MODELLİNG A MEDİCAL WHEELCHAİR FRAME, SUBJECT TO IMPACT LOADİNG

ИНТЕРФЕЙСНОГО СТОЛКНОВЕНИЯ С ТОЧКИ ЗРЕНИЯ МОДЕЛИ РЕПЛИКАЦИИ ШАССИ ДЛЯ ИНВАЛИДНОГО КРЕСЛА

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Abstract:
In this study, the direct impact test for wheelchairs was modeled and analyzed. The strength of the wheelchairs frame was analyzed using LS-DYNA computer code. Two frames of commercially used wheelchairs were modeled and analyzed under direct impact conditions. The stresses and deformed shapes for the loaded frames were obtained , compared and their soundness is evaluated. The results showed that, the existing wheelchairs frame is sound enough under impact loading but their soundness is not within the ANSI/RESNA standard .
Keywords: WHEELCHAIR, FRAME,MODELIND,IMPACT

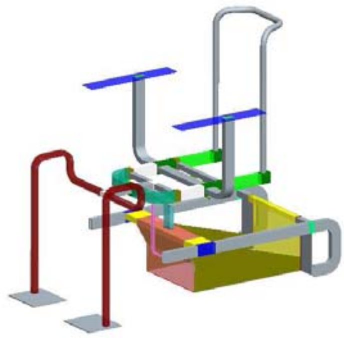
1. Introduction

Wheelchairs were designed to facilities and to cover the disability of disable persons by increasing their mobility. [1]. Wheelchair design is carried out and granted by the conditions of ANSI/RESNA (American National Standards Institute/ Rehabilitation Engineering and Assistive Technology Society of North America) WC-19. In this standard one of the most important tests is impact test. [2], [3]. In the standard the wheelchairs body (chassis) is impacted to a rigid wall at high acceleration of about 20g. Under impact conditions, for protection of the occupant, seat system strength, stiffness, energy absorbance, and position have been shown to have a direct influences on occupant kinematics, and in particular on submarining risk [4-8]. Crash conditions pose more severe loads on wheelchair components and frame, than typical mobility conditions [7]. ANSI/RESNA WC-19: Wheelchairs Used as Seats in Motor Vehicles addresses the crashworthiness of wheelchairs, assessing complete wheelchair systems through a variety of tests including 20g and 13.4m/s dynamic frontal impact testing [8]. In fact none of the present wheelchair has been examined under this condition for examining their reliability.

For a reliable drive, wheelchairs have to be designed with high safety standard. In this study, commercially available Electric Powered Wheelchairs frame were modeled and simulated, under direct impact conditions, using CAD codes (Pro_E and CATIA) and FEM software (ANSYS/LS-DYNA). Wheelchair chassis were modeled and analyzed under impact at velocity of 13.4m/s [1-4]. In this condition, the chassis of wheelchair hit towards to the rigid wall. The developed stresses were obtained and evaluated. Furthermore the reliability of the existing wheelchairs frames within the suggested existing standard was examined.

2.Modeling and Analysis

In this study for impact simulations, "Glide Power Assist Wheelchair Series 1 and 2 frames are modeled, analyzed and compared, using Pro_ENGINEER and CATIA V5. Figure 1 present the CAD model of these frames and Figure 2 presents their F.E models.



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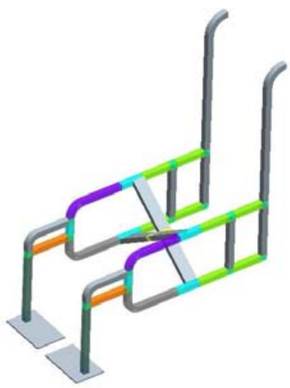

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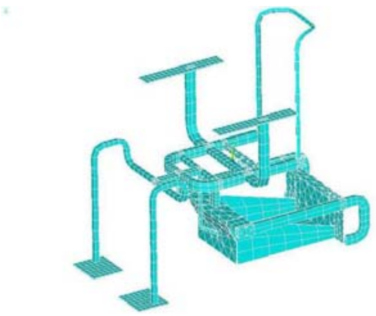
Figere1a A and B CAD model for Frames 1 and 2



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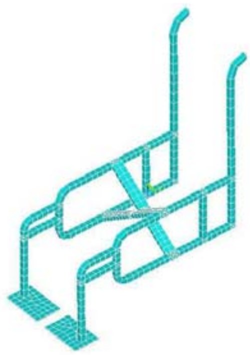

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Figure 2A and B F.E. models for Frames

1and 2

Models the frame material is A1010 steel, see table 1. In these models element type is solid 164 hexagonal. For number of elements and number of nodes, see table 2. According to the ANSI/RESNA standards for the frontal impact tests, wheelchairs must approach the rigid wall 13,4m/s speed [2], [3]. The impact period is 80millisecond .For this study in the impact process, friction of the wheelchair, weight of the human body and weight of the wheelchair components except frames are neglected

Table 1 Frame material 1010 Steel properties

Density (ρ)	7870 kg/m3
Ultimate stress (σmaks)	365MPa
Yield Stress (σa)	305MPa
Max. Elongation	50mm de %20
Modulus of Elastisity (E)	200GPa

Table 2 F.E. model node and Elements numbers

	Elements No.	Nodes No.
Wall	2499	5201
Chair 1	8153	13699
Chair 2	8277	6060

3.Results and discussions

Figure 3 shows the critical nodes at which the comparison of frame strength was evaluated. Figure 4 present the Von Misses stress contour for both frames. Table 3 present maximum stress levels for wheelchair 1 and 2 at different critical regions. It is clear from figure 4 and table 3 that the minimum stresses level is for wheelchair 1. Table 4 shows the maximum strain levels in 1 and 2 wheelchairs at different critical regions of the chair. It is clear from this table the lower level of strain is a gain for wheelchair 1. The results of the analysis show that wheelchair 1 frame design is more reliable and sounder design. In fact the level of the stresses and stain reached are well beyond the working stress and strain levels. This indicates that none of the commercial wheelchair pass the impact test standard ANSI/RESNA.

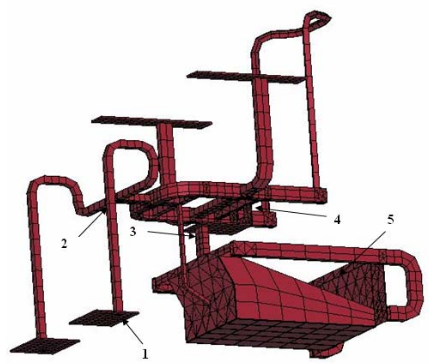

Figure 3 Critical regions of the wheelchairs

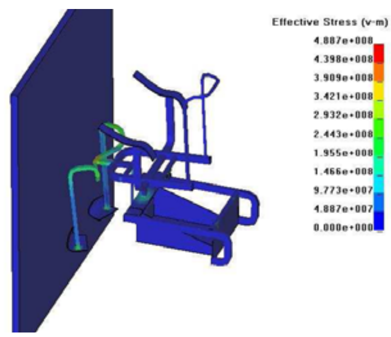

Figure 4 Von Misses Stress contour for wheelchair 1

Table 3 maximum stress level at critical regions of the wheelchairs

	Element 1 MPa	Element 2 MPa	Element 3 MPa	Element 4 MPa	Element 5 MPa
Chair 1	555	1000	580	700	700
Chair 2	480	900	880	750	720

Table 4 maximum strain level at critical regions of the wheelchairs

	Element 1	**Element 2**	**Element 3**	**Element 4**	**Element 5**
Chair1	3.55e-3	1.68e-1	5.08e-3	1.82e-2	0
Chair2	2.02e-4	2.82e-1	5.03e-2	7.48e-3	6.59e-3

4.Conclusions

- Non of the commercial wheelchair pass the impact test standard ANSI/RESNA
- These entire wheelchairs are in use therefore there is a need for more reliable standard for wheelchair.
- F.E. technique is a powerful route to model and analysis wheelchair frame design reliability and safety.

5. References

[1] COOPER, R.A., Engineering Manual and Electric Powered Wheelchairs, Critical Reviews in Biomedical Engineering, Vol. 27(1&2), 1999, pp. 27-73.

[2] ANDREW, J.R., Analysis of The ANSI/RESNA Wheelchair Standards: A Comparison Study of Five Different Types of Electric Powered Wheelchairs, Thesis from University of Pittsburgh, Faculty of Bioengineering, 2002.

[3] COOPER, R.A., BONINGER, M.L., RENTSCHLER, A., Evaluation of Selected Ultra Light Manual Wheelchairs Using ANSI/RESNA Standards, Archives of Physical Medicine and Rehabilitation, Vol. 80, April 1999, pp. 462-467.

[4] FIELD, D., Powered Mobility: A Literature Review Illustrating the Importance of a Multifaceted Approach, Assistive Technology, Vol. 11, No. 1 (1999), pp. 20-32.

[5] ADA Standards for Accessible Design (Department of Justice, Code of Federal Regulations), July, 1994.

[6] MITAL, A., Determination of Gross Weight Limit for Foldaway Powered Wheelchairs Through Isometric and Psychophysical Strength Simulations, Ergonomics, Vol. 37, No. 9, 1994.

[7] COOPER, R.A., DVORZNAK, M.J., O'CONNOR, T.J., BONINGER, M.L., JONES, D.K., Braking Electric-Powered Wheelchairs: Effect of Braking Method, Seatbelt, and Legrests, Archives of Physical Medicine and Rehabilitation, Vol. 79, October 1998, pp. 1244-49.

[8] SOSNER, J., FAST, A., BEGEMAN, P., SHEU, R., KAHAN, B., Forces, Moments, and Accelerations Acting on an Unrestrained Dummy During Simulations of Three Wheelchair Accidents, American Journal of Physical Medicine and Rehabilitation, Vol. 76, 1997, pp. 304-310.