

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 6, June 2017

Design and Virtual Validation of Ambulance Stretcher as per Automotive Industry Standard

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ABSTRACT: This paper presents design and virtual validation of ambulance stretcher to be more rugged, dependable & adaptable for used in field. The test was conducted to determine if the maintain systems (restraint systems) and the fixation of the equipment meets the requirements specified under Automotive Indian Standard. In this paper the model was designed with the use of CATIA V5 software. The dynamic analysis was done with the use of LS-DYNA software. The test of the ambulance stretcher with regards to its behaviour in the case of a collision was carried out. The stretcher was simulated by a rigid structure with ambulance floor. The stretcher is fixed (3 point fixation) to the stretcher support by means of two front retention hooks and one rear lock assembly. The stretcher carried on the road ambulance shall be restrained, to prevent them becoming a projectile when subjected to accelerations/decelerations of 10 g in both longitudinal (backward, forwards), transversal (left, right) and in a 10g vertical drop. The maximum distance travel of the ambulance stretcher should not move more than 150 mm.

KEYWORDS: Ambulance stretcher, Design, Hypermesh, LS-Dyna, Virtual validation.

I. INTRODUCTION

Healthcare is a growing industry that is essential to the longevity of humanity. It is an important aspect of everyday life that is always changing and adapting to compete with the everyday changes of the world. The advances in medicine can be as small as the medications developed for treating diseases to the actual equipment monitoring and caring for people. The ambulance stretcher or gurney is a piece of equipment used in the health field that may be overlooked at times. This item may be overlooked in importance, but it is a necessary step towards recovery. If this device does not fully meet the obligation it is designed for, the likelihood of saving multiple lives per day would drastically decline.

The objectives for this project are to redesign an ambulance stretcher to be more rugged, dependable, and adaptable for use in the field. The particular features that were chosen to concentrate on for redesigning the stretcher carried on the road ambulance shall be restrained, to prevent them becoming a projectile when subjected to accelerations/decelerations of 10 g in the forward, rearward, left, right and vertical directions. When subjected to these accelerations/decelerations, the distance travelled by an equipment or an item shall not endanger the safety of persons on the road ambulance.

II. LITURATURE REVIEW

According to Mr.Niu Fu et al. [1],they introduced a new type of vibration isolator using spring and metal rubber structure, and establish an ambulance stretcher suspension system. Real road experiments were finally undertaken to testify the ride com-fort and the evaluation of human exposure to whole-body vibration in recumbent position. The

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experiments are carried out on various roads, including the asphalt urban roads, the off-road surfaces and the all-terrain roads, with different velocity from 10km/h to 80km/h. Basic evaluation method using weighted root-mean-square (r.m.s.) acceleration is applied. Results show that the weighted r.m.s. acceleration values range is between 0.216 m/s^2 and 1.216 m/s^2 , which denote that the com-fort reactions to vibration are not uncomfortable on asphalt urban roads, fairly uncomfortable on off-road surfaces, and uncomfortable on all terrain roads. The reduction in r.m.s. floor vibrations is also observed, and results show that vibrations from the vehicle floor to the patient in recumbent position are reduced by 17%~45%.

Mr. Sachin N Waghmare et al. [2], Says Use of shock absorber can reduce the intensity of vibration shocks produced during traveling of patient. Rubber shock absorbers are light in weight and less costly also mounting of rubber shock absorbers is easy, they can mount using any mechanical mechanism. In critical situations, there are chances of death due to bleeding or damage to internal body parts because of vibrations produced. Use of rubber shock absorbers becomes helpful in such situations, since they can reduce the shocks to a minimum level.

Mr. Rashid Ahmed K. et al. [3], Says the caregiver avoid heavy lifting situations that put their back at risk of injury. The caregiver can merely shift the patient from a bed on to the device while the device is in the form of a stretcher. Then the device can be converted into a wheelchair automatically with a press of a button. This can be done in the reverse direction as well, when the patients in sitting in the wheel chair can be converted to a stretcher smoothly for the purpose of diagnosis etc.

Jyothish K Sunny et al. [4], here they are developing a system which is capable of shifting various positions (Chair, Semi-Chair and Stretcher) manually. These positions can be achieved by a lead screw connected with a hinge joint. Lead Screw translates turning motion into linear motion. Also the height of the stretcher can be adjusted using a Hydraulic jack manually. It is placed horizontally which pushes against a lever which lifts the main arm. And also there is a lid on chair which can be opened to eliminate human waste. This is a cost reducing project which helps mainly paralyzed patients to do their daily things.

III. DESIGN METHODOLOGY

Design methodology helps to find out the best solution for each design situations. A systematic approach and procedure is to be followed to achieve the suitable solution. It involves the following steps.

- Journals and patent research
- Market study and user survey
- Bench marking
- Quality Function Deployment (QFD matrix)
- Product Design Specification (PDS)
- Concept generation and selection
- Final concept refinement
- Modelling and virtual validation

Concept generation for stretcher

Based on Product Design Specification concepts are generated using mind mapping tool.

Mind Mapping

Mind mapping technique is used to visualize various ideas. So this classification considered all the aspects for the concept design.

Concept 1

The main criteria considered for this concept is the hinge joint and spring attached to the wheel. Due to this concept when stretcher is move on rough terrain or uneven floor surfaces vibrations are not transfer to the patient. It is work as suspension system

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Concept 2

In this concept lever is used to release lock of floor locking device

Concept 3

In this concept assisting wheel is used for easy loading and unloading of stretcher.

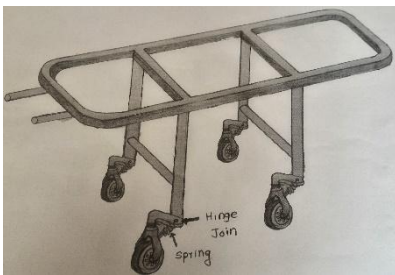


Fig.1: Concept 1

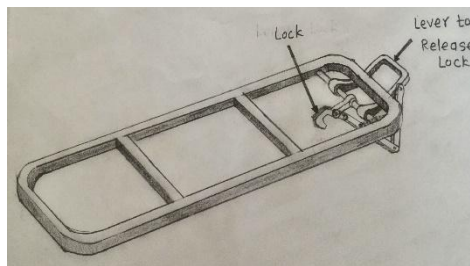


Fig.2: Concept 2



Fig.3: Concept 3

Fixation System

The stretcher is the tool that helps the paramedics to carry an injured person in and out from the ambulance, it is therefore important to make it as easy as possible for the paramedics to attach and detach it in the ambulance.

Concept generation for Fixation System

To generate concepts for the fixation system a brainstorming was used to get as many ideas as possible. In the following sections all of the generated concepts are described. Concept A-E is the actual fixation and concept 1-2 is how to locate the stretcher in right position.

Concept A

The left claw is grabbing (Take hold) the fixation point on the stretcher when the stretcher is pushed into the fixation system. The right claw is fixed and prevents the stretcher to move forward and upward.

Concept B

The function of this concept is shown in Figure. The attachment is inserted in a cavity and is blocked in five directions. To stop the movement in the direction upwards a plate is pushed through the loop.

Concept C

The left claw is grabbing the fixation point on the stretcher when the stretcher is pushed into the fixation system. The right claw is lock in the up and down valley.

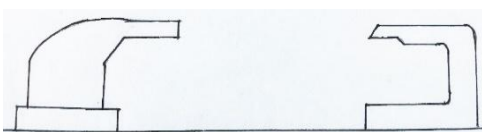


Fig.4: Concept A

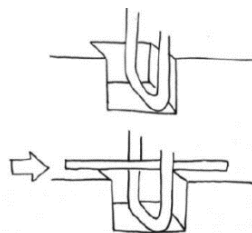


Fig.5: Concept B

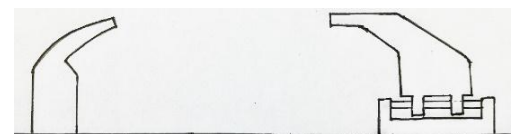


Fig.6: Concept C

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Concept 1

The stretcher must be lifted and thereafter be lowered down into the fixation system vertically.

Concept 2

To minimize the trouble of handling the stretcher, a rail can be placed on the floor of the ambulance floor.

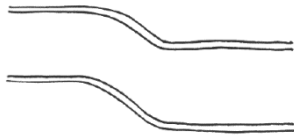


Fig.7: Concept 1



Fig.8: Concept 2

Concept selection and evaluation

The generated concepts were compared and studied using Pugh method with the bench marked product. It was verified with user opinion. The selected concept is modeled using CATIA V5.

Detailed Model of the Ambulance Stretcher

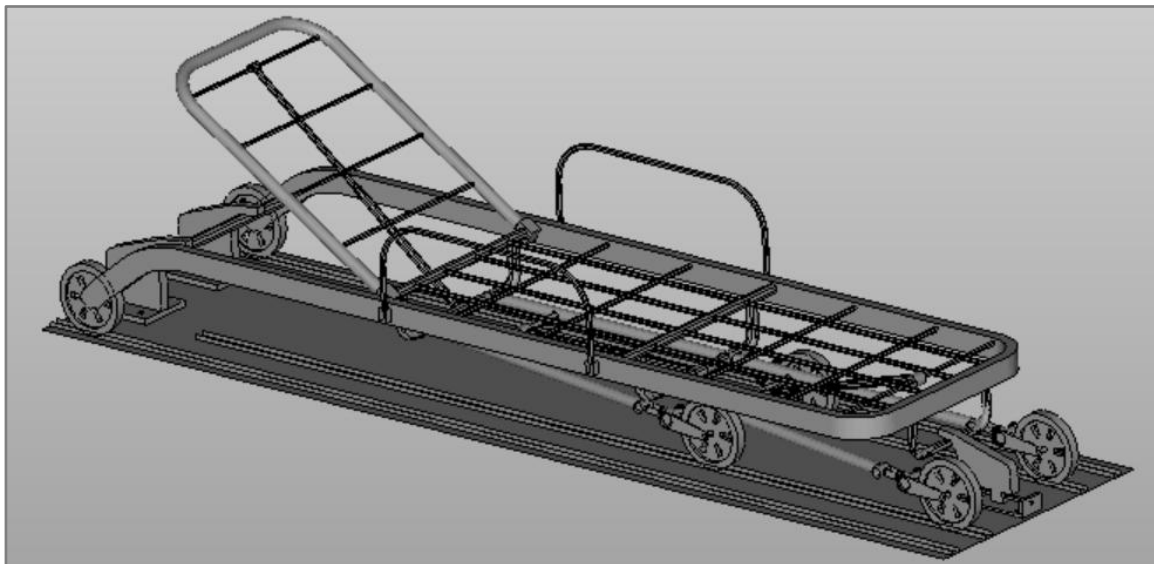


Fig.9: Detail CAD model of stretcher

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III. ANALYSIS RESULTS

An ambulance stretcher device for a patient weight of 200 kg was designed and analysis. Finite Element Analysis (FEA) is done with the help of Hypermesh and LS-Dyna software. Following are the analysis result of the mesh independent study carried out

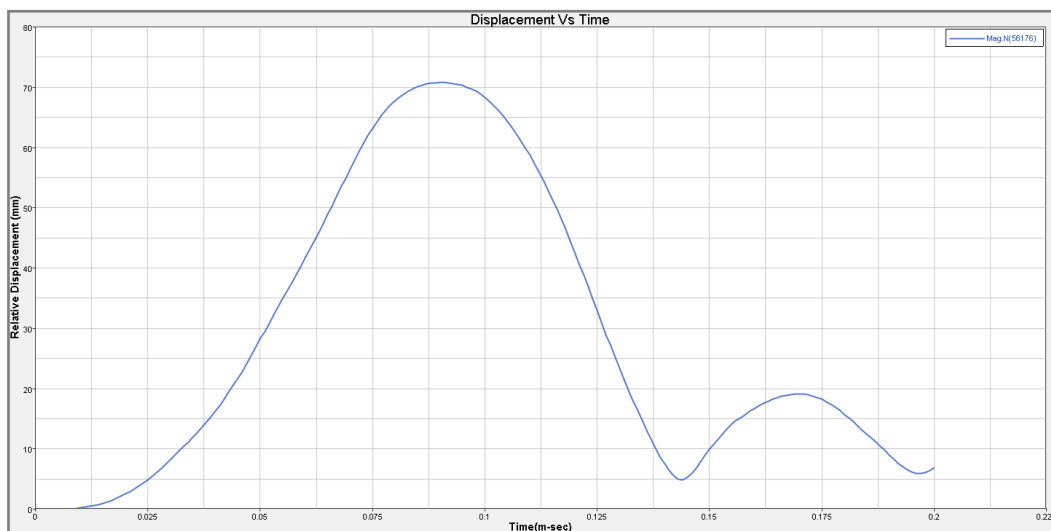


Fig.10: Displacement verses time plot in forward direction.

The maximum displacement acted on the backrest of stretcher and maximum displacement is 72 mm. The maximum distance of travel of the Ambulance stretcher did not exceed 150mm in horizontal direction.

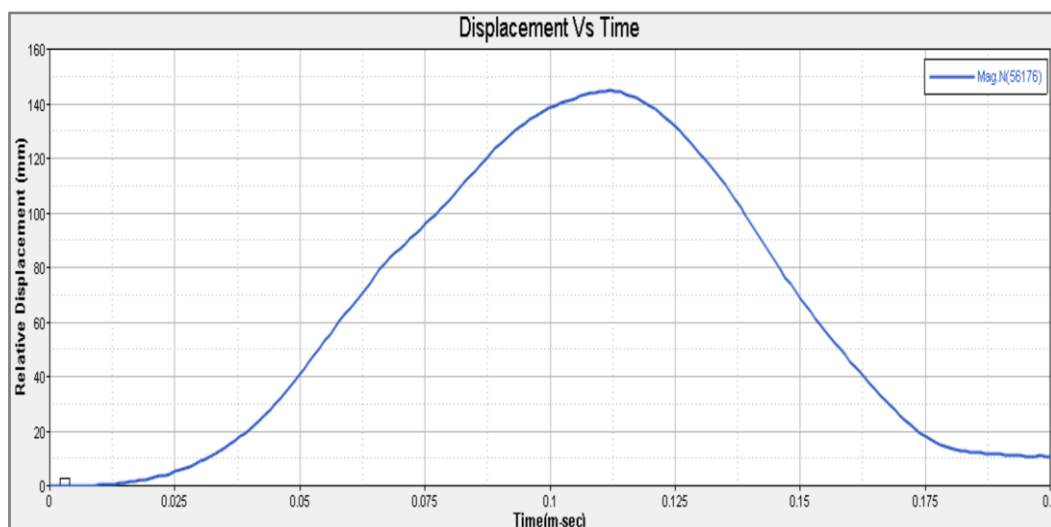


Fig.11: Displacement verses time plot in rearward direction.

The maximum displacement acted on the backrest of stretcher and maximum displacement is 147 mm. The maximum distance of travel of the Ambulance stretcher did not exceed 150mm in horizontal direction.

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Fig.12: Displacement verses time plot in transverse direction.

The maximum displacement acted on the backrest of stretcher and maximum displacement is 67 mm. The maximum distance of travel of the Ambulance stretcher did not exceed 150mm in horizontal direction.

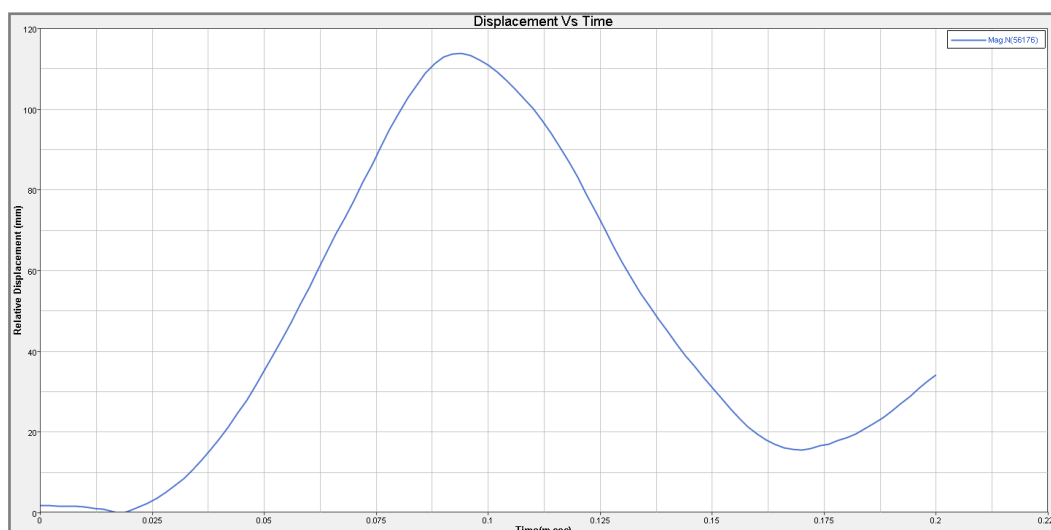


Fig.13: Displacement verses time plot in vertical direction.

The maximum displacement acted on the backrest of stretcher and maximum displacement is 118 mm. The maximum distance of travel of the Ambulance stretcher did not exceed 150mm in horizontal direction.

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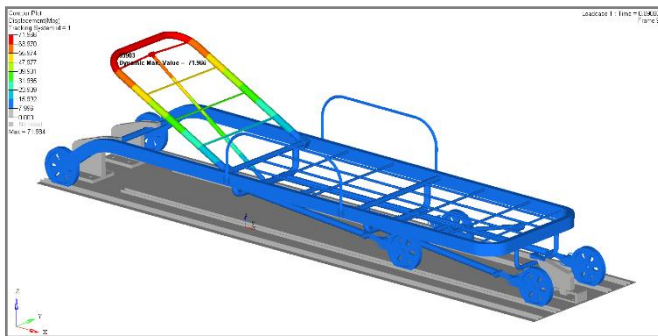


Fig.14:Displacement in forward direction.

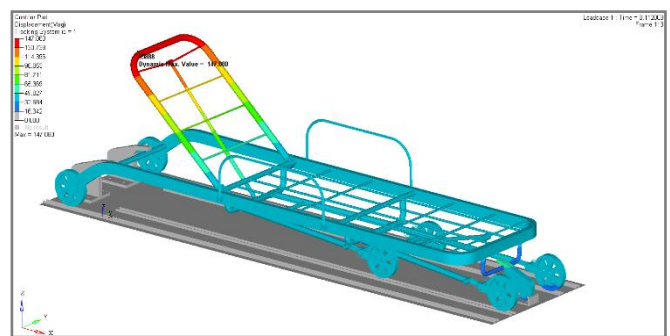


Fig.15:Displacement in rearward direction.

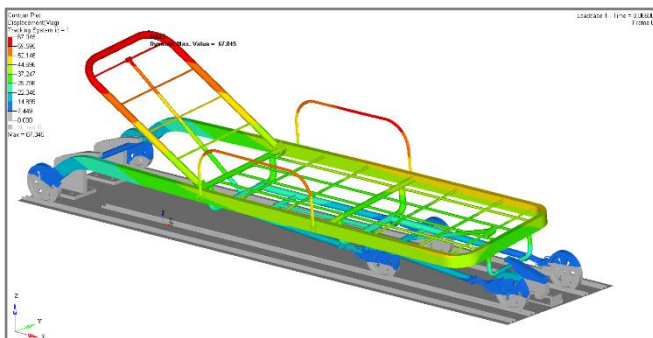


Fig.16:Displacement in transverse direction

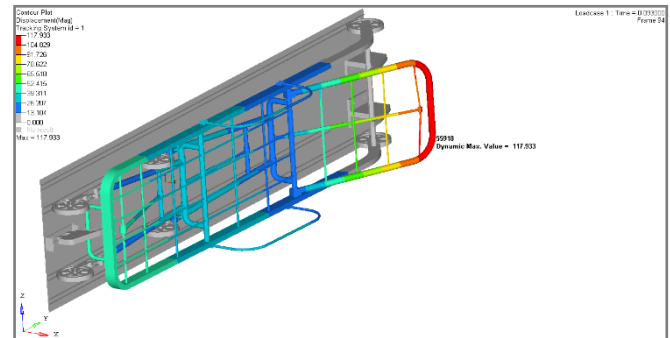


Fig.17:Displacement in vertical direction.

IV. CONCLUSION

Test object	Impact direction	Maximum displacement	
		Allowed (mm)	Actual displacement (mm)
Ambulance stretcher	forward	150	72
	rearward		147
	Transverse left		67
	vertical		118

Note:-Due to the symmetrical design of the test object and its fixation a test in transverse right was not necessary.

An ambulance stretcher device for a patient weight of 200kg was designed and analysis. The tested ambulance stretcher was strong enough to resist to the load created by the dynamic test. The tested ambulance stretcher or any item attached did not become a projectile or did leave their fixation. The maximum distance of travel of the ambulance stretcher and any item attached did not exceed 150 mm in the horizontal directions.

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