Chapter 2

Literature Survey
2.1. Introduction -

According to U.S. census Bureau of American Community survey released in 2006, workers spend more than 3.2 billion minutes commuting to their jobs on any working day. Time spent in buses, trains and other modes of transport are included in this survey. However large portion of this time is spent by drivers behind the wheel of their own vehicles with their rear end firmly implanted in cloth or leather rapped seats.

An Original Equipment and aftermarket seat supplier to premium vehicle market segments, ergonomics is at the top of its must achieve list while developing a seat. Correct ergonomics brings with it safety and low fatigue. Correct seats can prevent tired legs, reduce back pain and relieve shoulder tension. If these issues are resolved, then driver will not only feel comfortable but also will be alert.

In spite of this, decision of buying a vehicle is generally based on affordability, usage pattern, and driving comfort assessment by an individual. Within a particular type of vehicle category driving comfort plays a major role while selecting a vehicle. Driving comfort can also reduce fatigue and in short improve the safety.

Many a times, while designing vehicles interior package compromises are done on passenger compartment space allocation to maintain the overall foot print of the vehicle on the road, aerodynamics or some marketing / engineering reason. e.g. four seat sporty car or in compact economy hatch, may not comfortably accommodate large segments of population for leg room and head room (particularly 95 percentile) however there will be enough space for driver seat to accommodate shortest to tallest drivers. The frequency and importance of rear seat are not sufficiently marketable (except luxury vehicles like sedans/limousines) compared to vehicle mass, fuel economy, cost, styling, turning circle radius etc. In any case certain basic requirements for driver seating as well as driver envelope are must either mandatory by regulation or by market pressure.
The driver compartment / envelope, also has more demanding concerns. Drivers in a wide range of sizes, proportions and skills must be able to position themselves comfortably for vision, and control operation regardless of vehicle type, size, styling and cost. Driver’s space is also utilized 100 % whenever vehicle is in use.

The driver packaging process relies on human factors database created through years of research and practical applications. The research conducted in the laboratory, field, on road as well as on virtual work stations (CAD). The driver packaging mainly works around, driver’s eye, hand locations, hand reach, preferred seat positions, reach to pedals and protection from vehicle hard aggregates and systems in eventuality of an accident.

Many of the research studies involved hundred and thousands of human subjects and resulted in standardized drafting templates, mannequins, computer aided procedures, software like Ramsis.

2.2 Vehicle Accidents -

Hutchinson \(^{(1)}\) estimates that worldwide, half a million people are killed each year in traffic accidents. In addition, about 15 million people are injured each year. As per Trinca \(^{(2)}\) et. al. same number of people die in road accidents just in United States which are equal almost number of people died in Vietnam War.

Indian roads are known to be dangerous which can be seen by these figures. As per survey published in Times of India, 280 people die in road accidents every day. Amongst them metros Delhi tops with 1717 people died on roads in 2005. The victims were between the age group of 15-44. Amongst other metro-cities Chennai has dubious honor of occupying the second slot with 1055, followed by Bangalore (855), Mumbai (787), Kanpur (598), Hyderabad (577), Jaipur (495), and Calcutta (484). In causalities Tamil Nadu is at top (13961), followed by Andhra (10944), Maharashtra (10613), UP (9860), and Karnataka (6876).
At very general level accidents occur due to environment conditions, vehicle condition and human error. Older and Spicer (3) suggested that accidents can be the consequence of conflict situations involving the driver and the environment / vehicle that lead to evasive actions on the part of the driver causing collision or uncontrolled vehicle movement. Shinhar(4) collected samples from 2258 accidents and 420 deaths revealed human behavior is a predominant factor (almost 64.3%) and combination of Human error with environment causes contributing to 90% accident cases.

Human errors could be due to philological limitations of drivers, to understand this one need to study Human Machine interface and Ergonomics terminologies.

2.3 Work space anthropometry (5) –

Anthropometry is a science of human dimensions. In this human limb dimensions are measured and sorted based on standing height. Any measurement will follow the statistical bell curve and in case of these dimensions -3σ is shortest female (specified as 5th percentile) where as +3σ is tallest man (specified as 95th percentile). Nominal average value defines the dimension of average man (specified as 50th percentile person). Most of these studies ignore measurements of less than 5th percentile and above 95th percentile as non standard cases.

An old and well established branch of anthropology called anthropometry provides methodology for defining sizes of driver and passenger body dimensions. There are two distinct categories a) Conventional statistical anthropometric measurements, b) Functional task measurements.
2.3.1. Statistical anthropometric measurements –

Anthropometric measurements, when taken from a representative population sample, follow the normal bell shape curve or Gaussian distribution. This distribution curve can be described in terms of its average value and its dispersion about this average. An extremely useful statistics for designer’s and engineers is the percentile.

Health Examination Survey (HES) was conducted between 1960 and 1962 by United States public health services, Stoudt (6) et.al. A sample of 6672 people was carefully selected to represent racially, geographically, and socio-economically non military and non industrial American adult population between age group 18 to 79 years. This survey included 14 body measurements including body part sizes, seated height, leg room, torso width etc. Since people are becoming obese in developing countries, these measurements need updation time to time.

2.3.2 Functional task measurements –

In anthropometric statistical data, human dimensions in various postures are measured. These include dimensions like standing height, seated height, eye height (position), upper leg length etc. Functional task oriented dimensions are
measured with the human body at work, in motion, or in workspace attitude and typically expressed in three dimensional work space reference.

The tools used for measuring vehicle occupant package can be divided in three categories.

1) Templates - Task oriented accommodation design tool. These templates are statistical models of drivers and other occupants based on body landmarks like eye positions, head contours, H /Hip point locations, hand reaches, ball of foot etc. They are 2D/ 3D envelopes with present vehicle scenarios like fixed pedals and adjustable seats.

2) H point machine and motor vehicle Fiducial Marks\(^7\) - This takes care of certain major body dimensions as well as considers seat deflection when body weight is applied.

3) Properly defined vehicle dimensioning procedure (SAE J1100) \(^8\). These are standardized measurement procedures which can provide database for analysis and comparison of vehicle interior dimensions and volumes across all benchmark vehicles.

Various agencies developed their own methods for human body measurements. Society of Automotive Engineering (SAE) developed their own semi automatic anthropometers for driver body measurements in standing as well as seated postures. SAE also provides standardized procedure for vehicles as well as occupant dimensions.

2.4 Static measurements versus task oriented measurements –

In occupant packaging process (especially for driver), it may seem that applying conventional static anthropometric measurements is all what is needed to describe accommodation requirements. For example to obtain 5\(^{th}\) percentile hand-reach, place a 5\(^{th}\) percentile man and draw reach curve, however in practice this may create problem due to following reasons.
1) In a seated posture leg and arm length are important and between 5\textsuperscript{th} to 95\textsuperscript{th} percentile mannequin measurement differences occur in these organs compared to torso or head dimensions. There is no assurance that a 5\textsuperscript{th} percentile mannequin defined on the basis of standing height measurements would have 5\textsuperscript{th} percentile arms and legs.

2) Male and female population mix depends on vehicle type. e.g. user mix ratio for trucks or tractors could be 90\% male – 10\% female but for passenger cars it could be 50\% - 50\%.

3) Seat deflection and postures greatly affect mannequin positioning. Postures of actual drivers are much more flexible than a 2D or 3D available mannequin.

4) A conventional forward / backward adjustable seat can offset driver position such that tall drivers may have more restricted reach compared to short drivers or vise a Versa.

Figure 2.3 'H' point Machine

Considering these limitations SAE has developed functional task oriented models and procedures describing probabilistic body land marks like eye, head, hand, torso, feet trajectory. These probabilistic dimensions express design limits in percentile levels of accommodation.
2.5 Development of vehicle interior package

Packaging engineer develops the architecture for a vehicle with reference to the ground. Ground clearances, underbody structure, and suspension dynamic clearances define the interior floor height in vertical direction (typically known as Z axis). The accelerator and brake pedal hardware with their operating clearances with reference to body structure called bulk head or fire wall define driver foot position in longitudinal direction (X axis). Most of the vehicles are symmetric about their central plane (Y axis) and driver position is defined based on gearshift or air-conditioning package as well as driver location from side door for operating controls / switches on door pads and exterior mirrors.

Two major key reference points in driving workspace definition are -

1. **“R” point (SgRP point)** $(^9)$ – This is hip point for a particular percentile (as defined by vehicle manufacturer) used for further dimensioning reference (typical industrial practice is to use 95th percentile mannequin hip point as R point).

2. **Accommodation Heel Point** $(^{10})$ – This is heel point which is resting on the floor in un-pressed accelerator condition.

Small sports car is generally designed for two people, low floor height with contoured body for low Center of Gravity (stability) and good aerodynamics. While designing a Van or a Multi Purpose Vehicle, about seven occupant accommodation with minimum vehicle length is the major criteria. Hence occupants have high seating position with compromised styling contours, for efficient interior space utilization. This governs the driver position from almost lying horizontal for racing cars to sitting vertically erect for trucks.

Generally 3D CAD, layout defines major hard points of body such as heel, hip, shoulder, eye etc. using side and front views. Even with CAD it is difficult to get a feel of three dimensional tasks like ingress – egress, dynamic body clearances
etc. For this, static seating buck is produced and about 50 people are asked to evaluate particular occupant layout for static comfort.

SAE J 826\(^{(11)}\) – gives information about H point machine. This is replica of major human body parts like legs, buttock and torso. It also has flexibility to adjust length of legs, torso angle and weights according to 5\(^{th}\) to 95\(^{th}\) mannequin standards. H point Machine does not include parts like head or arm.

SAE J1517 \(^{(12)}\) – Defines drivers selected seat positions; this gives hip point trajectories for 5\(^{th}\) to 95\(^{th}\) percentile mannequin with different seated heights from vehicle floor. The curves also change with male – female population mix being selected i.e. 50/50 mix for passenger cars, 75/25 for Sports Utility Vehicles and 90/10 for trucks or tractors.

Figure 2.4 ‘H’ point envelop and Eye Ellipse

SAE J1050 \(^{(13)}\) and SAE J 945 \(^{(14)}\) – Define how to draw Eye Ellipse. This is an envelope of eye points in side and plan view for various percentile heights with given longitudinal and vertical adjustments for seat. The original study involves drivers with straight ahead viewing tasks without head turn. Further it also could
be used with correction factors for slight eye and head movements or various back rest angles.

SAE J 1052\textsuperscript{(15)} - Driver and passenger head position - defines two dimensional seated occupant head positions with normal neck movement and seat travels. This is useful for finding dynamic clearance of head with reference to vehicle aggregates.

SAE J287\textsuperscript{(16)} – Hand reach – this is envelope of hand with reference to H point for 5\textsuperscript{th} to 95\textsuperscript{th} percentile mannequins in various seated positions. This could be further optimized or adjusted for belted or free driver condition as well as for gripping the control to touch the switches by fingers.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{body_dynamic.clearances.png}
\caption{Figure 2.5 Body Dynamic Clearances}
\end{figure}

SAE J 1521\textsuperscript{(17)} – Knee shin clearances – This is envelope of knee cap of 5\textsuperscript{th} to 95\textsuperscript{th} percentile mannequins with given seat travel in longitudinal direction.
SAE J 1522 (18) – Stomach clearances – This is envelope of knee cap of 5th to 95th percentile mannequins with given seat travel in longitudinal direction.

2.6 Vehicle - Driver Sitting -

In good seat design, driver needs all round support which will enable him/her to carry out dynamic tasks easily. Seats are also designed to accommodate 5th percentile (short/thin) to 95th percentile (tall/fat) occupant body sizes. For defining the seating posture, designer’s use 2D or 3D mannequins which are simplified body parts with linkage system. Old SAE mannequins had legs, torso, head and hands however newly introduced aspect mannequins try to capture erect as well as slump seating postures to get correct visibility points.

The ischial tuberosities at the base of pelvis transmits most of the body weight to seat cushion. The contact point defines torso action of rotation and is defined as ‘D’ point by SAE Aspect mannequin’s procedure. The physiological consequence of high pressure on a capillary bed reduces blood flow. Diebschlag et.al. (19) recommended pressure under tuberosities of 3 N/cm². However, absolute pressure maxima may be difficult to achieve. The vascularized tissues around the ischia have a non linear elastic response to pressure that is related to age.

Japanese Automobile standard, JIS B407 (20) – Provides many test methods to evaluate of seat comfort. Some of them are load versus deflection curves, hardness distribution tests, surface hardness test, vibration transfer and damping tests.

2.7 Seat structure -

Seat is designed is for improving ride comfort, safety, and reclining/ resting. Seat frame and seat mounting stiffness are the main elements which contribute towards transfer of vibration to human body. Singshik Bank (21) has discussed modal analysis of seat frames and requirements for seat frame design. He also has compared first modal frequency with single and double recliners, seat
cushion position on longitudinal track i.e. rear, middle, and front position and its
effect on natural frequency.

Wassim El Falou et.al. (22), studied relation of discomfort with long duration
driving (more than 150min). They used Surface Electromyography technique to
understand muscle activities. Subjects were asked to report effect of vibrations,
localized pressure, heat cramp, or tingling after the test duration. The team tried
to establish conclusion that in spite of low level discomfort reported there was
no significant loss of performance during this test period. However, if the seats
are not designed keeping postural comfort there is significant reduction of
performance loss.

2.8 Seat foams -

Brian L. Neal et.al. (23) studied physical property response of polyurethane foam
for normal driving conditions. Polyurethane foams not only give soft cushion to
seated body but also isolate frequencies higher than 6Hz.

Designers consider 50 % deflection of foam for average human body. Automotive
foams are produced with Toluene Dilsoscyantes (TDI) and a conventional polyol.
Some automakers also use mixture of Methyl Diphenyl disocyonate (MDI) in
conjunction with low monol, higher molecular weight polyol. Overall density of
foams is 50 Kg/ m3 +/- 1 Kg/m3. Good foams also show dampening for
frequencies of dynamic cycles unto 4Hzs at an acceleration of 0.2g which results
in 6mm deflection.

For foam, seat designer first consideration is the nature of vehicle occupant and
exactly how they interface with the seat in engineering terms or laboratory tests,
to mass or pressure accounts of driver. Each of these produces reaction in the
foam – the foam is compressed / deflected by distance typically expressed as
percentage of original foam height.
Recovery to original form with removal of load is most desirable property of polyurethane foam hence it is best material for automotive seats. Generally 24 hours is necessary for partial or full recovery. Newly molded foam contains unbroken windows in the cells that must be removed by crushing so that there will not be physical dimensional changes of seat foam in use.

F.M. Casati et.al. \(^{(24)}\) studied effect of recovery time on deflection. Typically 100 mm foam slab is kept under load for different durations. After removing the load recovery is measured with period of 120hrs (with 2 hrs time interval). The result depicted prominent changes after 3hrs to one day. Beyond one day the recovery was negligible.

Also newly produced polyurethane foam contains unbroken windows in the cell that must be removed by crushing to avoid grater physical changes in dynamic loading cycle or seat in use.

Casati also studied load versus deflection curve changes with time cycle and its effect on comfort for polyurethane foams.

Products of automotive seat foam could be divided into four different technologies like – Hot cure, High resilient, base on TDI or MDI foams at ratio of 80/20, Hot cure TM 20 HR and MDI HR foams. Polyurethane foam is an important contributor to the automotive seat comfort and durability performance. As several of these properties, such as Resiliency or sag factor are dependent on the foam chemistry ball rebound test is found to be appropriate.

Indeed one needs foam with good airflow to get proper compression sets and fatigue properties. In same way resonance frequency under given weight is strongly influenced by the foam hardness, their later property being often related to foam density.

G. R. Blair\(^{(25)}\) et.al. conducted principal component analysis of sixteen different physical properties of polyurethane foams from comfort point. Some of these
properties are hardness, support ratio, % hysterisis loss, Ball rebound skin, cushion thickness, core density, resonance frequency, % height loss, % IFD loss, tear strength, 50% compression set etc.

In recent past posture analysis through interface pressure mapping was studied by many researchers like Giuseppe Andreoni et. al\(^{(26)}\). TEKSCAN system allows the recording of the load extended on a suitable thin flexible matrix of piezo - resistive sensors. The matrix used in the study consisted of 42 rows and 48 columns of sensors, measured 49x53 cm\(^3\) and was approximately 0.1 mm thick. The working range was 0- 255 mmHg with magnitude threshold of 3mmHg for noise reduction.

The analysis of pressure maps allows the assessment of two essential points. - Verification of the generally accepted parameter of comfort and identification of seat strategy. The most common comfort criteria largely adopted by seat designers, demands low as well as uniform pressure distribution. Local peaks are dangerous in prolonged seating postures. They will lead in local compression of the involved tissues and consequent poor blood flow. Andreoni also discussed most important seat adjustments which are most important in test sample perception and body weight transfer.

The vibration damping characteristics of foam cushions may be represented by the modified spring and dash pot model, which is a simplified model describing the foams viscoelastic response to forced vibrations. The foam response transmissibility is proportional to hysteresis loss. Hysteresis is directly proportional to resiliency and hence ball rebound test could be best test to get foam characteristics definition.

C.R. Mehta\(^{(27)}\) et.al. studied effect of seat cushion material on comfort due to pressure distribution strategy for tractor seats. They evaluated combination of material, thickness and density for this study. The materials tried were medium density Polyurethane foam, synthetic rubber and coir.
2.9 Aspect mannequin study –

Majority people, sit in slumped position due to improper weight distribution as well as excess loads on spine. Slumped and erect seating posture show substantial increase in (almost 30%) disc pressure. There is also requirement of change in spinal posture rather than fixed one for best spinal geometry while driving, hence automotive seating is a dynamic activity.

Tamara Reid Bush (30) et. al. studied force measurement of mid sized men in seated position. Vision zones are developed on location of head which is related to occupant posture and how much occupant deflects the seat. Lastly it is also important to decide body to metal clearances so that one can not feel the seat structure in any dynamic movement. Tamara also concluded what could be the mannequin part weights based on slumped, neutral and erect sitting.

![Figure 2.6 Aspect Mannequin](image)

Looking at the drivers seating postures and necessity of understanding effect of slumped, neutral and erect seating postures on dimensions, weight as well as various driving tasks, a common research programme was sponsored by Chrysler, GM, BMW, Ford, Lear, Johnson, Magna and many more at Michigan state university biomechanical design research laboratory – called Automotive seat and package evaluation and comparison tools (ASPECT). Lawrence W. Schneider (31) et. al. conducted number of surveys and designed new aspect mannequins. Same time Matthew P. Reed (28) et. al. studied effect of sitting
posture on dimensions specified in various previously defined SAE tools and methods like drivers hand reach, eye ranges, head position, Analytical Hierarchy Process (AHP) etc.

![Figure 2.7 Aspect Mannequin Weights](image)

2.10 Vibrations -

The driver perception of ride comfort is based on road shocks, impact and vibrations transmitted through automotive seat.

Exposure of whole body vibrations may cause serious health problems e.g. lumbago. The risk is dependent on intensity and exposure duration. Drivers of forwarder type vehicles and tractor are exposed to high intensity vibrations, Bore Rehn (29) et.al. captured the effect of vibrations for drivers of forwarder type vehicles. Passenger car drivers are exposed to low vibration intensity however the duration could be as high as 12-14 hrs /day (Taxi drivers).

Vibrations measurements were in accordance with ISO 2631-1, 1997, on interface between the seat and the pelvis. The signals were pre-amplified and band pass filtered (0.1 Hz – 1 KHz) by charge amplifier and then recorded on eight channel recorder (Sony PC 208 Ax).

To understand exact effect of vibration on human body, Nishiyama (30) et. al. developed a seating rig which could be exposed to vibrations of various intensity.
and duration. The rig had pedal, steering wheel as well as major controls which could be adjusted by the subject to its comfortable location. The input was in vertical direction with frequency range 2- 20 Hzs with sweep time of 90s. Experiments were carried on 9 male and 2 female subjects. The measurement was made in vertical and longitudinal directions for head, thigh, shin, upper arm, and lower arm. The observation findings were human body a complicated multi degree of freedom system eases vibration transfer. The transmissibility and resonance frequency vary with the body parts. Larger arm angles gave better dampening. They also found two resonating peaks for the hip, first at 4Hz while other one was at 6 Hzs.

P. Donati (31) experimented with various methods and devices to reduce intensity of vibrations which are experienced by drivers. These experiments were done for seat devises of mobile machinery /tractors. He also studied vibration transfer due to various type of tires, suspensions, body attachment methods and finally suspension of seat itself.

Long duration for vibration exposure also results in numbness in some organs, reduction in response time for controls like brakes/accelerator pedals . Marionne Schust (32) tried to capture this in his research. The observation was movement of the seat frame in relation to the base increased with growing magnitude of excitation and with the volunteer's weight. Experiment depicts no significant decrease of performance with increased vibration intensity however there was tendency of longer reaction time with increased vibration intensity.

Human body sensitivity to various thresholds of vibrations was studied by Neil. J. Mersfield (33). et.al. 10 male and 10 female subjects were exposed to vibrations of 0.2, 0.4 and 0.8 m/s^2. Subjects were asked to identify most uncomfortable test condition. Sungshik Baik (21) et.al. found seat frame and seat mounting stiffness plays major role in vibration characteristic damping / amplifying in seat system. They carried seat frame and mechanisms modal analysis subjected to lateral bending, fore/aft movement, twist and up/down mode shapes. Interestingly there
was not much change in natural frequency with single or double back rest recliner mechanism however there was improvement in fore-aft twist mode with double recliner. Worst vibration amplification occurs with seat in rear most condition due to unsupported moving Channel.

Wu et.al. (34) found interesting results of pressure mapping with vertically induced vibrations to car seats. The measurements were done under sinusoidal excitation of seat base with 1ms$^{-1}$ rms and 2 ms$^{-2}$ rms with frequencies 1-10Hz. The finding reveled contact area almost increases four times with doubling the subject weight. No characteristic or change of contact area pattern between static and dynamic (vibratory) mode.

While studying the driving comfort one can not ignore biomechanical aspects of human body.

2.11 Body weight distribution -

In automotive sitting posture, the pelvis and back transmit body weight to the seat through soft and hard tissues of the body which could be measured through pressure mapping or load versus deflection curves.

Seat cushion shows different pressure at various locations. Various standardized methods are developed for measuring pressure distribution of seated driver and co-related with seat foam stiffness and postural changes.

Female hip breadth is more than male. Thus the 95th percentile female breadth governs the cushion width as well as back width at lower portion. Similarly seat back width at top is governed by 5th percentile female so that there is no restriction of shoulder movement due to excess foam.

2.12. Driver Visual requirements -

In day to day life, driver needs sufficient clear vision in front of the car. e.g. If car has stopping distance capability of 0.8g (about 7.8 m/s$^2$) then at about 80Kmph
when driver will see emergency and apply the brakes, the vehicle will stop at a distance of approximately 31 m. Considering the lag in response time there should be at least 50 m visibility ahead of the vehicle. Similarly view close to bumper or bonnet is required while turning or parking. Sometimes vision also includes road alignment, street details, curbs, and information about road dividers.

Side and rear view is mainly blocked by the pillars which are structurally important members and could not be eliminated. There is also a need to turn vehicles sideways or rearward. If driver twists his back for side or rear visibility while driving his/her concentration will brake. This limitation of side and rear (direct) visibility is compensated by looking through mirrors. Modern cars have aerodynamics as well as styling constraints of providing extra large side mirrors hence the bigger field of view is compensated by providing convex mirrors. This gives perception of objects nearer compared to direct vision. Visual aspects could be divided in four categories

2.12.1 Direct field of vision -

The visual field of human eye is complex and limited by anatomical as well as optical factors. It can be drawn by sight lines in 2D or planes in 3D from eye ball to all points one wishes to see collectively defining field of vision.

2.12.2 Indirect Vision or field of view through mirrors -

The driver’s view through mirrors could be defined same way but here the view is restricted by the image seen with in the boundary of the mirror. The image boundaries are determined by mirror size, its location with reference to eye point and optical characteristics like flat or convex mirrors. To reduce the mirror size many times at least two way adjustments are provided so that driver can rotate it to his/her best visual orientation.
2.12.3 Driver visual aspects for day and night driving –

Additional gadgets are provided in modern cars to improve visibility during night time like antiglare mirrors or reduce visual blindness due to excess light like sun-visors, auto-dip headlamps.

2.12.4 Visual aspects for information transfer -

These are studies related to instrument cluster, various display and external road signage visibility. The study also covers accuracy and time required to collect such information by the driver and methods to overcome human visual limitations of human.

2.12.5 Visual limitations -

Visual acuity is related to ability of eye to detect fine details. When higher illumination is available the relation between illuminant colours and acuity for black and white targets are negligible. Luminous comfort, colour comfort, illumination level, exposure time are more important to acuity than colour. Good visibility is also affected by the brightness relationship between elements with in the visual field. Similarly light to dark adaptation is also a necessity for drive. This is time taken to transit from high to low level light intensity.

SAE J 985 (34) – This standard reviews important capabilities like visual acuity, motion perception and anatomical vision constraints. Similarly "A" post creates a blind spot for vehicles coming from side lanes. SAE J985 elaborates procedure to find 'A' pillar obscuration (6) and its minimum requirements.

Similar to visibility, seating is key element in vehicle packaging. Diversity of seat design is due to the need to match seat and vehicle requirements. Before understanding seat system one need to understand postural requirements for driver.
2.13. Biomechanical aspects -

This covers study of human body movements as well as response of organ to different tasks being performed by the specific part or complete body. Some tools used by various researchers are Electromyograms (EMG) \(^{(40)}\) - muscle reactions, Electrocardiograms (ECG) - heart rates, Electroyrograms - joint kinematics, Electroneurograms (ENG) - motor nerve stimulation study, Electroretinograms (ERG) - cornea movements and Electroencephalogram (EEG) - fluctuations observed at motor nerve, brain or brain surface. All these studies may not be useful in automotive driver context however there are studies which are very much useful in driving task assessment.

Mathew Vargese et al. \(^{(35)}\) studied back pain syndrome in tractor vibrations through MRI analysis. The findings depict that there is no major degeneration observed in tractor driver’s spine who reported back pain, but it could be due to changes in tissues rather than disc deformation.

Mr Gunter P. Siegmund \(^{(36)}\) et al. collected electro-myograms of deep neck muscles and head during isometric, voluntary and reflex contraction. He tried to find correlation of these with fatigue being reported however no specific conclusions were drawn from the study.

R.K. Sivamani \(^{(37)}\) et al. studied skin tribology for hydration with various loads where as T.W. Secomb \(^{(38)}\) et al. studied tribology of blood flow in capillary. These studies also could be extended in driving tasks to understand moisture creation and sweat / heat transfer at back rest skin and blood flow in capillaries under pelvis.

2.14 Social and other miscellaneous aspects -

Very few articles were found related to gender or age factor on driving habits. It could be due to subject is very vast and difficult to find some correlation or researchers found no significant findings in driving characteristics related to
these factors. Information through Indian driving scenario surveys show younger people drive very fast / rash where as old people or female drivers show slower response time while driving cars in crowded roads.

2.15 Summary -

Above study depicts that lot of research is already done in the field of driving comfort, postural studies, general ergonomics as well as influence of vehicle aggregates like seat for driving discomfort. However if one wants to understand combine effect of all these factors or individual factor importance on other there is no evident study found in the literature survey as well as through published material.

This indicates there is need of some procedure to establish attribute balancing of these factors, using relational logic perceived by users. This will also be useful to predict the position of newly designed vehicle on discomfort to most comfortable scale.