IMPLEMENTATION OF ERGONOMIC CONCEPT IN DRIVING ASPECTS

BY

K.S.Sabarigirivasan

Reg No. 0720104006

of

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE-641 006

(An Autonomous Institution affiliated to Anna University, Coimbatore)

A PROJECT REPORT

Submitted to the

FACULTY OF MECHANICAL ENGINEERING

In partial fulfillment of the requirements

For the award of the degree

Of

MASTER OF ENGINEERING

IN

INDUSTRIAL ENGINEERING

MAY 2009

ANNA UNIVERSITY:: CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report entitled "**IMPLEMENTATION OF ERGONOMIC CONCEPT DRIVING ASPECTS**" is the bonafide work of

MR. K. S. Sabarigirivasan - Register No. 0720104006

Who carried out the project work under my supervision.

Signature of the Head of the Department	Signature of the supervisor
Dr.T. Kannan	Assis.Prof S.R.Rajabalayanan
HEAD OF THE DEPARTMENT	**SUPERVISOR**

Internal Examiner **External Examiner**

DEPARTMENT OF MECHANICAL ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE 641 006

TAMILNADU STATE TRANSPORT CORPORATION (COIMBATORE) LTD.,

(A GOVT. OF TAMILNADU UNDERTAKING)

37, Mettupalayam Road, Coimbatore - 641 043. (Erode Region)

Date : 2.5.2009

Ref. No. ______________

CERTIFICATE

This is to certify that Mr.K.S.SABARIGIRIVASAN, Final Year M.E.(Industrial Engineering) student of Kumaraguru College of Technology, Coimbatore - 641 006 had undergone project work titled as "IMPLEMENTATION OF ERGONOMIC CONCEPTS DRIVING ASPECTS" in our Transport Corporation from 18.9.2008 to 18.3.2009.

[illegible] உதவி மேலாளர் (டெக்)
தமிழ்நாடு அரசு போக்குவரத்துக் கழகம்
(கோவை-கோட்டம்-2) லிட்.,
பள்ளிபாளையம்-638 006.

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE , TAMILNADU

DEPARTMENT OF MECHANICAL ENGINEERING & KCT-TIFAC CORE

ADVANCES IN MECHANICAL SCIENCES

CERTIFICATE

his is to certify that Mr/Ms/Mrs K.S.SABARIGIRI VASAN

participated and presented a paper entitled Implementation of ergonomic

ncepts driving aspects an investigation in tamilnadu state transport

poration in the 3rd National Conference on "ADVANCES

MECHANICAL SCIENCES" during 26- 27, March 2009.

PALANISAMY Dr. N.MOHANDAS GANDHI
CO-ORDINATORS

Dr.T.KANNAN
CONVENOR & HOD I/C

Prof.R.ANNAMALAI
VICE PRINCIPAL

ABSTRACT

The advancements made in the field of technology have helped the automotive sector in last decade, which has been its key customer. Safety and comfort of the passengers has emerged as one of the prime concerns for the vehicle manufacturers due to the stringent government regulations, which are updated with time.

The paper provides a brief overview of the conditions under which the body is completely comfortable. Hence they have been taken into account while designing the seats. The proper design of seats increases the aesthetics and ergonomics of the vehicle and also adds to its ability as a safety feature. The feasibility of implementation of such sophisticated seats in Indian conditions has also been gauged.

Keywords: Booster seat, child car seat, child safety, seating comfort, ergonomics.

ACKNOWLEDGEMENT

The Author thanks our principal, **Prof. R. Annamalai**, Vice Principal, Kumaraguru College of Technology, Coimbatore for his kind patronage and encouragement.

The Author express our heart full thanks to our beloved guide **Mr. S.R.Rajabalayanan**, Assistant Professor, Mechanical Engineering Department, Kumaraguru College of Technology, Coimbatore for his valuable suggestion, guidance, and constructive critism and help valuable suggestion, guidance, constructive critism and help throughout the project.

The Author is highly indebted to **Dr.T.Kannan**, Head of Department, Mechanical Engineering Department, Kumaraguru College of Technology, Coimbatore for his encouragement and facilities extended throughout the course of this project.

The Author would like to pay his deep gratitude to the esteemed person Mr. **M.Govindarajan** Assistant Engineer, Tamil nadu State Transport corporation, Erode Division for the encouragement and moral support of this project

The Author also thanks all the technical and non technical faculty of mechanical engineering department of Kumaraguru College of technology for their help during the thesis work.

CONTENTS

Chapter 1

Introduction

CHAPTER 1 INTRODUCTION

Drivers spend a great deal of time behind the wheel and encounter a wide range of road conditions. Consequently, they are frequently exposed to shocks when their vehicles encounter irregularities. Shocks are transmitted to the driver when the seat suspension runs out of a travel, a phenomenon called as "bottoming" and "topping". Heavy drivers who adjust the seat height away from the centre of seat travel are at increased risk of bottoming and topping. Researchers generally agree that exposure to shock increases the risk of spinal injury and lower back pain for drivers. Extremely high shock levels, such as those encountered in an accident, can cause compressive fracture of the spine, while chronic exposure to lower levels can lead to disc degeneration and lower back pain. In addition to increased health risks, drivers who experience frequent bottoming and topping report increased levels of fatigue. Topping and bottoming also presents a safety risk, as these events can cause the driver to temporarily lose control of the vehicle as his feet and hands are thrown off the pedals and steering wheel.

1.1 Ergonomics

The term ergonomics comes from the Greek syllables "ERGON" which means "WORK", AND "NOMOS" which means "LAWS", first appeared in a Polish article published in 1857. The study of human factors did not gain much attention until World War 11. Accidents with military equipments were often blamed on human errors, but the investigations revealed that some were caused by poorly designed controls. The modern discipline ergonomics was born in United Kingdom on July 12, 1949, at a meeting of those interested in human work problems in the British navy. At another meeting held on February, 16, 1950, the term ergonomics was formally adopted for this growing discipline.

Today in the United States, ergonomics professionals belong to Human Factors and Ergonomics Society (HFES), an organization with over 5000 members interested in topics ranging from aging to aerospace to computers. Ergonomic design make consumer products safer, easier to use, and more reliable.

Ergonomics or human factors are the scientific discipline concerned with the understanding of interactions among humans and other elements of a system." i.e. it deals with the scientific study of the relationship between the humans and its environment. It is "fitting a job to a worker."

1.2 Applications Of Ergonomics

Size and shape

Some years ago, researchers compared the relative positions of the controls on a lathe with the size of an average male worker. It was found that the lathe operator would have to stoop and move from side to side to operate the lathe controls. An 'ideal' sized person to fit the lathe would be just 4.5 feet tall, 2 feet across the shoulders and have an arm span of eight feet. This example epitomizes the shortcoming in design when no account has been taken of the user. People come in all shapes and sizes, and the ergonomics takes this variability into account when influencing the design process.

The branch of ergonomics that deals with human variability in size, shape and strength is called anthropometry.

Vision

Vision is usually the primary channel for information, yet systems are often so poorly designed that the user is unable to see the work area clearly. Many workers using computers cannot see their screens because of glare or reflections. Others, doing precise assembly tasks, have insufficient lighting and suffer eyestrain and reduced output as a result.

Sound

Sound can be a useful way to provide information, especially for warning signals. However, care must be taken not to overload this sensory channel. A recent airliner had 16 different audio warnings, far too many for a pilot to deal with in an emergency situation. A more sensible approach was to have just a few audio signals to alert the pilot to get information guidance from a visual display.

1.3 Ergonomically Designed Products

An ergonomically designed toothbrush has a broad handle for easy grip, a bent neck for easier access to back teeth, and a bristle head shaped for better tooth surface contact. Ergonomic design has dramatically changed the interior appearance of automobiles. The steering wheel once a solid awkward disc – is now larger and padded for an easier, more comfortable grip. Its center is removed to improve the driver's view of the instruments on the dashboard. Larger, contoured seats, adjustable to suit a variety of body sizes and posture preferences, have replaced the small, upright seats of the early automobiles. Equipped with seatbelts and airbags that prevent the face and neck from snapping backwards in the event of a collision, modern automobiles are not only comfortable but they are also safer. Virtually, all automotive and component manufacturers already recognize ergonomics as an important part of the vehicle design process.

Job design

One goal of ergonomics is to design jobs to fit people. This means taking account of differences such as size, strength and ability to handle information for a wide range of users. Then the tasks, the workplace and tools are designed around these differences. The benefits are improved efficiency, quality and job satisfaction. The costs of failure include increased error rates and physical fatigue - or worse.

Human error

In some industries the impact of human errors can be catastrophic. These include the nuclear and chemical industries, rail and sea transport and aviation, including air traffic control.

When disasters occur, the blame is often laid with the operators, pilots or drivers concerned - and labeled 'human error'. Often though, the errors are caused by poor equipment and system design.

Ergonomics working in these areas pay particular attention to the mental demands on the operators, designing tasks and equipment to minimize the chances of misreading information or operating the wrong controls

Chapter 2

Literature survey

CHAPTER 2 LITERATURE SURVEY

The purpose of this study was to design a new forward facing child car seat, taking into consideration the child's comfort and safety as well as ease of use for different users. Subjective, objective and theoretical methods were used to gather information. The study resulted in a new design with improvements in ergonomics and safety as compared present child seats. The results have been verified by means of a digital car mock-up with child dummies.

A third of the deaths of Swedish children in car crashes could have been avoided if the child had been seated in an approved child seat or if the seat had been used properly (Anund et al. 2003). A study at Chalmers University of Technology resulted in ergonomic guidelines for the design of a child seat. The conclusions of the study were that a child seat must have an adjustable seat, support the child's legs, be easy to use and have clear instructions for adjustments (Ingelsten H, Johansson Å. 2005)

2.1 Objectives

The purpose of our recent study was to develop a new forward facing booster seat. The focus was on safety, ergonomics and ease of use. A digital mock-up of the final design was produced to verify the geometry against a car interior including child dummies of the chosen age range. The basic idea is that good ergonomics provides safety.

2.2 Methods

Subjective, objective and theoretical methods were used to explore design possibilities. Subjective methods were used such as a workshop and interviews with children. Objective methods used for benchmarking, anthropometric studies, ergonomics simulations and geometric studies. Theoretical methods were used for design evaluation as well as research about ergonomics and safety.

Function decomposition was preformed and the main functions broken down. The purpose of this was to transfer the problem to a manageable level (Johannesson H, Person J, and Pettersson D, 2004). The different sub functions were used to generate ideas and were formed into a morphologic matrix. This was then used to generate different concepts and finally one concept was chosen after being evaluated in a Pugh's matrix (Ulrich K T and Eppinger S D, 2003). The chosen concept, described in Results below, was further developed and a CAD model developed and used to perform ergonomic simulations in a virtual car environment.

To evaluate the final design we used the ergonomics software Transom Jack togetherwith child dummies in the ages 3, 6 and 10 together with a simple interior and exterior mock-up of a family car. The first task was to make sure that the seat would fit into the cars interior, witch is a major problem for many child seats. The second was to check that the seat would fit the chosen age range.

2.3 Results

The first part of the study was to define which ages we needed to target. According to Jacobsson L who has studied the use of child restraint systems, the biggest risk of injury occurs when the parents have switched from a rearward- to a forward facing system (Jacobsson L et al. 2005) One reason for this is that the parents switch too early so that the child is too small for the new system. In the anthropometric study the key measurements for optimal comfort for the chosen population were defined, according to Dinoff M (2004). The results of this study which shows that to fully satisfy the age range 3-10 the seat needed to be very flexible. For design reasons the seats adjustment was limited to 100mm in length and 100mm in height.

A: Elbow

B: Lower back-knee hollow

C: Knee hollow

D: Shoulder width

E: Shoulder height

F: Hip width

G:Head height

AGE	A	B	C	D	E	F	G
3 years 5 %tile	110	225	195	200	310	175	530
9 years 95%tile	230	405	380	320	490	285	750
DELTA [mm]	120	180	185	120	180	110	220

2.4 Conclusion

A new design for a child seat with ergonomics and safety taking into consideration.The higher position gives the child a better view. A diagonal adjustment of the seat improves the child's seating comfort and ease of use for the parents. A head silhouette on the backrest helps the parent to position the child correctly. Folding the backrest makes the seat easier to store. Isofix provides extra safety. A footrest helps to relive pressure from the thighs.

2.5 Dicussions

To fit the child seat into a car seat taking into consideration different age groups of children turned out to be the biggest challenge during the project. The seat is designed for children 3-10 years old. The recommendation from the Swedish road administration is to use rearward facing seats up to the age of 4 as the neck and pelvis are still developing and the head is proportionally large. However as seen in Jacobsson L´s research parents tend to switch systems much earlier than recommended. This gave us the choice to either accept the recommendation or adapt the system to how we believe it will be used. The seat is designed to fit and protect younger children then 4 years, meanwhile we still believe that the Swedish road administrations recommendation should be followed. In this study no real crash tests or studies with humans have been preformed. The improvements mentioned in the report are therefore only expected benefits and the next step as we see it is to produce a prototype to be used for ergonomics evaluation and to perform crash tests. Evaluate the final design we used the ergonomics software Transom Jack together with child dummies in the ages 3, 6 and 10 together with a simple interior and exterior mock-up of a family car. The first task was to make sure that the seat would fit into the cars interior, witch is a major problem for many child seats. The second was to check that the seat would fit the chosen age range.

Optimization and design work. Parallel to this a benchmark arrived at using four different child seats was set. Complexity, function and geometry were evaluated and also the seats were measured. To find out the children's opinion a two a half hour workshop with a group of eight year olds was held.

Chapter 3

Profile Of The Company

CHAPTER 3 PROFILE OF THE COMPANY

3.1 TNSTC Coimbatore LTD., Erode Region

The transport means moving goods or service from starting place to decided place. In ancient days the transportation of goods and the people are used various animals like a cows, camel, etc. In the modern days the transport can be done in the broad classification (i.e., Airways, Road ways and Water ways). In roadway, there are several classification like Railways, truck, tramways, etc. In decade of 21^{st} century, the passenger transport handled by both government and the private concerns

3.2 Evolution Of Tamilnadu State Transport Corporation (TNSTC)

Tamilnadu is in the front of the Indian sub-continent in providing an efficient transport service to the people. Transport facility is a basic ingrain in a modern society in beginning people together and for the improvement of the society. The TNSTC provides various types of services like Metro, Moffusils, express, ghat services etc to bring the people together from the nook and cornor. Whether it rains or shines Efficient and safe transport operation is continuing in all parts of Tamilnadu by the state Transport undertakings.

The transport departments having under its control 7 state transport undertakings with 19 regions. Tamilnadu Transport Development Consultancy Services Ltd., Institute of Road Transport Chennai and Motor Vehicle Maintenance Department which is a head of department.

The transport department is also nodal agency in the state government in respect of project implemented by Southern Railway, Postal and Telecommunication department and Civil Aviation Department of the Government of India with in the state of Tamilnadu.

3.3 TNSTC Erode Division Infrastructure

Accordingly, the Erode division consists of its supporting units, which provide maintenance to the vehicles.

1. Reconditioning Unit - Chithode
2. Tyre Retreating Unit - Chithode
3. Body Building Unit - Pallipalayam, Dharapuram

The TNSTC (CBE) Ltd, Erode region consist of totally 15 branches. The following are inventory of vehicles and total kms covered by all vehicles.

Town Service Vehicles = 416

Route Service Vehicles = 639

Total Kilometers Covered By

Vehicles per day = 4.85 lakhs kms.

Passengers Travelled Per Day

Day (avg) = 10 lakh passenger per day.

Inventory Of Workers

Total employee strength = 6516

Category Of Work Running Staff

Drivers = 2370

Conductors = 2394

Workshop / Maintenance Staff

Workshop related = 935

Technical Superiors = 113

Acts Applicable To The Employees Of Tnstc

As TNSTC is the government- undertaking sector, are regulated under various acts, which are applicable for the employees. The following are acts regulated to employees

a. **Factories act 1948**

This act is applicable to all level of workers up to supervisory level. This will formulate and control the welfare measures, working hours, wealth, leave, irrespectivenous of employees,

b. Industrial disputes Act-1947

This act is mainly focuses towards settlement of disputes between employees and employees, employers and employees and vice versa. Here, various machineries like working committee, conciliation, adjudication, arbitration, labour court, etc.

c. Workmen compensation Act- 1923

The Act considered to the compensation payable by an employer to his workmen in case of an accident as a measure of relief and security. Injured workmen may either file a civil suit for damages against the employer.

Other Acts

- Motor Transport Workers Act.
- Employee Provident Fund Act-1952.
- Payment of gratuity Act – 1972.
- Payment of Bonus Act – 1966.

Among the all mentioned above, Industrial Establishment and Standing Orders Act- 1946 is mainly framed for conditions of recruitment, discharge disciplinary action , holidays of workmen employed in Industrial establishment, et

SEAT DESIGN.

Fig: 3.1 Seat Design

Figure 1.–Original seat.

Figure 2.–Ergonomic seat.

Chapter 4

Anthrapometry

CHAPTER 4 ANTHRAPOMETRY

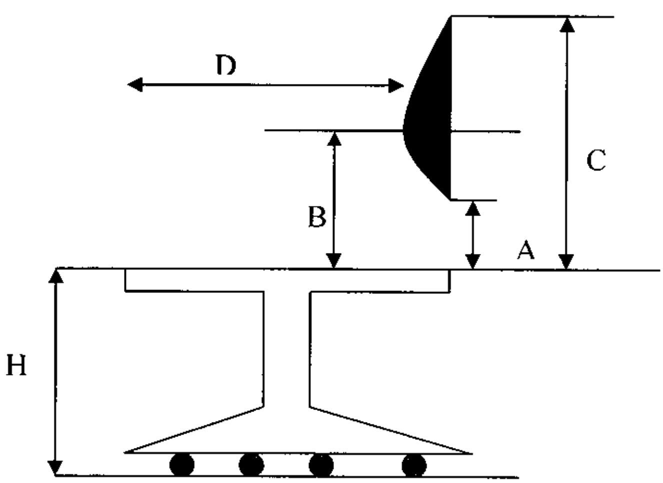
In order to design a seat it is necessary to consider the structure of the human body. Various aspects such as seat height, width, depth, backrest and armrest depend on the dimensions of the body. The further discussion aims at understanding the anthropometrics of seat design.

The branch of ergonomics that deals with human variability in size, shape and strength is called anthropometry. Tables of anthropometric data are used by ergonomics to ensure that places and items that they are designing fit the users.

A positive seat angle helps the user to maintain good contact with the backrest and helps to counteract any tendency to slide out of the seat. Excessive tilt reduces hip/ trunk angle and ease of standing up and sitting down. For most purposes 5 - 10° is a suitable compromise.Elimination of springs in vehicular seating has helped cut the cost of recovery for recycling by about two – thirds. However, the move to deep, all – foam_se dampen the vibration created by the dynamics of the vehicle and irregularities of the roadbed. Some designers specify that a seat should be highly resilient.

4.1 Anthropometric Aspects Of Seat Design

Fig.4.1 Anthropometric Aspects Of Seat Design



4.2 Seat Height (H)

As the size of the seat height increases, beyond the popliteal height of the user, pressure is felt on the underside of the thighs. The resulting reduction of circulation to lower extremities may lead to 'pins and needles', swollen feet and considerable discomfort. As the height decreases the user will (a) tend to flex the spine more (due to the need to achieve an acute angle between thigh and trunk); (b) experience greater problems in standing up and sitting down, due to the distance through which his centre of gravity must move; and (c) require greater leg room. In general, therefore the optimal seat height for many purposes is close to the popliteal height and where this cannot be achieved a seat that is too slow is preferable to one that is high. If it is necessary to make a seat higher than this, shortening the seat and rounding off its front edge in order to minimize the under – thigh pressure may mitigate the ill effects. It is of overriding importance that the height of a seat should be enough for comfortable driving.

4.3 Seat Depth (D)

If the depth is increased beyond the buttock – popliteal length, the user will – not be able to engage the backrest effectively without unacceptable pressure on the backs of the knees. Furthermore, the deeper the seat, the greater are the problems of standing up and sitting down. The lower limit of seat depth is less easy to define. As little as 300 mm will still support the ischial tuberosities and may well be satisfactory in some circumstances. Tall people some – times complain that the seats of easy chairs are too short – an inadequate backrest may well be to blame.

4.4 Seat Width

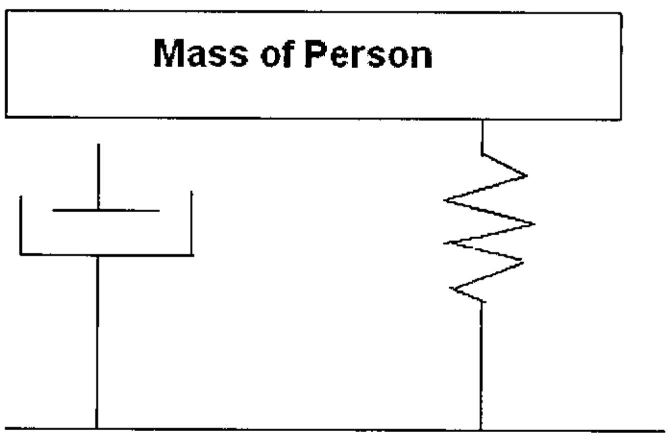
For purposes of support a width that is some 25 mm less on either side than the maximum breadth of the hips is all that is required – hence 350 mm will be adequate. However, clearance between armrests must be adequate for the largest user. In practice, allowing for clothing and leeway, a minimum of 500 mm is required. The higher the backrest, the more effective it will be in supporting the weight of the trunk. This is always desirable but in some circumstances other requirements such as the mobility of the shoulders may be more important. We may distinguish three varieties of backrest, each of which may be appropriate under certain circumstances : the low – level backrest; the medium – level backrest and the high – level backrest. The **low – level backrest provides** support for the lumbar and lower thoracic region only and finishes below the level of the shoulder blades, thus allowing freedom of movement for shoulder and arms. e.g. Old – fashioned typists chairs generally had low – level backrests. To support the lower back and leave the shoulder regions free, an overall backrest height (C) of about 400 mm is required. The **medium – level backrest** also supports the upper back and shoulder regions. Most modern seats fall into this category. For support to mid – thoracic level an overall backrest height of about 500 mm is required and for full shoulder support about 650 mm. A figure of 500 mm is often quoted for office chairs. The **high – level backrest** gives full head and neck support – for the 95th percentile man an overall backrest height of 900 mm is required. Whatever its height, it will generally be preferable and sometimes essential for the backrest to be contoured to the shape of the spine, and in particular to give 'positive support' to the lumbar region in the form of a convexity or pad. To achieve this end, the backrest should support you in the same place as you would support yourself with your hands to ease an aching back.

4.5 Backrest Angle Or Rake (A)

As the backrest angle increases, a greater proportion of the weight of the trunk is supported – hence the compressive force between the trunk and pelvis is diminished. Furthermore, increasing the angle between trunk and thighs improves lordosis. However, the horizontal component of the compressive force increases. This will tend to drive the buttocks forward out of the seat counteracted by (a) an adequate seat tilt; (b) high – friction upholstery; (c) muscular effort from the subject. Increased rake also leads to increased difficulty in the stand – up sit – down action. Interaction of these factors, together with a consideration of task demands, will determine the optimal rake, which will commonly be between 100° and 110°. A pronounced rake is not compatible with a low – or medium – backrest since the upper parts of the body becomes highly unstable. A positive seat angle helps the user to maintain good contact with the backrest and helps to counteract any tendency to slide out of the seat. Excessive tilt reduces hip/ trunk angle and ease of standing up and sitting down. For most purposes 5 - 10° is a suitable compromise. Improvements and refinements to the "miracle material" introduced in the early 1950's continue to expand FPF use and add valuable benefits within the transportation industry. Protecting the environment by recycling vehicle seats to keep them out of landfills is of paramount importance. Elimination of springs in vehicular seating has helped cut_the cost of recovery for recycling by about two – thirds. However, the move to deep, all – foam_se dampen the vibration created by the dynamics of the vehicle and irregularities of the roadbed. Some designers specify that a seat should be highly resilient. Others are much more concerned about vibration – dampening qualities of the seat.

4.6 Mechanical Equivalent Of A Seat

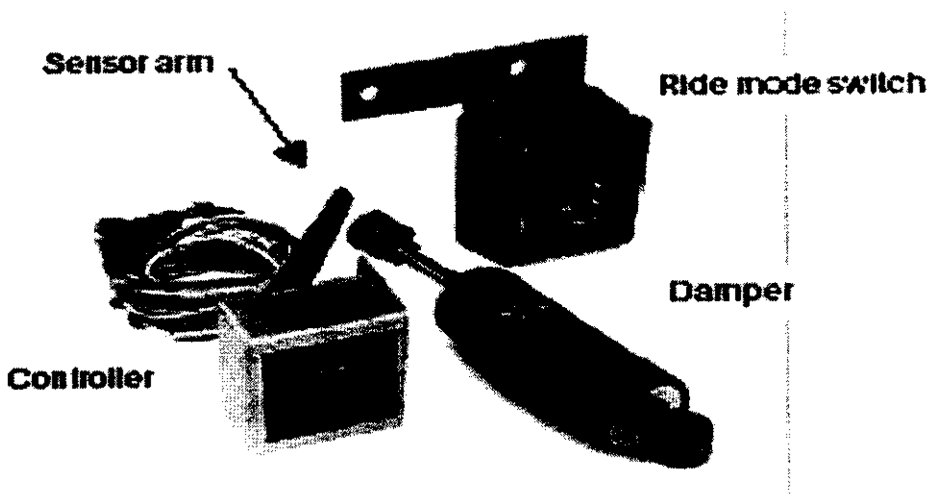
Fig:4.2 Spring and dashpot models are used to predict foam-cushioning behavior.



4.7 Active Seat Design

The active Management System of seat design overcomes the limitations of passive suspensions by sensing changing vibration characteristics and instantly adjusting damping force, providing effective vibration damping and shock protection across a much wider range of road conditions and driver weight than passive systems. This system consists of a controllable damper filled with magnet or heological fluid ("MR fluid"), a sensor arm that measures the position of the seat suspension, a controller with a programmed algorithm that adjusts the damping force in response to changes in seat position. The Motion system senses suspension position and adjusts damping force 500 times per second. The system includes a ride mode switch with three settings (firm, medium, and soft) to allow the driver to easily adjust the feel of the ride. Testing performed by vibration experts on a popular on – highway seat model showed that replacing the standard passive shock absorber with Motion Master reduced the Vibration Dose Value and maximum acceleration (or "shock") transmitted to a 200 – pound driver by up to 40% and 49%, respectively.

Fig: 4.3 Active Seat Design



Chapter 5

Methodology

CHAPTER 5 METHODOLOGY

The general objectives of the seat project were to develop a bus operator's seat that would accommodate the extremes of the bus driver population with minimal mechanical adjustment, and was durable enough to withstand daily, prolonged use. However, designing a bus operator's seat presents a unique challenge. Because a particular bus may be driven by as many as six (6) different drivers within a single day, the great variation in driver size within the driver population demands the various adjustments have an adequate range of adjustment to accommodate the wide differences in driver size and shape. Because of the limited amount of time allocated for the preparation and start of transit service, the actions to adjust the seat must be easy, intuitive, understandable, and quick.

It is not uncommon for many bus drivers to start their shift away from the bus yard and on the road, relieving drivers from buses already in service. Finally, the seats must fit into the wide variation of urban transit bus workstations available. This lack of uniformity exists not only between bus manufacturers, but also among the bus models themselves. It is not uncommon for bus procurement specifications for operator workstations to vary from one transit system to another transit system for the same model bus.

5.1 Ergonomic Bus Operator's Seat Design Considerations

The prevention of musculoskeletal disorders is achieved by interventions which reduce the probability and severity of injuries. It is estimated that through ergonomic design up to one-third of compensable low-back pain in industry can be reduced. The primary interest in the bus operator's workstation is the relationship between the operator's seat, steering column and wheel, and pedals. Bus operators are required to interact and maintain constant contact with each of these components. It is the use and combination of these components that influence the operator's posture.

5.2 Seat Placement Reference Point

In conjunction with the bus operator's seat, the position or placement of the seat in the operator's workstation was also a consideration. The heel reference point was used in the placement of the seat within the operator's cab. Placement of the seat should permit the full range of seat adjustments, unobstructed visibility out of the front windshield, and comfortable reach of the controls and foot pedals. Although the functional design relationships are significantly useful in the bus operator workstation, little work has been done in this area.(10) The Society of Automotive Engineers Handbook (1994) provides several techniques for describing the location of the operator in the workstation.

For these reasons, the use of SRP, SIP, and DEP as referencepoints was dismissed. The HRP approach assumes various size operators have a common point for placement of the operator's seat - the accelerator. Although this concept required large adjustment ranges for the seat in order to accommodate the various size and shapes within the driver population, it provided a readily identifiable reference point from which to compare existing seats against the new recommended guidelines.

5.3 Anthropometric Data

Anthropometric data are used in design standards for new systems and in the evaluation of existing systems in which there is a human-equipment interface. The purpose of the data is to ensure that the worker is comfortable and efficient in performing work activities and in the use of the equipment. Traditionally, anthropometric data used by industrial designers has come from military studies. Because no comprehensive and current information on the U.S. civilian population is available, military data sets are the best possible estimate of present anthropometric data on U.S. civilians. However, military personnel do not represent the extremes of height and weight body dimension of theU.S. Population. Military males are healthy

5.4 Bus Driving Postures

Driving postures used by bus drivers should take into consideration musculoskeletal and biomechanical factors, and ensure that all driving tasks are conducted within a comfortable reach range. The posture of the seated person is dependent on the design of the seat itself, individual sitting habits and the work to be performed. Seated postures are defined as the body position in which the weight of the body is transferred to a supporting area - the ischial tuberosities of the pelvis and their surrounding soft tissue.(22) The biomechanical considerations of seated postures include the spine, arms, and legs. The muscles at the back of thethighs influence the relative position of the spine and pelvis.

The location and slope of the work area influence the position of the neck, shoulders, and upper extremities, when an individual is in a seated posture. The posture of the seated person is dependent on the design of the seat itself, individual sitting habits and the work to be performed. Seated postures are defined as the body position in which the weight of the body is transferred to a supporting area - the ischial tuberosities of the pelvis and their surrounding soft tissue.(22) The biomechanical considerations of seated postures include the spine, arms, and legs. The muscles at the back of the thighs influence the relative position of the spine and pelvis. The location and slope of thework area influence the position of the neck, shoulders, and upper extremities, when an individual is in a seated posture. Therefore, along with the seat itself, it is essential that the work to be performed be taken into consideration

5.5 Preliminary Design Review

The objective of this phase of the project was to develop specific specifications for the prototype seat. The seat was divided into three primary components headrest, seat back, and seat pan. Additionally, each component was further divided into dimensional attributes which characterized the design variables: length, width, depth, angle, adjustment range, and travel distance.

5.6 Determination of Required Adjustments

Ergonomic Consulting, and USSC Group, and Tri-Met reviewed all available adjustments currently available on different seat models, including the USSC Group, Recaro, Bostrom, Grammer, American Seating, Isringhausen, National, and others. In total, twenty-one adjustments were identified. The number of adjustments was determined to be too many, primarily due to the short amount of time typically available to the driver to adjust the seat. In order to simplify the seat adjustment procedure, ten (10) adjustments were identified as being.

5.7 Determination of Adjustment Mechanisms

After determining which adjustments were needed, the type of adjustment mechanisms were reviewed and specified. Primary emphasis was placed on reliability, user friendliness, intuitive perception of how to make an adjustment, and what people are used to doing. Most seats in the bus market use turning-knobs to actuate a mechanical or air adjustment mechanism. These typically are difficult to operate, and require awkward movement of the driver's arms and/or hands. Simple levers were developed and used, where possible, for the adjustment of the various adjustment mechanisms to allow for quick, minimal effort adjustments. The use of electric adjustments was dismissed due to concerns with durability and cost. The types of mechanisms currently used and those considered ideal from a user and maintenance viewpoint. The prototype seat was constructed using the ideal mechanisms.

5.8 Determination of Adjustment Ranges

Adjustment ranges for the driver seat were developed from the driver population data collected and from a review of the literature. The ideal ranges developed are listed. The other adjustments were to be fixed with guidelines established. The backrest height was to be fixed at 24 inches above the flat. uncompressed seat cushion. The seat cushion itself was to be 20 inches wide. Cushions any wider may not fit into some cab areas as controls must be accommodated on the sides of the seats. Backrest width was to be 23 inches wide. Frequently, armrests are not specified by urban transit bus systems. However, they should be considered as an option. The armrests should be allowed to move out of the way in order to accommodate bus driver preference in the use of armrests. Adjustment controls should be located on the right side of the seat in logical clusters. Left-sided controls would be hard to reach in many transit buses due to insufficient room between the seat and the instrument.

Chapter 6

Health And Safety Hazards

CHAPTER 6 HEALTH AND SAFETY HAZARDS FOR BUS DRIVERS

Bus drivers frequently report tension, mental overload, fatigue and sleeping problems. Bus drivers also have more frequent absences from work and of longer duration than workers in other occupations. A large proportion of the work absences are attributable to stress-related disorders such as digestive problems and anxiety. Bus drivers retire earlier and at a younger age than other civil servants. Early retirement is usually accompanied by disability. The main health problems leading to disability are related to the back, tendons and joints, mental illness, and heart and blood vessel disease. Stress is believed to play a significant role in causing two of thediseases (heart and blood vessel disease and digestive disorders) found in excess in bus drivers.

Typically, stressful jobs are those which have high psychological demands and little decision-making control, in combination with low social support on the job. Bus driving is a classic example of a stressful job. Bus drivers must respond to multiple demands over which they have little control. The main tasks of a bus driver are to drive safely, keep on schedule, and treat passengers in a professional and courteous two ways. The job itself is solitary with little chance for face-to-face contact between coworkers. The work schedule disrupts family and social life. How buses are designed and how work is scheduled may account for musculoskeletal problems associated with driving a bus. Musculoskeletal problems include back, neck, and shoulder problems. Muscle cramping, pressure points and poor circulation in the legs and buttocks are other examples. Long term exposure to whole-body vibration and impact while driving over bumps in the roads and rough road surfaces can result in low back problem.

6.1 Key aspects of a bus driver's schedule

- Length of working week and working day
- Number, length and quality of break periods
- Daily rest between two consecutive working days

- Regular or day-to-day assignments
-
- Continuous or split shifts
- Days off and weekends off
- Forward rotation/backward rotation

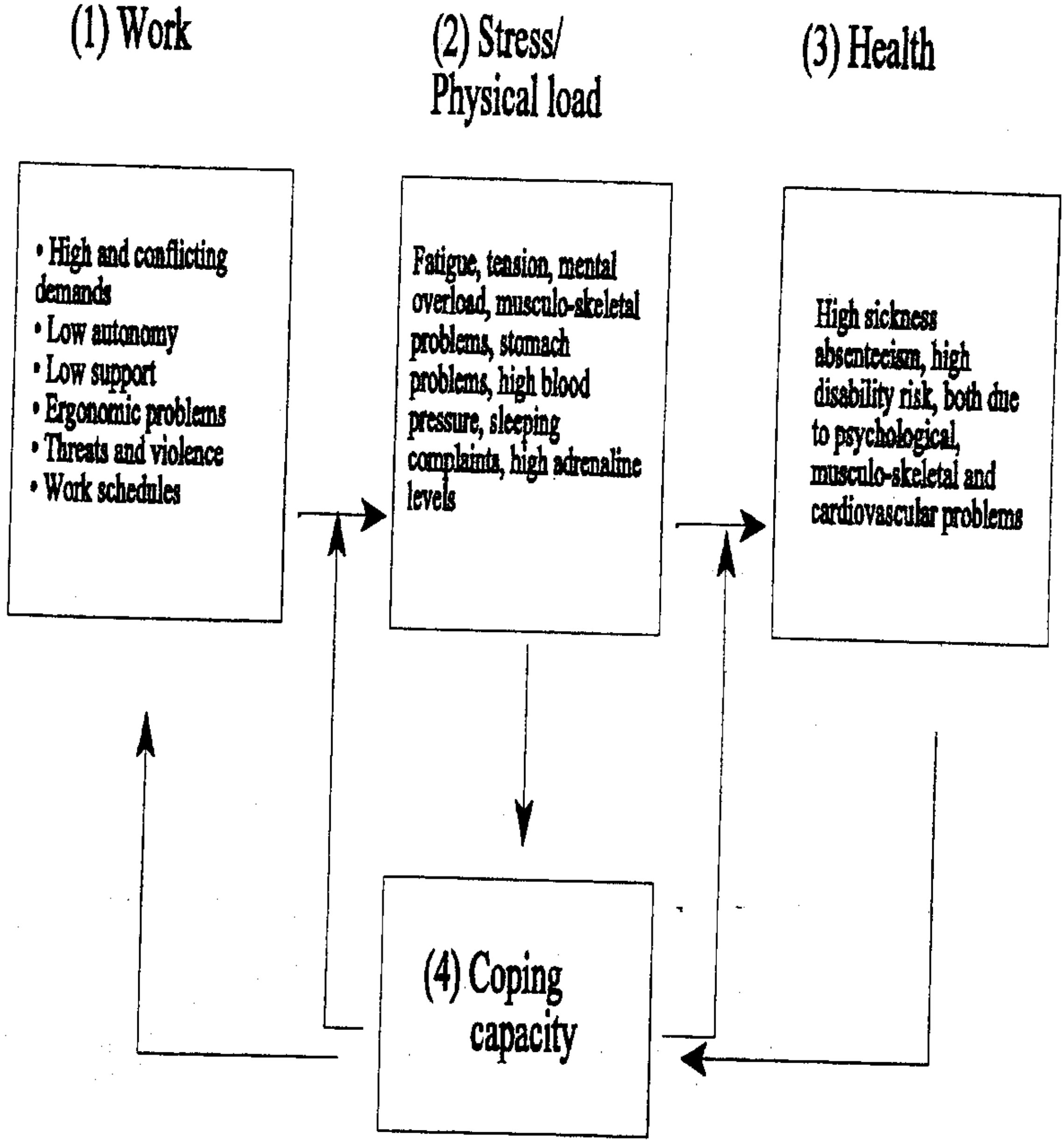
6.2 Main health problems of bus drivers

- Muscular-skeletal problems (lower part of the back, neck,
- shoulders, upper part of the back, knees)
- Psychological problems (fatigue, tension, mental overload)
- Stomach and intestinal disorders
- Sleeping problems

Fig: 6.1 Specifications of seat designs

Specifications	Design 1	Design 2
Out size*W*H	520*560*935mm	520*560*935mm
Seat height	330mm	330mm
Seat width	485mm	485mm
Seat depth	430mm	430mm
Backrest height	650mm	650mm
Backrest width	485mm	485mm
Backrest elevation angle	80-80+41°	80-80+41°
Front&back sides angle	65mm	65mm
Horizontal adjustment	±80mm	±80mm
Pillow adjustment	3lever	3lever
Seat cushion adjustment	±30mm	±30mm
Adjustment	Vertical locking	Vertical locking

Figure 4. Work, stress and health of bus drivers



DESIGN 1

- Out size*W*H):550*485*1120mm
- Backrest height: 650mm
- Backrest width:485mm
- Backrest elevation angle80-80+41°
- Front&back sides angle: 65mm
- Horizontal adjustment: ±80mm
- Pillow adjustment:3lever
- Seat cushion adjustment:±30mm
- Vertical locking adjustment
- Connect sizeL/R×F/B216×295.5

DESIGN 2

- Out size*W*H):520*560*935mm
- Backrest height: 650mm
- Backrest width:485mm
- Backrest elevation angle80-80+41°
- Front&back sides angle: 65mm
- Horizontal adjustment: ±75mm,
- Vertical locking adjustement
- adjustmentConnect sizeL/R×F/B216×295.5
- Operating on left hand control

FRONT ELEVATION COMMAND

Command: limits

Reset Model space limits:

Specify lower left corner or [ON/OFF] <0.0000,0.0000>: 0

Specify upper right corner <12.0000,9.0000>: 1000,1000

Command: z

ZOOM

Specify corner of window, enter a scale factor (nX or nXP), or

[All/Center/Dynamic/Extents/Previous/Scale/Window/Object] <real time>: a

Regenerating model.

Command: l

LINE Specify first point:

Specify next point or [Undo]:select

Specify next point or [Undo]:151

Specify next point or [Close/Undo]:5

Specify next point or [Close/Undo]:151

Specify next point or [Close/Undo]: *Cancel*

Command: l

LINE Specify first point:

Specify next point or [Undo]:select

Specify next point or [Undo]:300

Specify next point or [Close/Undo]:76

Specify next point or [Close/Undo]: *Cancel*

Command: mi

MIRROR

Select objects: Specify opposite corner: 4 found

Select objects: Specify first point of mirror line: Specify second point of mirror line:

Erase source objects? [Yes/No] <N>:n

Command: l

LINE Specify first point:
Specify next point or [Undo]:select
Specify next point or [Undo]:6
Specify next point or [Close/Undo]:43
Specify next point or [Close/Undo]: 6
Specify next point or [Close/Undo]:43
Specify next point or [Close/Undo]: *Cancel*
Command: mi
MIRROR
Select objects: Specify opposite corner: 4 found
Select objects: Specify first point of mirror line: Specify second point of mirror line:Erase source objects? [Yes/No] <N>:n
Command: l
LINE Specify first point:
Specify next point or [Undo]:select
Specify next point or [Close/Undo]:43
Specify next point or [Close/Undo]: 29
Specify next point or [Close/Undo]:c
MIRROR
Select objects: Specify opposite corner: 4 found
Select objects: Specify first point of mirror line: Specify second point of mirror line:
Erase source objects? [Yes/No] <N>:n
Command: l
LINE Specify first point:
Specify next point or [Undo]:select
Specify next point or [Undo]:6
Specify next point or [Close/Undo]:43
Specify next point or [Close/Undo]: 6
Specify next point or [Close/Undo]:43
Specify next point or [Close/Undo]: *Cancel*

Command: l

LINE Specify first point:

Specify next point or [Undo]:select

Specify next point or [Close/Undo]:193

Specify next point or [Close/Undo]: 15

Specify next point or [Close/Undo]:7

Specify next point or [Close/Undo]:365

Command: arc

Specify start point of arc or [Center]: line end select

Specify second point of arc or [Center/End]: e

Specify end point of arc: another end select

Command: mi

MIRROR

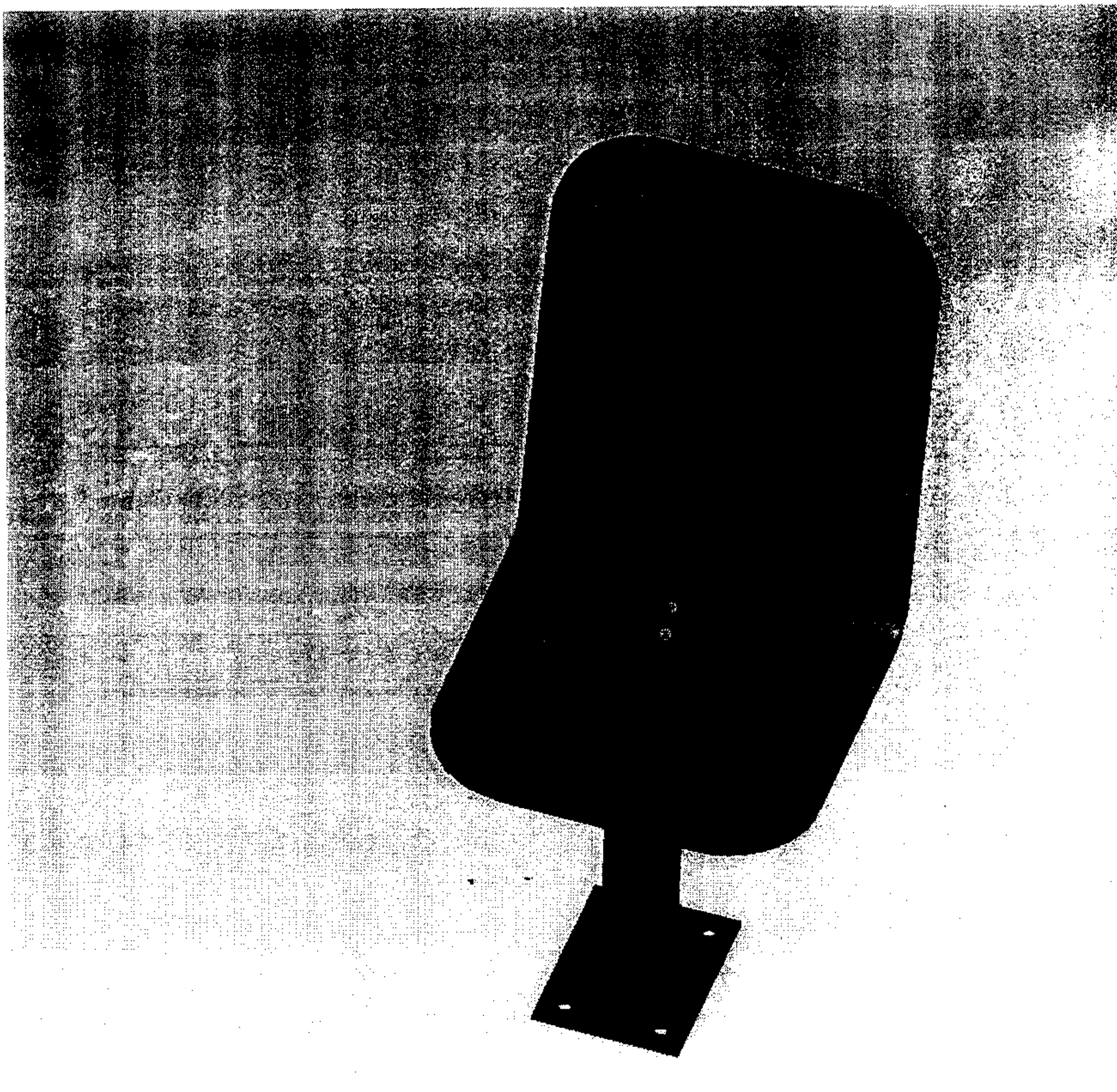
Select objects: Specify opposite corner: 4 found

Select objects: Specify first point of mirror line: Specify second point of mirror line:

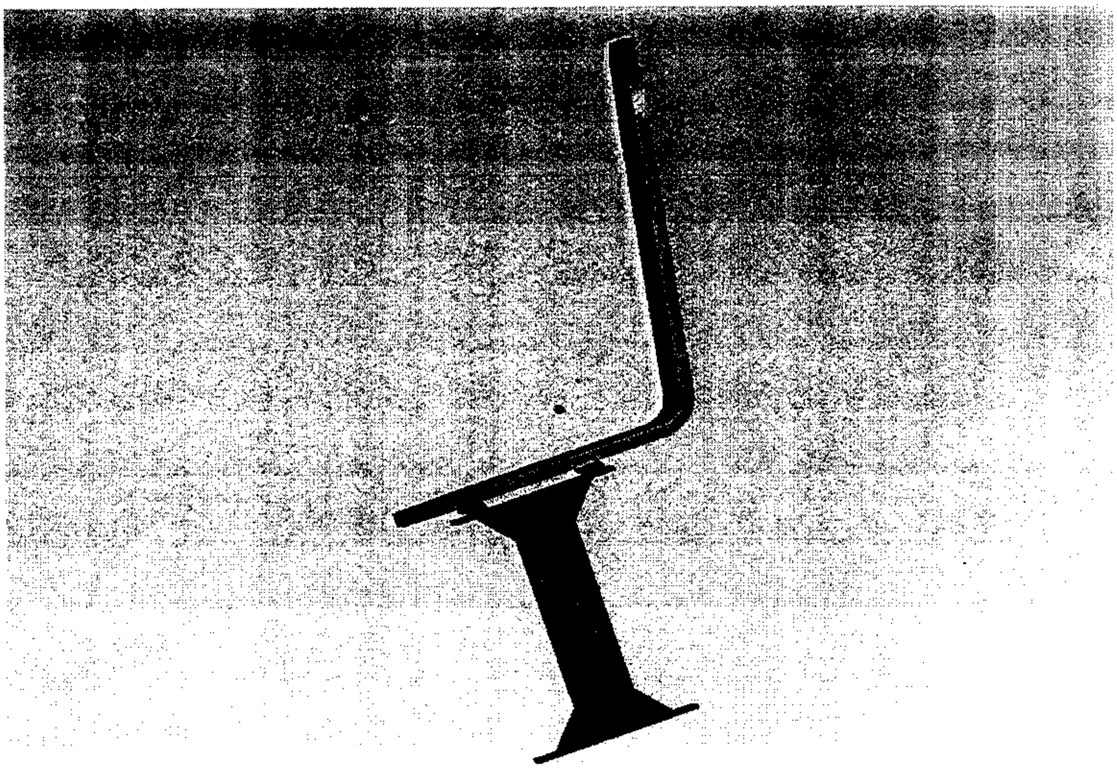
Erase source objects? [Yes/No] <N>:n

SEAT VIEWS

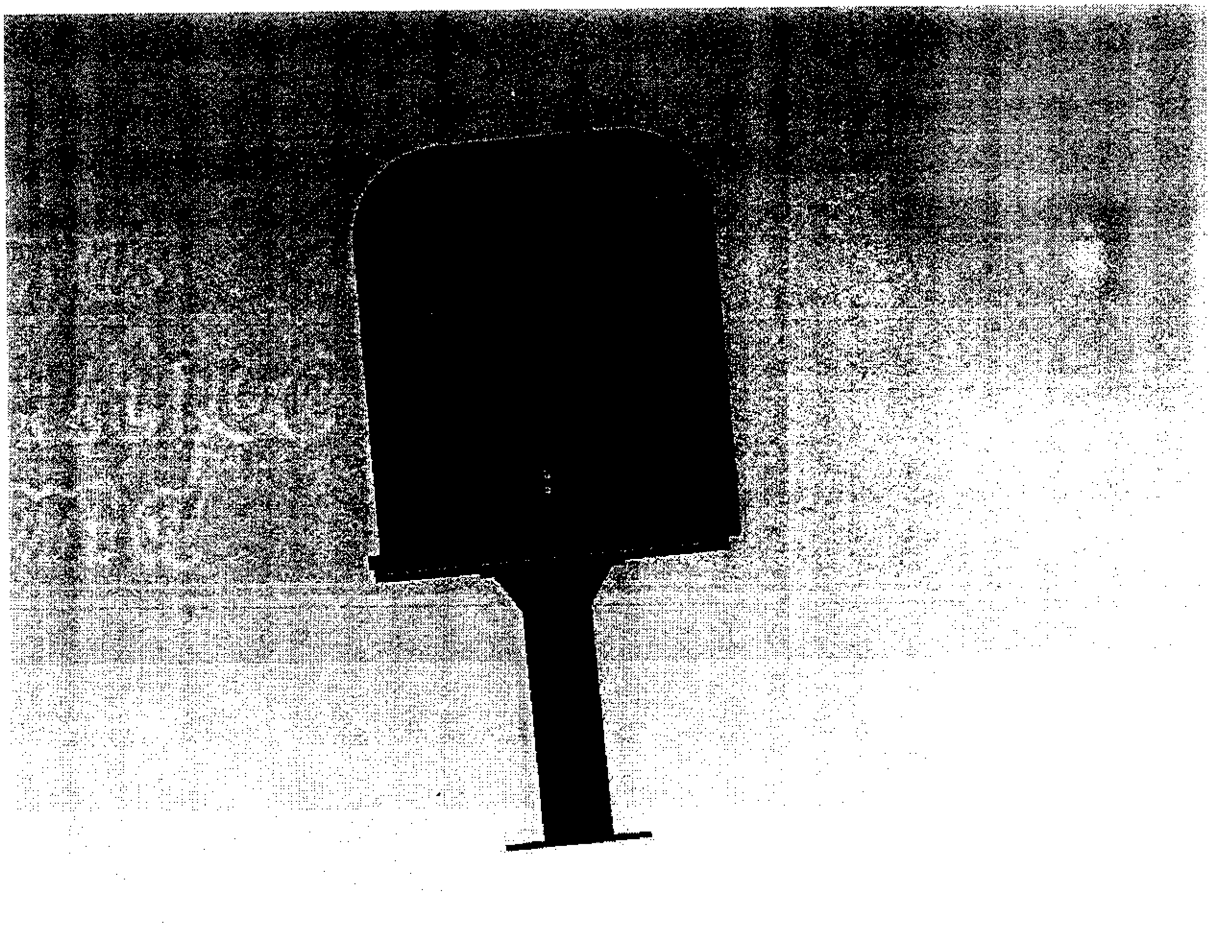
Front View



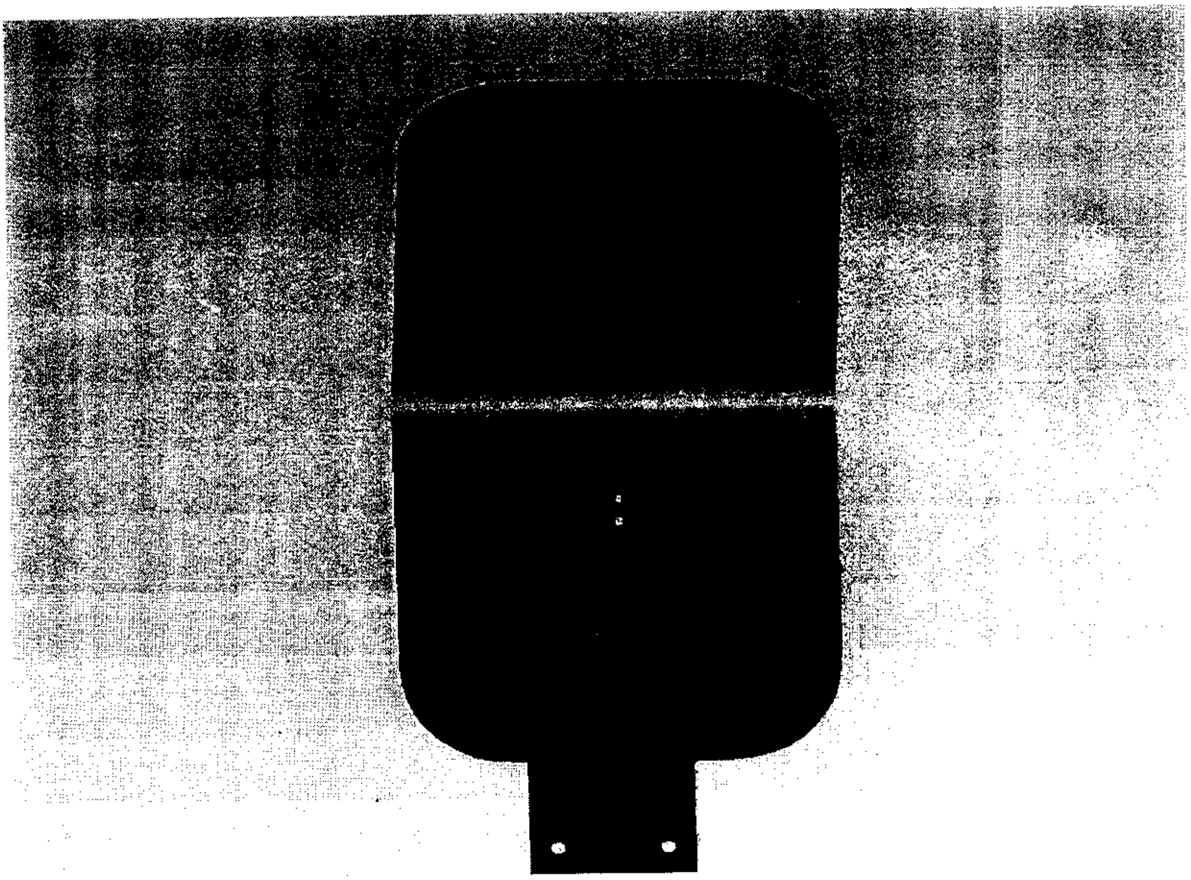
Side View



Back View 1



Back View 2



Chapter 7

Conclusion

CHAPTER 7 CONCLUSION

Though the condition of Indian roads is improving, the uncomfortability and danger caused to the passengers is not a hidden fact. In such a scenario the advancements made in the field of automobile design should be included in all the cars introduced on the Indian roads. Though this may increase the cost of production marginally, the aesthetics and ergonomics of the vehicle improve. This also increases the comfort level of the vehicle and provides a sense of satisfaction to the customers. Market research has showed that the purchasing power of an Indian has increased over the past few years. Hence he certainly wouldn't mind spending the extra bit on his comfort. Eventually it is the customer who is the king in this liberalized economy and any loss to the customer is loss to the company

References

REFERENCES

- A.L. Backman: **"Health survey of professional drivers"**, in Scandinavian Journal of Work Environment and Health, Vol. 9, 1983, pp. 30-35.

- A.J. Courtney and M.H. Wong: **"Anthropometry of the Hong Kong male and the design of bus driver cabs"**, in Applied Ergonomics

- **C.A. Duffy and A.E. McGoldrick: "Stress and the bus driver in the U.K. transport industry"**, in Work and Stress