Work System Design
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Lecture – 58
Case Study: Car Seat

Namaskar friends, welcome to session 58 of our course on work system design and as you are well aware that now we are towards the closing sessions of our course and we have seen a lot of theoretical aspects related to work system design, as we have divided the course into 4 important modules, we have covered the basic aspects of productivity, basically focusing on that why do we need to study this course, why do we need to undergo this course.

Because each and every organisation wants to improve their productivity, so that was the first module or the first chunk of information that we have shared, then we shifted towards methods study, which is an important technique for improving the work methods or the way of doing the work using the current method. So, method study we have seen that there can be different levels of analysis, we can do the system level analysis may be using an outline process chart.

Or we can do the micro motion analysis using the therbligs, so from different perspectives we can try to improve the way the work is being done. Once we were able to find out the best method of doing the job in module 2, we shifted our attention to find out that how much time must be given to experienced worker to perform the task and there also we have seen different techniques like the stopwatch time study, the predetermined motion time systems, the work sampling approach, the synthetic data approach.

So, different methods can be used for setting the standard time for performing the task by an experienced worker, then in the last module we are trying to focus on the application areas that where the principles of methods study can; principles of work study can be applied, now a person who is doing any kind of work maybe he is just speaking only for that also there can be certain guidelines that at what pitch you must speak, in what body position it is better to speak.

If you have to speak loudly, how you should speak, whether you should be standing or you should be sitting, so the size has gone into each and every aspect of the work being done and therefore, if you are driving a car you require a specific type of interaction between you and the car or the controls and displays of the car. If you are working on a shop floor, you are managing a machine in that case also, you would definitely like to have a good interactive design between the operator and the machine tool that the operator is operating.

So, today our target is to study the design of a car seat or what are the factors, parameters, guidelines, values which have been already established for the design of a car seat. Already, if you remember we have taken one case study of our design of a chair in which we have seen that what are the important components of a chair and if you can just remember, we have seen that starting from the top, we can have a head rest, back rest, armrest, seat, height adjustable column and then the wheels or the casters and the leg support; 5 leg support.

So, we have seen that there are different components of the chair, now that is a office chair, now today we are focusing on a car seat, you can yourself appreciate the difference when we are designing the 2 things. In an office chair, we have provided the wheels, so that if suppose the person instead of getting up from his seat just want to move by feet or 2 feet, he can just move the chair because of the arrangement of wheels.

But here when a person is driving a car, he will not move the seat, so seat has to be stationary but it has to be flexible depending upon the height of the driver or the person who is driving the car, so this is maybe some adjustments have to be made in the seat, so some flexibility has to be given in the car seat also but we have seen that we give lot of flexibility in case of an office chair.

So, today we will focus on car seat and now our target is to learn more and more rules and guidelines, which have already been established for designing different physical objects or different types of physical or the environment that we provide to the operator. For example, operator has to work and he has to do a very precise work, so the kind of illumination required, there will be some guidelines.

If a person has to do a work in a very hot and humid require; hot and humid and environment what is the requirement for ensuring his or her comfort? There are guidelines; air conditioning or ventilation guidelines which must be taken into account to ensure that the person is able to perform his or her task in the most efficient manner, so there are standard guidelines for each and every type of work that we are doing.

Similarly, when we are designing a car seat also, there are standard guidelines, so in a short span of 30 hours it is very difficult to focus on each and every aspect in a much more detail but at least, the learners can acquaint themselves with this information that there are standard guidelines for each type of work being done and they can use or make use of these guidelines in their designing process or during the design conceptualisation and implementation.

So, therefore just the information is really important and then how to use this information that depends upon the designer. So, today let us take a case study of a car seat and try to see that what are the important factors, parameters to be taken into account, what are the standard guidelines and how these guidelines ensure a comfortable driving experience for a driver, so let us now start our discussion.

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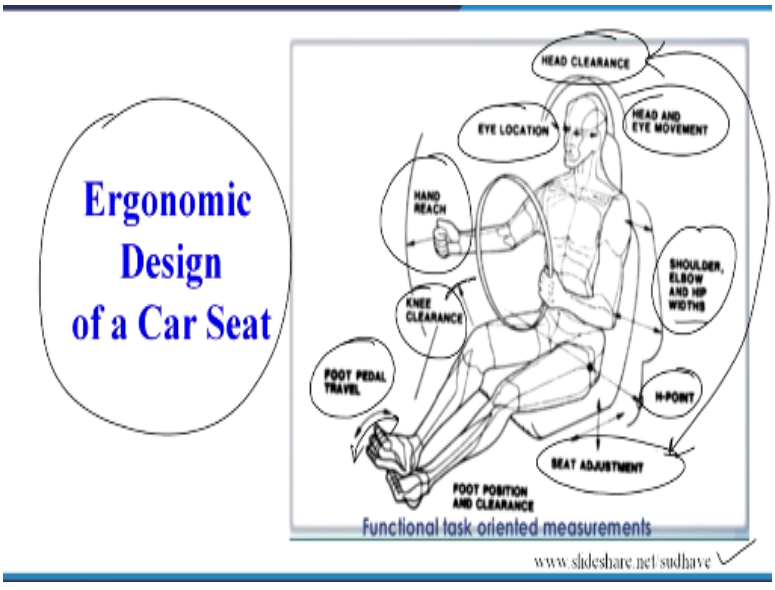

Now, here we see the source is already given, so this is basically ergonomic design of a car seat that we have to ensure, so the steering wheel is given, the hand reach is an important parameter,

eye location, head clearance, now I can take my example only whenever I drive, I wear a turban, so many times the head clearance is an issue with me and I have to adjust my seat while driving a car, so that the turban does not touch the roof of the car.

So, head clearance is one issue, head and eye movement, another important thing that we have to ensure, foot pedal travel, so this is given here, again I will draw an enlarged view, so foot pedal travel is can be one parameter that will affect the driving experience, seat adjustment already I have told in order to ensure head clearance for me specially for my case, I have to adjust the seat, then this H point, we will see what is this.

Shoulder and shoulder elbow and hip width, so that is also very, very important, so we have to see all these parameters, knee clearance is also important, this knee clearance you can see, this is given again I will draw for you, so that you are able to understand, this is a knee clearance, this is the knee and this much clearance must be given, so knee clearance also has to be provided, so you can see now some of you may be wondering that I am wearing a turban, I have a problem with head clearance.

So, a person who is shorter than me may not have that problem and a person who is still taller than me maybe even 4 inches 5 inches taller than me will definitely have his turban touching to the roof of the car definitely, yes and therefore, when we design we usually take the averages, we designed as per the average and we try to design with certain flexibility for example, I have told that when my turban touches the roof, I adjust the seat may be forward and backwards so that I feel comfortable while driving the car.

So, there is an element of flexibility in the design which helps us to adjust, so we cannot say that this particular seat is for this much height, height of the person has to be this much only, then only he can use this seat, even a taller or a smaller person can also use with a little bit of adjustment, sometimes the steering can also be adjusted depending upon the height of the person or the anthropometric data of a person who is using the car or who is driving the car.

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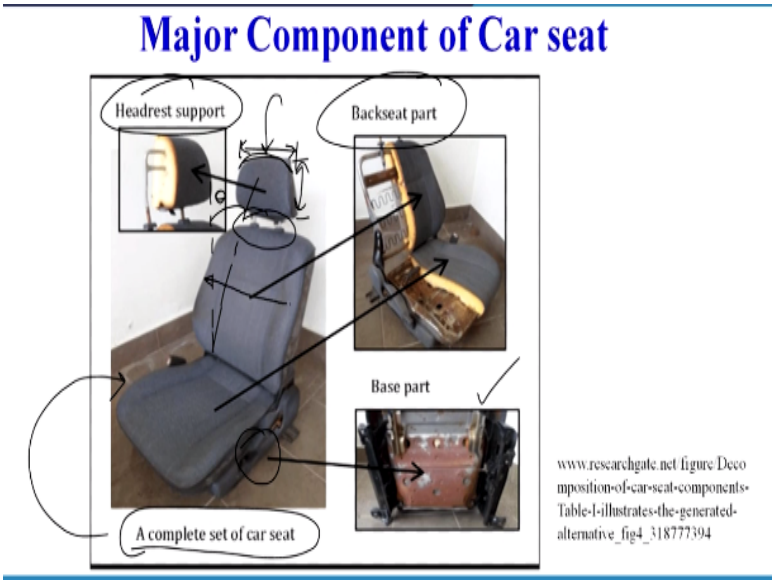

So, you can yourself see a very simple diagram but how many independent parameters we have to control in order to ensure a good driving experience for the driver. Now, this is the major components of our car seat, we can see there is a headrest support, most of the cars provide this, then there is a back seat part, this is a back seat part shown here, then a complete set of car seat this is a complete set shown here, complete set with the backrest, headrest and the seat.

So, and this is the base part which is shown here, this is the base part which has been enlarged view is shown here, so we can see if we just as a common knowledge, if we just try to look at this seat without going into the nitty-gritties of the guidelines and the design, we can say parameters, we can just look that what are the parameters that we can control here or how we can design this seat.

So, first thing let us see, this headrest we can design; we can decide on this width, we can decide on this height, we can decide that then there can be an angle to this headrest like this that also we can decide the radius of curvature for this, this is the backrest, then there is an adjustment possible here, how much adjustment has to be provided that also we can decide, then coming to the backrest, we can decide, we can draw vertical line here and this is an angle.

So, we can decide this angle theta that how the backrest or up to what theta or degree it can; it can be slanted back so that can be taken into account, the width of this backrest can be decided,

the height of the backrest can be decided, even the angle for the backrest can be decided, similar things can be decided for the seat also the depth of the seat, the width of the seat, this angle can also be decided.

So, the point is that there are standard guidelines for based on the previous experience of the drivers as well as the experience of the designers as well as on the basis of the anthropometric data or the average anthropometric data, there are certain guidelines and those guidelines, we will try to see in our subsequent slides. So, you can just have an idea that the seat we use, so much of thought process has gone into the design of that seat.

The seat design; the seat is not just coming out of the box, it is something which has been thought of, it has been something which has been designed, it is something which has been well proven to be comfortable for the drivers who are driving the car, so the basic design guideline is to ensure a fatigue free safe driving experience for the workers or the drivers. Now, let us see the design parameters now.

We have seen that when we look at a seat, what are the things that will come to our mind as the designer, otherwise when we look at a seat, we do not have that kind of design thinking, we take the seat as it has been provided to us in the car but a mechanical engineer or a product designer will definitely look at the various parameters of the seat and I am quite sure that most of the learners who may have just accepted the seat as it is will definitely, when they get into the car will look at the seat from the designers point of view.

That what are the additional features or what are the special features in this seat as compared to the other car seats that he or she may have seen. Because once your thought process gets oriented in that direction, we start looking at the product with a designer's point of view and that is what is the purpose of running this type of courses that we orient the thinking process of the learners towards the design thinking.

Towards the thinking that targets the design of each and every product that comes to or that comes to them or that they are observing in and around them, so therefore let us again bring back our discussion to the car seat.

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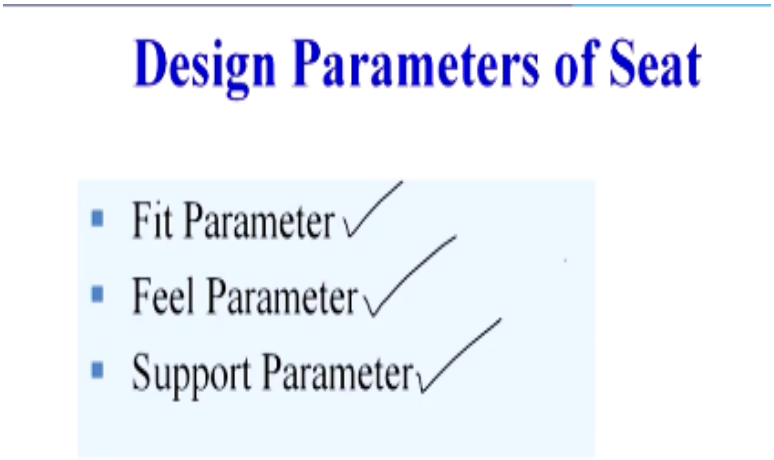

So, when the design parameters of car seat have to be decided, we see the fit parameters, we see the feel parameters and we see the support parameters, so we will see each one of these.

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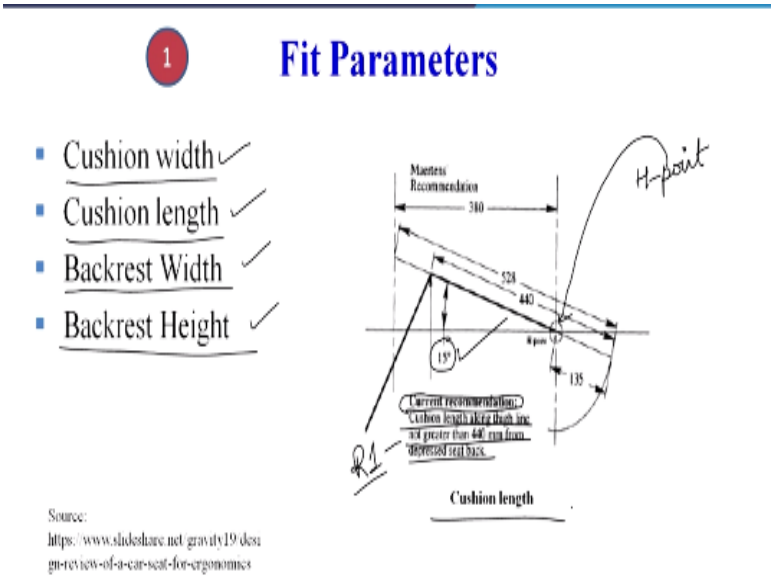

Now, these are the fit parameters, so as I have already highlighted, now we will use the technical terminology to understand the design of a car seat. So, first thing is the cushion width, we will try to see that and there was a terminology called H point, this is the H point which is commonly

used as a reference point while designing the car seat, so there is a cushion width, there is a cushion length, backrest width and backrest height.

So, each one of these has got certain standard dimensions, so standard dimensions, again I must emphasise are not the values, it is a range that the cushion width can be in this range, the cushion height can be in this range, so we will see each one of these and here you can see the current recommendation I have already told that whatever work is being done or whatever product or the equipment or the device is being designed, there are standard specifications available if the product is in use for quite some time.

Yes, if a product is a new product, it is being designed for the first time, then as a product designer I have to develop the standard specifications for that product, so the cushion length along the thigh line must not be greater than 440 millimetre from the depressed seat back. So, this is you can see, the seat this is the H point, this is we can say 15 degree angle, so whenever you sit on a car seat or a driver seat, you will see that it is at an angle.

It is not straight or it is not leaning down like this, it is at slightly at an angle and that angle sub prescribed is 15 degree and this is a H point in the next slide; when we go to the next slide, you will be easily able to understand what is this H point, so this is given, this is a length that is 440 millimetre from the depressed seat back. So, we will again come to this slide, if required, so we will try to understand that fit parameters.

What is the range for cushion width, cushion length, backrest width and backrest height? so let us try to go, this is just one seat, the side view shown for the seat, H point is shown and the cushion length along the thigh line must not be greater than 440 millimetre from the depressed seat back, one recommendation is even we can call it R1, one recommendation regarding cushion length is given, so this is cushion length marked here.

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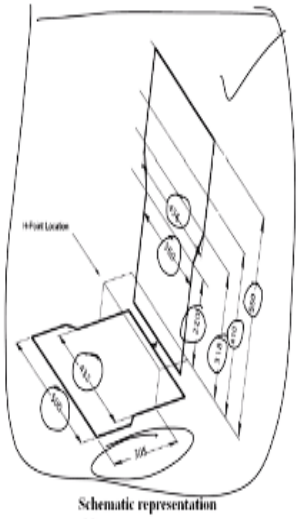
Parameter	Minimum (mm)	Maximum (mm)
Cushion width		
• actual width at H point	432	
• clearance at H point	500	
• width at front of cushion	500	
Cushion length		
• forward of H point on thigh line		305
Backrest width		
• at waist (220 mm above H point)	360	
• at chest (318 mm above H point	456	
Backrest height	410	550

Source: https://www.slideshare.net/gravity19/design-review-of-a-car-seat-for-ergonomics



Schematic representation of fit parameter

Let us now try to understand, now this is I think a better representation of the seat, so here we can see that this is available from the review of a car seat; design review of a car seat for ergonomics, this is taken from a slide share PPT, which is available online, so the parameters we can see, cushion width, cushion length, backrest width, so there are 3 parameters and backrest height is also there, so 4 parameters, so this is the cushion now.

So, the cushion width; actual width at H point, so the H point is somewhere here, so the H point; at H point to the actual width is 432, so that this is the value 432, actual width at H point somewhere here, so this is the width which is shown here 432, clearance at H point, 500 millimetre, this is given here and width at front of the cushion is also 500, so these are the 2 things regarding the width range between 432 at the H point.

So, the seat is like this, 432 millimetre here and 500 millimetre at the end of the seat, which is given here, then the cushion length we can see, it is 305 maximum length which is given here, this is the cushion length, this is a cushion width and cushion length is given, backrest width; you can see at waist, 220 millimetre above the H point, H point is somewhere here, so 220 millimetre above the H point, the backrest width must be 360 millimetre, which is given here.

And at chest level, 318 millimetre above the H point, this is 318 millimetre above the H point, it must be 456 millimetres, it is given here and the backrest height may be the minimum can be

410, which is given here backrest height and the maximum can be 550, this is the maximum height for the backrest, so you can see that there are standard guidelines regarding the width of the seat, regarding the height of the backrest, regarding the cushion length and cushion width.

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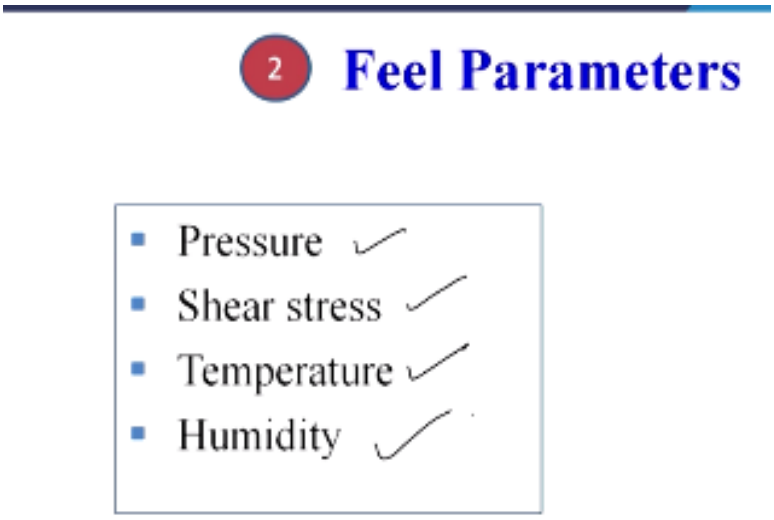

So that is width also is fixed, length also is fixed, height also is fixed, so this is just you can say a very good data, which can be used by the car seat designers. Now, feel parameters like these are pressure, sheer stress, temperature, humidity because when you are sitting on a seat, sometimes you have lot of sweating.

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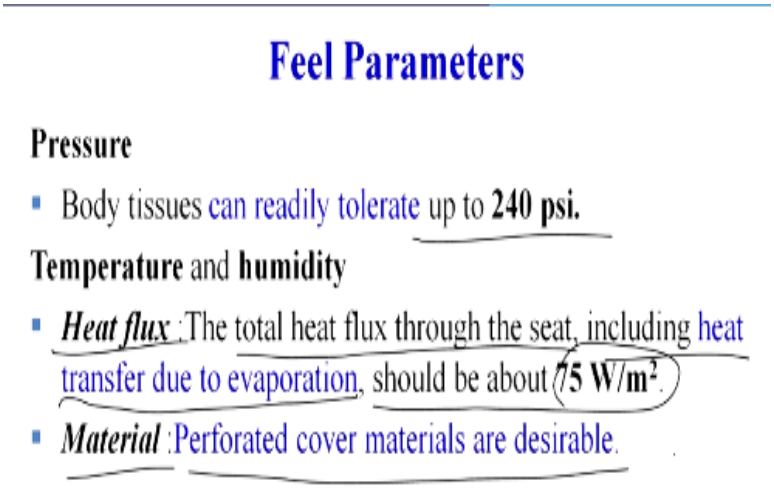

So that is a poor feel parameter that you do not feel comfortable while sitting on the car seat for a longer duration of time, so those feel parameters also have to be taken into account, so body tissues can readily tolerate up to 240 psi means we have to ensure that the; there must not be too much pressure on the body tissue because of the design of the car seat. Temperature and humidity, there are 2 parameters; here heat flux and material.

The total heat flux through the seat including the heat transfer due to evaporation should be about 75 watts per meter square and the material must be perforated cover material are desirable, so a breathing material must be used for the car seat, so that we have a comfortable feeling while driving for long distances, so then maybe in a more detailed manner, if you are interested, you can go through the different types of materials, which can be used for the design of the car seat.

So, there; from our point of view, discussion point of view within the next maybe 15 minutes or in the total half an hour, we can have a discussion on the various parameters that have to be taken into account, while designing the car seat. So, for individual parameters, I will advise that you look for the different materials, which are breathable, through which there is proper flow of air, so that we feel comfortable while driving.

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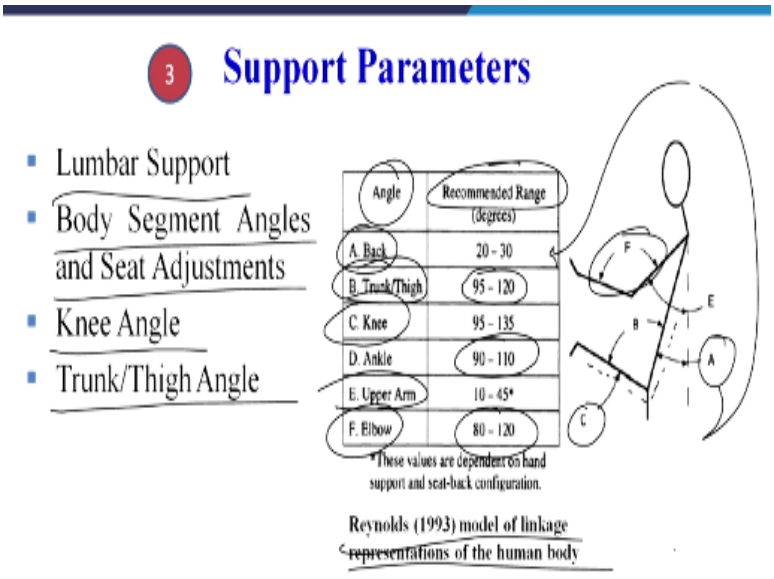

Similarly, the heat flux between the body and the seat must also not be too high then, the support parameters, we have already seen 2 types of parameters; the fit parameters where we have seen

the cushion length, cushion width, the backrest width and the backrest height are fit parameters. Second one are the feel parameters just I have tried to; there are so many parameters which affect the feel.

But still I have tried to just introduce the concept that we have to take into account, the feel parameters also and then finally the support parameters; so lumbar support, body segment angles and seat adjustments, knee angle, trunk, thigh angle, so we can see that different angles are there, which we need to take into account and this is a; these are the you can say recommended range for the design of the car seat.

This is the angle, A is the back angle, so here you can see A is given here, this is the back angle and you can see the range is 20 to 30 degree, similarly the trunk thigh angle that is B, so this is a maybe I can call it as trunk and this is a thigh and this angle B must be 95 to 120 degrees, then knee, we can say C, this is knee, this is C, so this angle can be 95 to 135 degree, Ankle; 90 to 110 degree that is given by D, which is not shown in this image.

E is the upper arm, this is the upper arm, so the upper arm, this angle E must be 10 to 45 degree and the elbow F; this is the elbow F, so this must be 80 to 120 degree, so it is given these values are dependent on hand support and seat back configuration, so hand support means that when you are holding the steering wheel, so this was a; these are based on Reynolds model for linkage representations of the human body.

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Key Areas to be Focused

- Dimensional factors in seating comfort
- Hand controls
- Seating system
- Suspension seat

So, you can see here that we have different types of recommendations regarding the various angles, so these are the support parameters. Now, lastly we will try to quickly rushed through these key areas to be focused, we can see that we need to focus on the dimensional factors in seating comfort as we have already seen the fit parameters, hand controls, seating system and the suspension seat.

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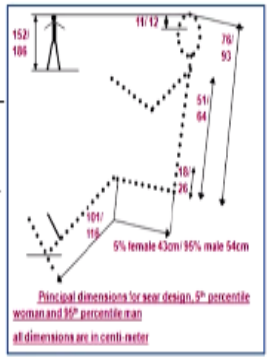
1 Dimensional Factors in Seat Comfort

- Special consideration should be taken for those, who have, **for example**, long legs and a short trunk, or vice versa, and **do not conform to the averaged percentile norms.**
- Degree of freedom of movement must be provided, holding the body in position.



Source: https://www.slideshare.net/gravity19

So, let us see that what is the role of suspension here, now these are the dimensional factors in seat comfort already we have seen, this is again the same representation, so special consideration must be taken for those who have, for example long legs and a short trunk or vice versa,

sometimes short legs and long trunk and do not conform to the average percentile norms. So, sometimes there can be certain deviations we are designing as per the standard data.

But here, there can be people who are exceptional, so that must also be taken into account and how that is possible, when we adjust or when we provide certain flexibility, so that flexibility can be in the movement of the seat or the backrest angle can be adjustable, so the even if you are providing arm rest; the armrest can be flexible, it can be taken back, so providing flexibility in the design will help us to accommodate more number of people or sometimes the exceptional people also.

So, degree of freedom of movement must be provided holding the body in the position, so that is important if we provide degree of freedom, we will be able to design it in a much flexible manner, so this is just standard data which has been given.

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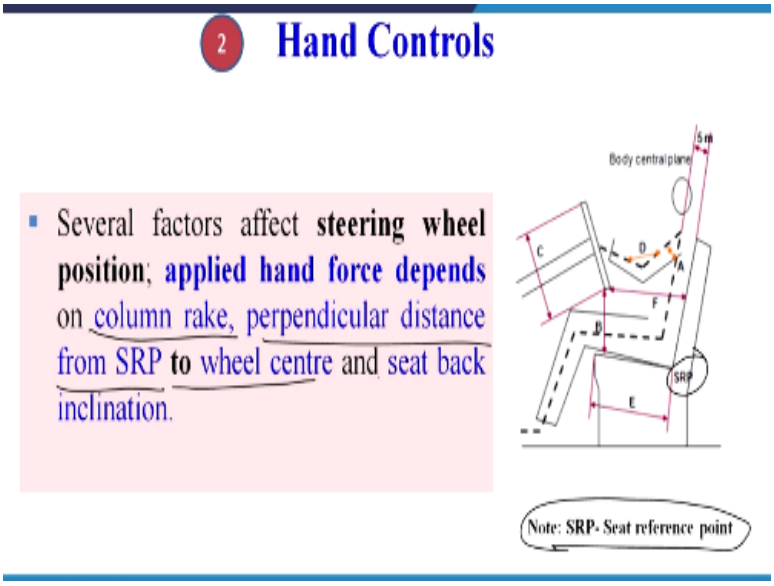

Then, hand controls; several factors affect the steering wheel position, applied hand force depends on the column rake perpendicular distance from the SRP, now what is SRP? SRP is a seat reference point, so perpendicular distance from the seat reference point which is given here to wheel centre that is the distance between the SRP and the wheel centre and a seat back inclination, so seat back inclination is also very, very important.

The distance between the SRP and the wheel centre is also equally important and the column rake is also equally important, so when we are able to design these 3 things, we will be able to design the steering wheel in a proper manner. Several factors affect steering wheel position; applied hand force depends on column rake perpendicular distance from SRP to wheel centre and seat back inclination.

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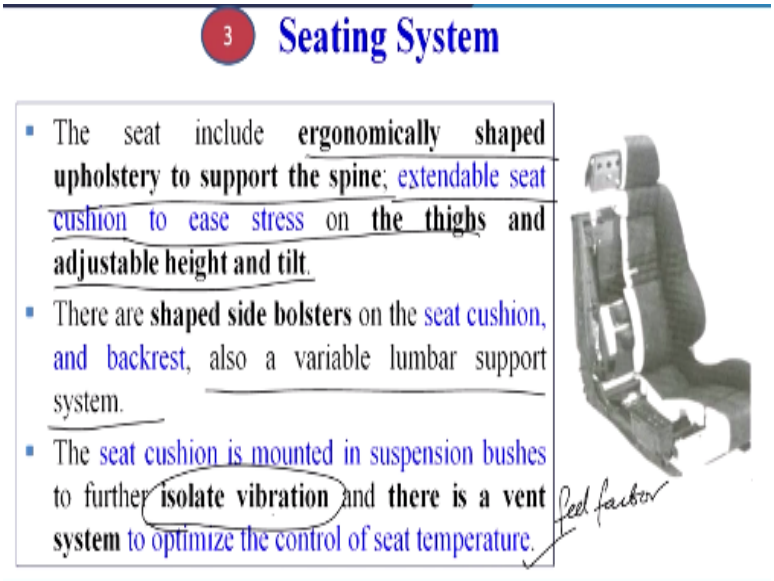

These are not the only parameters; there can be additional parameters which will affect the position of the steering wheel. Then the seating system we can see, include economically shaped upholstery to support the spine, extendable seat cushion to ease the stress and adjustable height and tilt, so you can see extendable seat cushion is the stress on the thighs, adjustable height and tilt, ergonomically shaped upholstery to support the spine.

So, the design of the seat is not a simple design, you have to take into account all these parameter, we have to make it extendable in order to ease other stresses that are coming on the thighs and the height must be adjustable, the tilt must be also be adjustable, there are shaped side bolsters on the seat cushion and backrest also variable lumbar support system is an integral part of the seating system.

So, variable lumbar support system is there, shaped size bolsters on the side cushion and backrest also are there, so when you get into a driver's seat now, just have a close look at the design of the

car seat, you will definitely see the profile because right now, we get into the car and start driving just by switching on the ignition but now after going through this session, just have a closer look, informed look at the car seat, you will be able to appreciate all these points.

The angle, the lumbar support has been provided, shaped size bolsters are there on the seat cushion and the backrest or you can easily appreciate that the seat cushion is mounted in suspension bushes to further isolate the vibration and there is a vent system to optimise the control of the seat temperature, so this is kind of a feel factor here to control the seat temperature. The seat cushion is mounted in suspension bushes to isolate the vibration.

And if you refer back to our previous discussion, in the previous session we have taken an example of a tower crane cabin, the whole body vibration was a big, big, big problem and we have shown some recommendations that if the vibrations are beyond this much hurts, these physical problems can happen to the operator, so here also when you are driving certainly there will be certain vibration.

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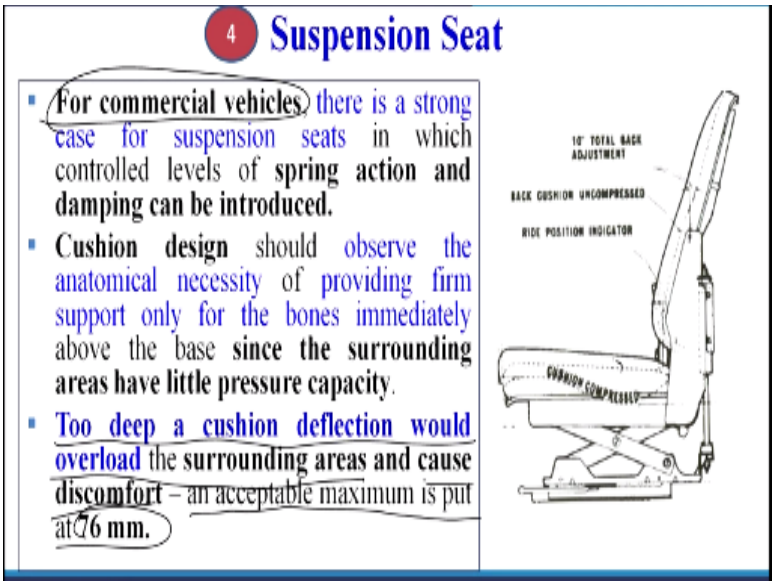

So, the seat design must be such that it is able to isolate those vibrations and the driver feels comfortable while driving the vehicle, so the suspension seat you can see here for commercial vehicles, so this is not for the car seat but this is for the commercial vehicles, there is a strong

case for suspension seats in which controlled levels of spring action and damping can be introduced.

Cushion design must observe the anatomical necessity of providing firm sport only for the bones immediately above the base, so we have the bones when we sit which come in contact with the base since the surrounding areas have little pressure capacity, so we must provide firm support to the bones, so that the vibrations can be isolated. 2 deep a cushion deflection would overload the surrounding areas and cause discomfort.

So, 2 deep a cushion deflection would overload the surrounding areas and cause discomfort, so there is a recommendation and acceptable maximum is put at 76 millimetre, so too much of cushion deflection is also not advisable, so we can see this is a cushion compressed position which is shown with the help of an arrow, so this is back cushion uncompressed, so we can see that there are standard guidelines.

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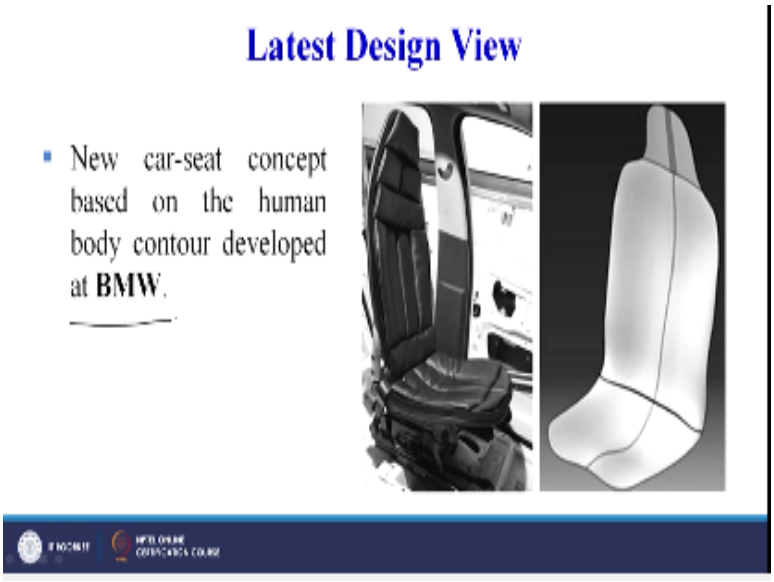

This is 10 degree total back adjustment which is possible for this type of a seat, so this is the latest design view, we can see new car seat concept based on the human body contour developed at BMW so, this is a good design which seems to be working fine.

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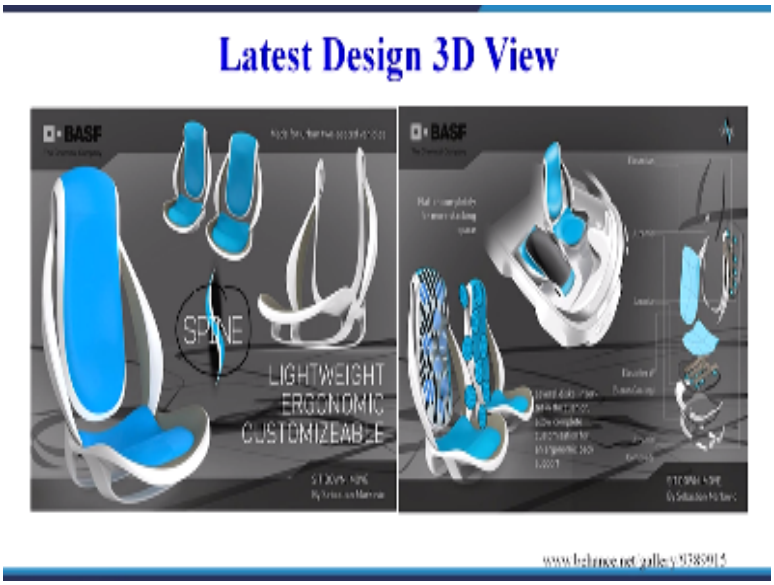

And this is the latest design 3D view which can say, lightweight ergonomic and customisable design where we can see, it can be adjusted as per the spine and there are other parameters also which are given here, which we have already more or less covered and I was talking about the design or the selection of the material for covering the seat or the cloth material, so there also, there are certain guidelines that what type of; what type of material we must select for the seat.

So that it is comfortable for a good feel factor or feel good factor for the driver, so we can see there are lot of literature available on this topic, so the basic idea for undertaking this course or undertaking this particular session was that we are able to highlight the importance of in depth analysis of a simple product such as a car seats, so if you talk about a complicated device or any equipment, which the operator has to use.

You can yourself imagine the amount of thinking or the design thinking that you have to put in order to ensure the comfort, the safe, safety, the fatigue free performance, the maybe comfortable performance I think is summing up everything and a feel good factor for the worker who is operating the device, so we to ensure that the person does not feel tired after performing his works.

So, here also a person has to drive for 10 hours in a day, suppose and he has to sit on these seat, we must ensure that after 10 hours also, he feels comfortable, he feels; he is not tired and he is

not feeling a sense of fatigue, so if we can design the chair in such a way, then our design thinking is right, our design thinking is successful and we are able to design the work system in such a way that we have whatever we have learnt as a course.

Or during this course of work system design, the theories, the practical aspects are successful, so with this, we conclude the today's session, I think all the learners must appreciate the in depth analysis is required to design the car seat and in next session, we will focus on another important system work system which is each one of us is associated with it and then finally in the 60th session, we will close the course, thank you.