Integrated Approach Of Ergonomics And Fem Into Truck Drivers Seat Comfort

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***Abstract*— Seats are one of the most significant components of vehicles where truck driver spend most of their time and hence call for comfort. The present research work is focusing on the ergonomics approach for driver's seat comfort. Driving a truck in Indian condition cannot be compared with driving in developed countries because of the external factors such as road conditions, maintenance of vehicle, drivers habits etc. Driving throughout the day in such conditions leads to various health problems for the drivers which may even lead to accidents. So it is important to design the comfortable seat for truck drivers keeping in view the ergonomic factors such as anthropometry, physiological workload, psychological stress etc.**

Since from last few decades, it is observed that the truck drivers are facing various muscle-skeletal injuries due to lengthy driving hours. The foremost cause for all the injuries are the improper design of driver's seat. Present research is divided in two parts. First, to conduct survey amongst the truck drivers, examine the travel time factor, and seat discomfort. Second is to design and recommend best possible alternatives of driver's seat with the aid of ergonomics and advanced design tools like CAD CAE.

Keywords— Seat design, truck, Ergonomic Study of Driver Seat, Comfort, Anthropometry, CAD, CAE, FEM etc.

I. INTRODUCTION

Today's era is marching towards the rapid growth of all sectors. The faster is your transport; more is your profit is today's thinking. In India, the truck driving on the bad condition roads is really a tedious task for drivers. It is also painful that not much research is carried out with reference to driver's seat of Indian trucks.

Various earlier researches suggest that the normal office chair design can be used to design the automotive seat. But, there are several important considerations which are taken into account while designing the automotive seat. In particular, the control locations and sight line requirements serve to constrain postures to a greater extent than in most other seated environments.

This project is basically carried out to make more comfortable seat for the six wheeler trucks running on construction sites for Musale Contractions Pvt. Ltd., Nagpur.

The data of various truck drivers is collected from the site of Ambakhapa (Madhya Pradesh) where the dam construction is going on.

The company majorly focusing on the safety and comfort of truck drivers as they believe if driver's health is proper the output rate is higher.

1.1 Objectives

The seat design must support the occupant with adjustable lumbar support, bolsters, and spinal posture correction.

- To design comfortable seat for 6 wheeler Truck.
  - To get clear idea to locate the seat and exact position of seat.
  - To make use of anthropometric dimensions while designing the seat.
  - To modify the dimensions if it is not correct.
- Lumbar support
  - Proper Lumber support should be provided in order to increase the comfort level of driver in long hours of journey.
- Seat lengthening option
  - Adjustable arrangement should be there in order to accommodate maximum number of driver's population.
- Ergonomic pan contour
  - Design the seat with proper pan contour for safety of drivers.
- Reduce risk of musculoskeletal injury. Improved benefit of long-term physical health of drivers.

The figure 1 shows the rigid seat installed in the 6 wheeler trucks are which are mainly responsible for various body pains of drivers. Hence to be changed or modify.

Fig.1. Rigid and non adjustable seats in 6 wheelers trucks in India.

II. DATA COLLECTION

The data is collected from Musale Construction Pvt. Ltd., Ambakhapa, Madhya Pradesh Fig. 2. The anthropometric dimensions of 68 truck drivers were taken for study.

- 68 trucks of different make (TATA and ASHOK LEAYLAND) were considered.
- 68 truck drivers from Nagpur and Madhya Pradesh were interviewed personally and the detailed questionnaire was filled by them which include details regarding seating posture, driving habits, body parts dimensions, problems due to driving etc.
- Feedback results were used to decide the average dimension for seat design as per ergonomic standard and working situations.

Fig.2. Site images from ambakhapa site of Musale firm.

The data of different drivers are collected by using the photographs, survey and detailed questionnaire which includes the data related to the truck type, truck maintenance schedule, driver's habits, drivers body dimensions, drivers pain history etc. The 14 different parameters are found out which are essential for designing a seat for drivers.

2.1 Body pain comparison between the normal people

It is observed that most repetitive problems of truck drivers are

- Foot cramp
- Lumbar pain / Back pain
- Stiff neck or neck Problem
- Headache/eye strain

The above four major body pains are experienced by the truck drivers due to long period of journey e.g. above 6 to 8 hours journey.

All these pain area where also compared with the normal people who is not driving the truck. For this sample data of 58 people were considered.

The comparison is shown in the graph Fig. 3.

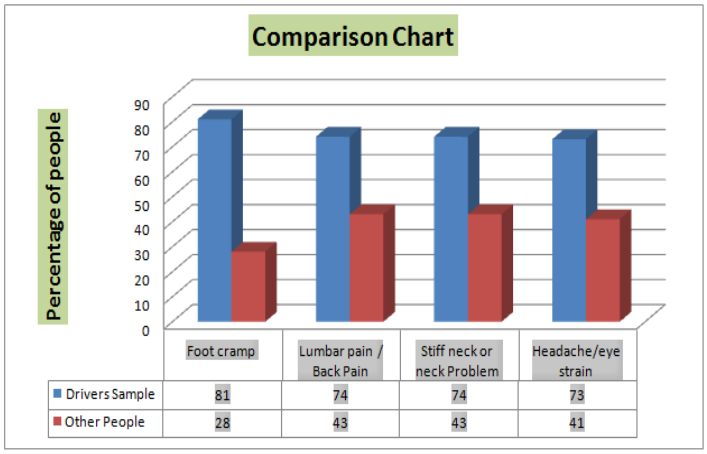

Fig. 3. Comparison graph between normal people and truck driver pain area

The above comparison shows that the normal people experience the pain in the same area where the truck drivers found maximum. But the percentage of occurrence is less. Hence, those body pains are due to excessive truck driving on rigid, non adjustable seat. Table 1 shows the considered parameters which are necessary for the seat design and the average values, std deviation calculated by obtained data of sample through questionnaire.

The averages of each parameter along with the standard deviation are calculated. Figure 5 shows the proposed dimensions and the notation that we have used.

TABLE I THE AVERAGE DIMENSION ALONG WITH STD. DEVIATION

Notation	Parameters	Avg. value	Std. Dev.
A	Normal sitting	752	28
B	Eye length	669	29.6
C	Lower lumber	84	26.9
D	Mid shoulder	562	25.5
E	Elbow rest	234	43.1
F	Knee	518	25.4
G	Vertical upward reach from mid shoulder	745	31.4
H	Popliteal	373	24
I	Buttock to pop.	387	28.4
J	Vertical upward reach from seat surface	1330	25.6
K	Arm reach from floor	1558	24.5
L	Buttock to leg length	779	26.3
M	Comfortable length	968	24.5
N	Bi deltoid	484	28.3
O	Waist	242	26.7

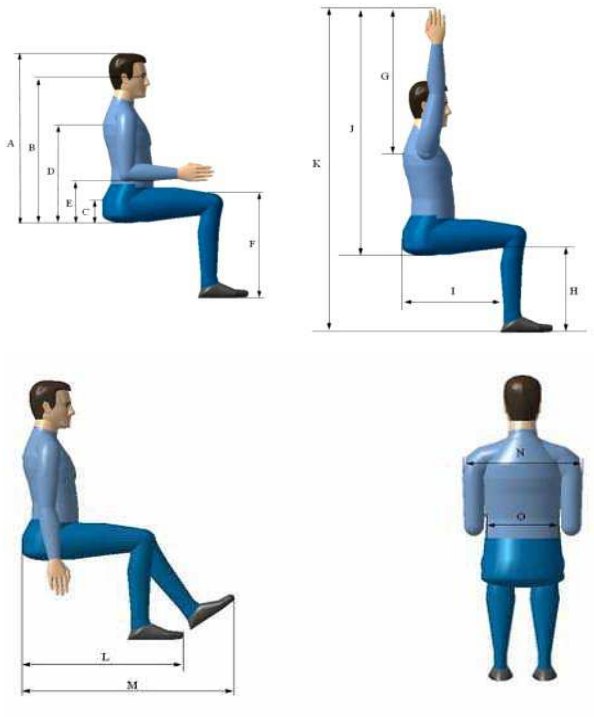

Fig. 4: The body parts showing the location of important factors

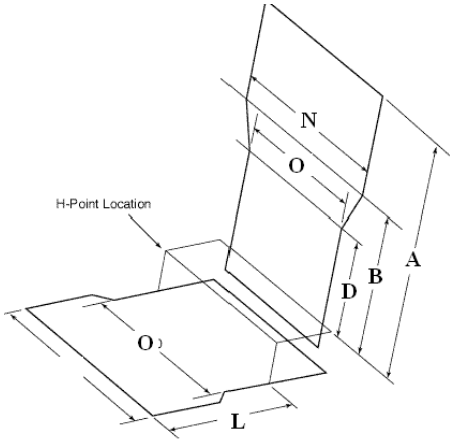

Fig. 5. Proposed conceptual seat having the notations for dimensions

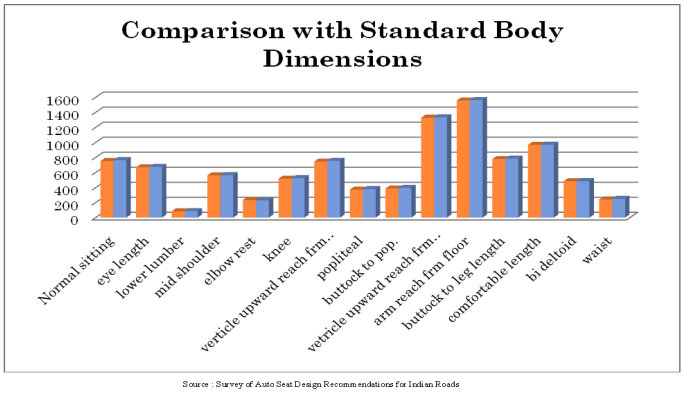

Fig. 6. Comparison with standard body dimensions

2.2 Assumptions

The following assumptions are made before actually designing the seat. The assumptions are based on some earlier study and the comfort level study.

- Back angle must be around 90 – 115 degree)
- Sit up straight with your head close to the headrest
- Thigh angle must be around 90- 115.
- Visibility must be clear in all sense

III. DESIGN OF SEAT

Driving is a combination of ABC process i.e. Acceleration Braking and clutching. If any miscommunication happens, it may lead to accident. Therefore it of a prime importance to consider the drivers comforts in order to maintain the concentration during driving. According to analysis of data related to pain area and other anthropometric body dimensions, it is observed that following factors are essential to design a seat for truck driver.

- Backrest Width, Height
- Cushion Width, Length

- Seat Height
- Lumbar Support
- Neck height
- Thigh height
- Backbone height
- Back angle must be around 90 – 115 degree)
- Visibility must be clear in all sense

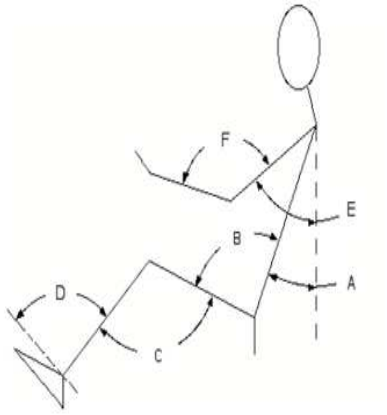

Fig. 7. Important Angles Measurement

TABLE II: THE ANGLE CONSIDERATION FOR THE SEAT DESIGN

Notation	Description	Value Considered
A	Back Angle	15-20 Degree
B	Thigh Angle	90-95 Degree
C	Knee Angle	95-100 Degree
D	Ankle Angle	90-95 Degree
E	Upper Arm Angle	13- 35 Degree
F	Elbow Angle	60-83 Degree

3.1 Importance of H point

In vehicle design and especially automotive seat design, the H-point (or hip-point) is the theoretical, relative location of an occupant's hip, specifically the pivot point between the torso and upper leg portions of the body, either relative to the floor of the vehicle or relative to the height above pavement level and pertinent to seating comfort, visibility from the vehicle into traffic and other design factors. The position of H point must be as close as possible to centre of gravity as shown in Fig. 8.

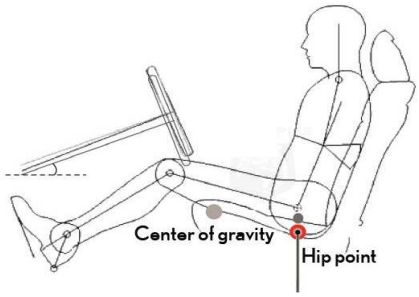

Fig. 8. Position of H point while driving

3.2 Angle Setting Attachment

The seat is provided with the angle adjustment arrangement provide at the back. The two rollers are used to set the angle of bottom rest and back rest of seat as per the requirement of driver. Also the two position arrangement is available to adjust the back cushion described in Fig. 9 and 10.

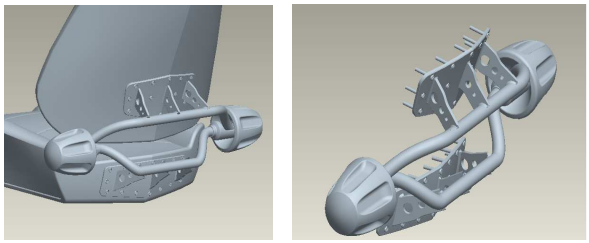

Fig.9. Angle setting arrangement provided at back and bottom of seat

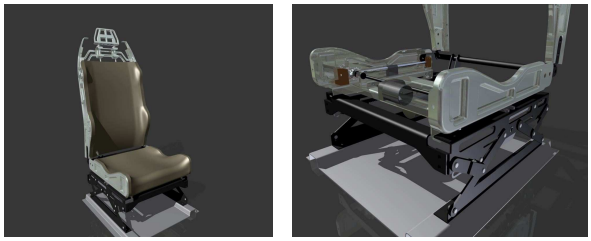

Fig.10. Two position, leg room setting and height setting arrangement.

3.3 Lumber Component

The lumber component provided has following specification

- Vertical range of 5 inches, 7-12 from center of lumbar form to seat pan
- Depth range of 2 inches
- Collapsible design for injury prevention

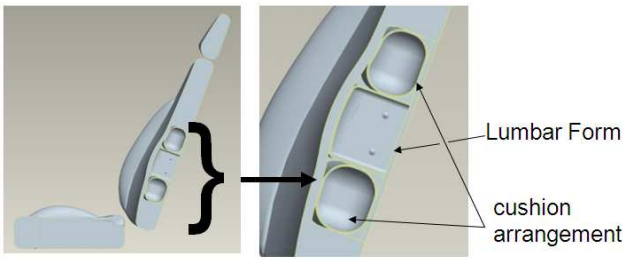

Fig.11. Lumber component arrangement

3.4 Pan Lengthening Mechanism

The pan adjustment should be such that it should provide comfort for both shorter drivers and taller drivers during driving.

- Shorter Drivers:
  - Pan retracts relieving pressure on popliteal fold
  - Avoid restricting circulation
- Taller Drivers:
  - Supports longer legs
  - Increases sense of comfort

IV. FEM Analysis Of Designed Seat

The comfort level of new designed seat is tested by using FEM. The CAD model of new designed seat and earlier seat along with human dummy model has been created and tested using ANSYS Workbench software.

During the seating position the drivers are exerting two forces on seat. The forces acting on seat are

Force due to the self weight of driver on seat

i.e. 100kg max(Assumed maximum) = 980N

Force at back rest actual 421 N

for safety side 50 - 55 % more load considered i.e. 66kg max at back rest = 653.33 N

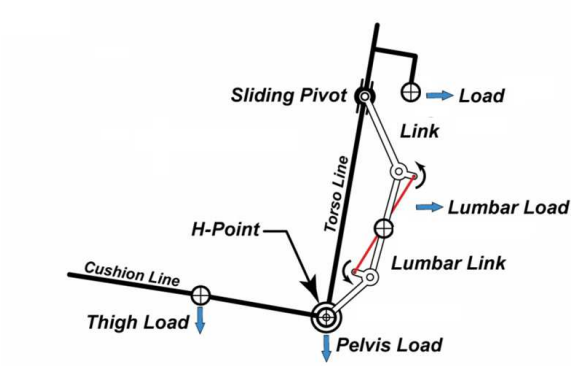

Fig.12. Forces acting on seat

Fig.13. Forces acting on bottom and back rest of seat during driving.

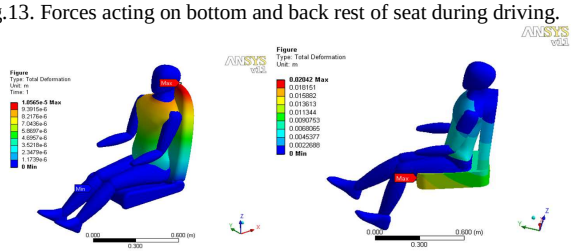

Fig.14 The deformation contours in new designed seat & existing seat

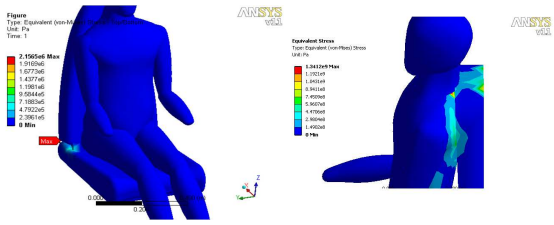

Fig.15. Equivalent stresses in new designed seat & existing seat

V. Conclusions

The Ergonomic and FEM investigation is carried out to estimate the seat dimension which can accommodate the majority of the driver's population. The parameters are listed which are required to design a seat. The major focus of this project is on the seat for 6 wheeler truck working on the various sites of Musale constructions, Nagpur.

The dimensions of seat are worked out with available data and rest with sample data. The conceptual model is created using CAD packages and comfort level test is carried out. The seat consists of various attachments for height adjustment, pan length setting, lumber component, neck adjustment to accommodate maximum number of drivers.

The dimensions of seat are finalized by testing it with the help of CAE software and with RULA. The comfort is the key feature in this context and safety of driver is other. The results show the designed seat is more comfortable to drivers driving for long time than earlier rigid seat.

There are two major factors which are not considered during analysis and they are noise and vibration but further research is going on in the same context.

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