 6- Transmission system; 7- Joystick; 8- Paw; 9- Foot support; 10- Wheelchair structure; 11- Batteries and engine structure.

The wheelchair was designed fallowing the NBR9050 rules. These rules show the correct sizes that have to be consider in a wheelchair design.

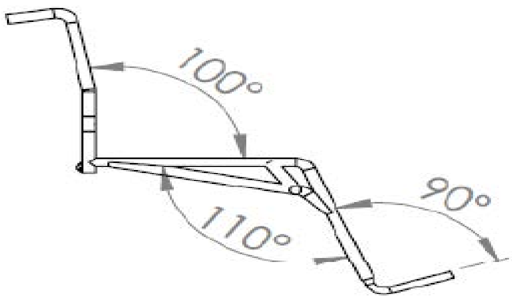

Figure 3. Used angles on wheelchair project.

The used tubes are curved on an unique plan making the construction more easy, because it have just two identical structures, linked by transversal bars.

The pictures (4) and (5) show that the new wheelchair configuration allows the height configuration of the arms and foots of wheelchair user. Besides, the configuration can admit the use of the wheelchair by users of different heights, allowing the user to configure the positions, optimizing your comfort.

Figure 4. Guide tube detail. That tube allows the arm set up.

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Figure 5. Guide tube detail. That tube allows the foot set up.

3. RESULTS

The specified material for the wheelchair construction was SAE 1020 steel. That material has a traction and yield resistance of 400MPa and 200MPa, respectively (NORTON,2004), and that material is resistant enough to any effort that the wheelchair can be subjected.

A comparison can be made with the used tubes of the project Baja SAE, using for this comparison calculus of bending resistance and flexural rigidity.

The regulation requires tubes of 1” as minimal diameter and 3,05mm thickness. So, the bending resistance(RF) and flexural rigidity(P) can be calculated as shown bellow:

$$RF = \frac{Sy\,I}{c} \tag{1}$$

$$P = E\,I \tag{2}$$

Where, Sy is the shear stress, E is the elastic modulus, c is the radius and I is the inertial moment. For the required tube on Baja SAE project, the bending resistance is RF=396,829 N.m, and the flexural rigidity is P=2,792x10^3 N.m^2. For the used tubes in the wheelchair, a substitution of values was made to find the new RF and P.

$$RF = \frac{(370{,}10^6)\ ^{\pi}/_{64}\,[(25{,}4\,.10^{-3})^4 - (23{,}6\,.10^{-3})^4]}{(12{,}7\,.10^{-3})} \tag{3}$$

$$RF = 151{,}63\ N.m \tag{4}$$

$$P = (205\ .10^9)\,\frac{\pi[(25{,}4\,.10^{-3})^4 - (23{,}6\,.10^{-3})^4]}{64} \tag{5}$$

$$P = 1{,}07\ .10^{-3} N.m^2 \tag{6}$$

These values represent 38,21% and 38,32%, respectively, of the recommended by the Baja SAE.

Considering that Baja SAE is a vehicle for off-road competition, designed to go trough highly hugged terrains. The values of RF and P found are acceptable, because the wheelchair will be used in different conditions.

For the mass center calculus, the wheelchair was considered as many particles, that, when united, form one singular structure. Supposing that the m1 coordinates are (X1,Y1), m2 are (X2,Y2) and so on. Is defined as mass center, the point whose coordinates are (X_{cm},Y_{cm}) (YOUNG, 2003).

$$X_{cm} = \frac{m_1X_1 + m_2X_2 + \ ...}{m_1 + m_2} = \frac{\sum_i m_iX_i}{\sum_i m_i} \tag{7}$$

$$Y_{cm} = \frac{m_1Y_1 + m_2Y_2 + \ ...}{m_1 + m_2} = \frac{\sum_i m_iY_i}{\sum_i m_i} \tag{8}$$

After the SolidWorks modeling, every component coordinate can be found, with a reference to an axis.

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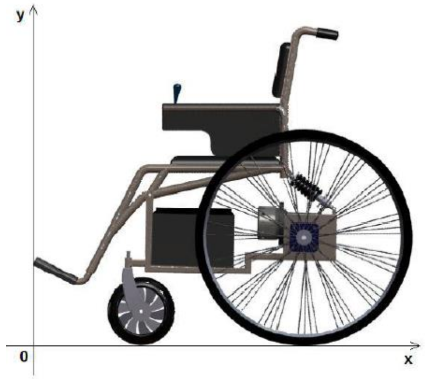

Figure 6. Adopted coordinate system.

The chart(1) shows the coordinates of every wheelchair component.

Components	Mass(Kg)	Quantity	X(mm)	Y(mm)
Front Wheel	0,38*	2	323,37	101,60
Rear Wheel	2,50*	2	808,20	324,70
Battery	8,30*	2	473,66	324,70
Engine	1,30*	2	702,4	367,27
Reducer	3,00*	2	808,20	324,70
Dumper	0,45*	2	818,60	470,50
Roller bearing	0,60*	2	808,20	324,70
User	70,00	1	655,50	649,40
Structure	14,70	1	655,18	400,63

*Specified by manufaturer.
Chart 1. Used components in the wheelchair manufaturing.

Replacing all related mass and your respective coordinates in the (7) and (8) equations, the following points were found:

$$X_{cm} = 645{,}27 \text{ mm} \quad (9)$$
$$Y_{cm} = 529{,}62 \text{ mm} \quad (10)$$

Knowing the mass center position, the reactions in the front and rear wheels can be calculated.

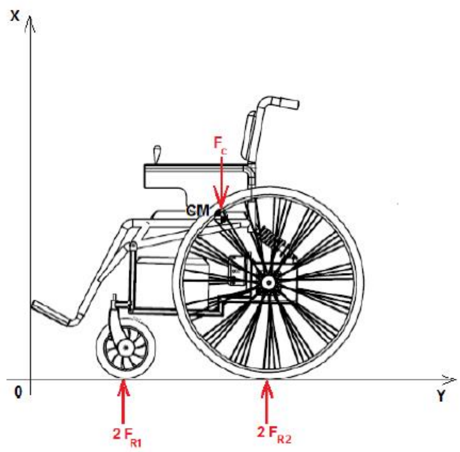

Figure 7. Front and rear efforts.

Doing the same in the Y axis:

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$$2F_{r1} = -2F_{r2} - F_c \quad (11)$$

From the modeling, the correct distance of the front wheels in relation with the rear wheels is:

$$-(1148{,}55\ N)\ (327{,}14mm) + 2Fr2\ (488{,}14mm) = 0 \quad (12)$$

$$Fr2 = 384{,}87\ N \quad (13)$$

Replacing the result, the reaction in the front wheel is:

$$Fr1 = 189{,}41\ N \quad (14)$$

For the calculus of the wheelchair stability, was necessary to find the tipping angle. The tipping angle represents the maximum angle, that the wheelchair can be subjected until to its tipping.

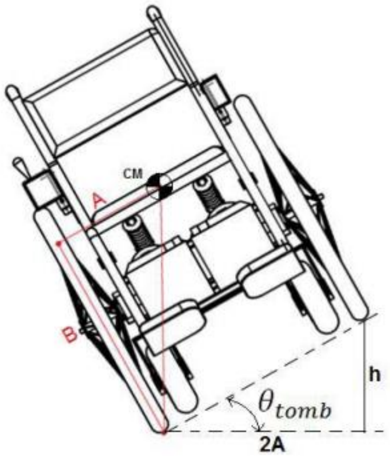

Figure 8. Tipping angle representation.

$$\theta_{tomb} = \text{arctg}\left(^{A}/_{B}\right) \quad (15)$$

Replacing the values of A and B, the tipping angle found is 28,32º.

In case of the wheelchair to be inclined with an angle bigger than 28,32º, it will tip. That is an acceptable angle, because the wheelchair will never be subjected to terrains with that level of inclination angle.

4. CONCLUSION

Was developed a rich study about the difficulties found by the people with physical disability, looking to develop an accessible technology that can be used by these people. The motorized wheelchair comes to make the life of disability people more comfort and easy. The designed wheelchair show a good quality level and as its best attractive, a low price.

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6. RESPONSIBILITY NOTICE

Willian Moura Feijó de Figueiredo, José Bismark Medeiros and Juracy Emanuel are the only responsible for the printed material included in this paper.