Work System Design
Dr. Inderdeep Singh
Department of Mechanical & Industrial Engineering
Indian Institute of Technology – Roorkee

Lecture - 56
Case Study of Office Chair

Namaskar friends, welcome to session 56 of our course on work system design and as all of you are well aware that today we are going to start our discussion for the last week of our course as it is a 12-week course. So today we are going to start the discussion for the 12th week with focus on applications of the principles that we have already studied. If we just look back at the 11th week, we have discussed the various aspects of ergonomics.

We have seen the anthropometry or the use of anthropometry for design of a work system. Then we have seen the man-machine system in which we have tried to understand that how the interaction between a man and the physical environment around him affects his performance in any organization. We have seen that we need to understand the interface, the interaction between the 2 major components of any work system that is the operator as well as the system in which he is working.

And on numerous occasions I have given this example that we are recording these lectures. So this is also a work system where as an operator I am speaking, trying to explain the certain facts and figures or principles and theories with the help of the power point presentation and then we have the environment. We have the physical objects. We have the video recording cameras. We have the lighting arrangements.

This is a physical environment in which the work is being done. So basically when the work is being done, there are 2 or 3 important elements. So we need to understand from the workers point of view which is a very diverse topic from workers point of view we have to see his skills. We have to see how much experience does the worker have? his physiological, psychological conditions, his moral, his motivation towards the work.

So there are n number of parameters related to the operator which can be studied in detail, but it is not possible to completely understand the behavioral aspects related to the operators. So we assume that the operators are coming to the organization so they are motivated, they want to work for the organization and if we are able to or when we are able to provide them with a good working environment, good assistive devices, a safe working condition in those cases.

They will deliver the objectives or they will deliver the output that is desired out of them. So we will see that if we can design our physical environment around which the workers have to perform their task it will be helpful for us in improving the productivity of their work or in general the productivity of the organization. So we will try to cover different case studies and try to just develop an understanding that if we are focusing on a specific physical thing.

Or a physical object how it has to be designed, what are the parameters to be taken into account so that thing becomes comfortable. For example, today we are talking of office chair, so it becomes comfortable. The worker feels happy sitting on the chair and while performing his or her task he enjoys working. He enjoys his task and the chair is not creating any unnecessary hindrances or hurdles or hassles for him to perform his task.

So that is the basic purpose in which a physical object is helping the operator to perform his task in a much more efficient effective and productive manner. So our focus primarily will be to understand the design of various physical objects that the worker usually encounters during his work or that usually interacts with or there is a interface between the worker and the system. So we will try to see 1 or 2 such systems in this week.

So the first example that we have taken is an example of a chair or example of a chair. Why we have selected chair for discussion because it is common we can say equipment or a common device or we can say a common commodity which is used by the workers all across the industry. So maybe it is a (()) (05:07) there also we will see chairs if it is a banking sector we will see chair, in corporate sector also we will see chairs.

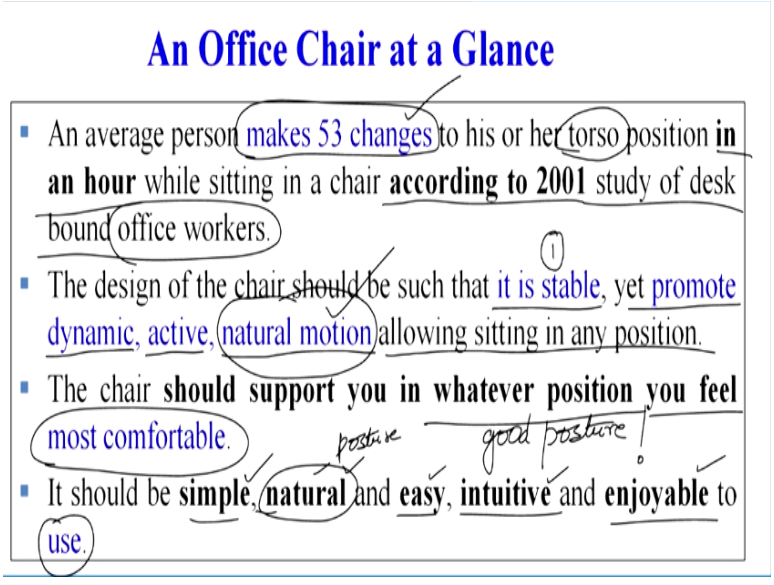
So the design of a chair will just give us an idea the approach that we must follow for designing similar such things or similar such commodities. So let us try to understand the basic aspect of office chair and try to see that what are the parameters or the factors that we must take into account while we are designing a chair which is going to be used by different people in different sets of environment. So let us try to start our discussion on this topic.

(Refer Slide Time: 05:46)

Design of Ergonomically Efficient Office Chair

So design of ergonomically efficient office chair.

(Refer Slide Time: 05:51)



So what is the importance so we can see an average person makes 53 changes may be this is documented to his or her torso in an hour. So in 1 hour you can see may be slightly I feel this is

on the higher side, but still we can say that when a person is sitting on a chair, he keeps on changing or may be torso of the body part keeps on moving in an hour a person makes lot of different positions while sitting on the chair.

So according to this data is according to 2001 study of the desk bound office workers. So the office workers who are working on the table and desk in those cases or table and chair in those cases this data is important. Now we can see that when the person has to move around on a chair how it can affect or what can be the consequences of a person continuously sitting on a chair so that we will try to understand.

First thing is the important thing that the person has to manipulate his torso number of times while sitting on a chair. The design of a chair should be such that it is stable. So these are the design guidelines. It must be stable, yet promote dynamic, active, natural motion allowing sitting in any position. So, natural motion must be allowed. So it must be dynamic and active. It must be stable also, but it must be dynamic and active.

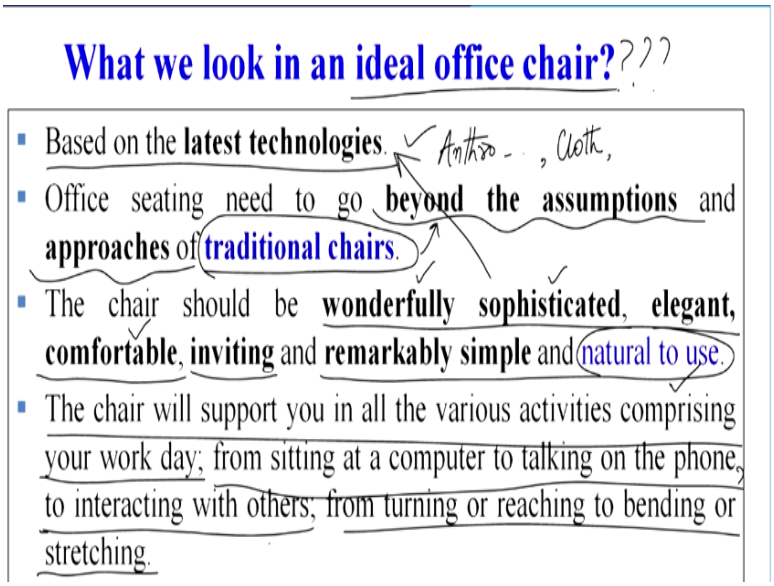
So that it allows the natural emotions in the sitting in different positions. The chair should support you in whatever position you feel most comfortable. So here there is a slight disagreement that is creeping in that we will feel most comfortable in a particular position, but that may not be good for our natural posture or may not be a good posture and later on may be after weeks or after months we may start having some pain or a kind of a symptoms of MSDs which we have already covered musculoskeletal disorders.

So, therefore the chair must support the body in such a way, that we maintain a good posture, a natural posture which is not going to affect our important biological parts such as tendons or ligaments or they must not get hampered or disturbed or may be damaged due to the wrong posture. So what I believe as a teacher, the chair should support you not in whatever position, but must ensure that we maintain a good posture while sitting on the chair.

So slightly I have a different opinion on this point. It should be simple. I agree with this. It should be natural, easy, intuitive, and enjoyable to use. So intuitive we must get an idea how to

sit on the chair. It must be pleasurable experience, easy to operate suppose it has to be bent or it has to be the back rest has to be made at an inclined angle. It must be easy to operate. It must produce this is important. Natural posture it must support and it must be simple in design.

(Refer Slide Time: 09:23)



Now what we look in an ideal office chair? So previous slide if you go back is again just giving us an idea the importance of an office chair and next is what we look in an ideal office chair, what is the requirement there are question marks here. What do we look? It must be based on the latest technologies, may be the technologies may be related to the latest anthropometric data may be used for a design of a chair for a particular country or a particular geographical reason.

And then we can use technologies like the cloth to cover the seat may be designed which is a breathing cloth which gives you a kind of a comfort even in muggy conditions so that can be one of the advancements where the latest technological advancement in the form of the design of a cloth we are using for covering the seat. There can be a number of latest advancements which can be used on selection of materials, selection of manufacturing processes for fabricating the chair.

So we must focus on the latest technologies. Office seating need to go beyond assumptions and approaches of traditional chairs. So there are chairs being used for so many years. So we must look beyond the assumptions and the approaches of the traditional chairs. So we must look for

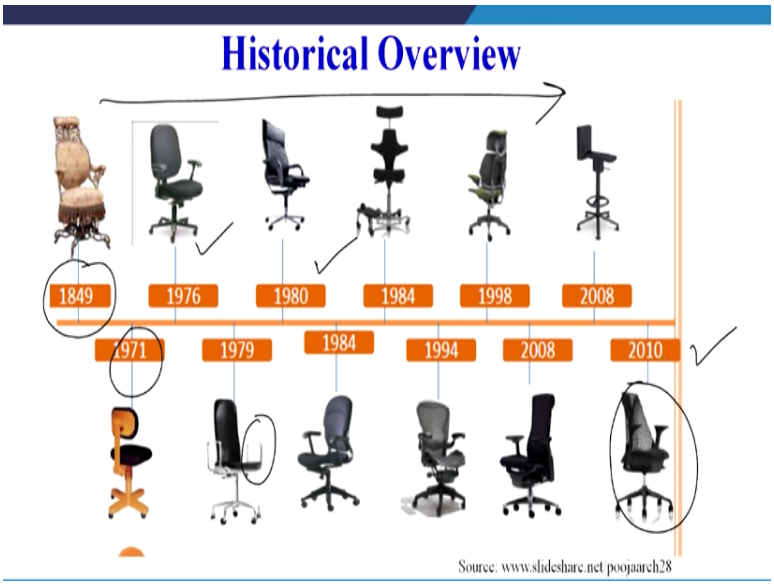
new designs of chairs which may be unconventional in nature, but are very, very suitable, very, very relaxing, very, very comfortable for the workers who are using those chair.

The chair should be wonderfully sophisticated, wonderfully also and sophisticated also. So maybe it must be using the latest technologies which we have already covered. It must look elegant, comfortable. This is more important than elegance from my point of view, inviting, and remarkably simple and natural to use. This is very, very important. The chair will support you in all the various activities comprising your day to day work.

So sometimes the chair must we need to bend also while in the sitting position sometimes we need to get up and then again sit back, sometimes while sitting only we need to reach for a different object or may be it can be a file or something that we are using while sitting on a chair. So the chair design must ensure that when we are moving the chair helps us in those motions. So the chair will support you in all the various activities comprising your day work from sitting at a computer.

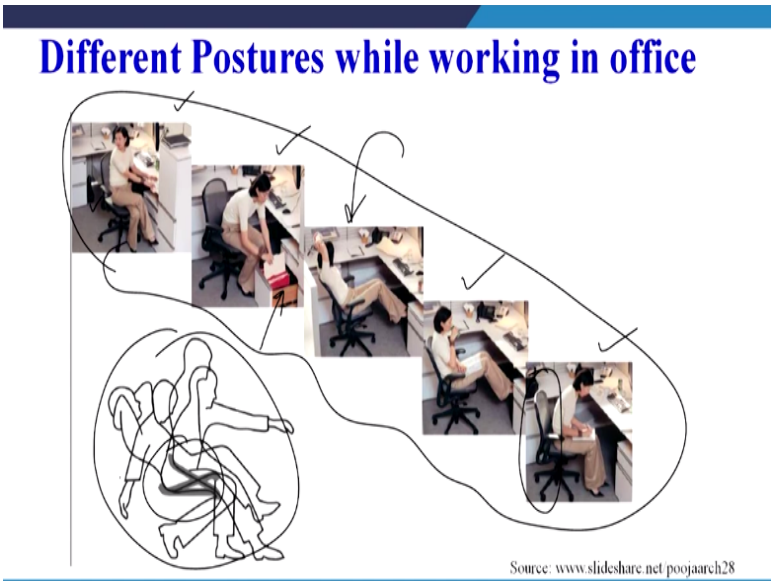
To taking on the phone to interacting with others from turning or reaching to bending or stretching. So while on the sometimes we sit on a chair and we like to relax or stretch so there also the chair must support us. So if we want to bend in a particular direction, the chair must support us. So that is basically the requirements for a ideal chair. Now this is just a historical overview.

(Refer Slide Time: 12:40)



We can see 1849 the design of a chair, modifications, 1976, 1980, and this is we can say 2010. So we can see that different types of arm rests have been designed conceptualized fabricated and used. So we have different types of chairs which are in use. This is 1971 so it has evolved in this direction and finally this is the latest, but this is also approximately 7 or 8 years old design. So if today you go and look for ergonomically designed chair you may get n number of variants that you can choose from.

(Refer Slide Time: 13:22)



Now these are the different postures while working in an office. You can see the worker sitting, sitting in a particular posture, then bending, taking out some files from this table, then may be already I have told stretching, relaxing, having a cup of tea, then may be writing on the lap, or

you can yourself imagine as we have seen that we do usually photographic evaluation or we do the continuous capture of the images.

Or the videography of the person doing a particular work in a (()) (13:54) similarly a person operating computer in a company we can do videography of the person and see what type of postures the person usually makes while he is sitting on the chair, and the chair or the ideal design of the chair must accommodate for all those postures that the person usually makes while sitting for long duration.

It is not that we are going for a meeting for 15 minutes and we sit on the chair and we say this is the best design of the chair. We have to ensure that a person who has to sit on a chair for maybe 8 hours in a day how the chair must be designed so that he feels comfortable while performing his or her task. So it is not a matter of 10 or 15 minutes, because it is a specific case where a person is only going for a meeting.

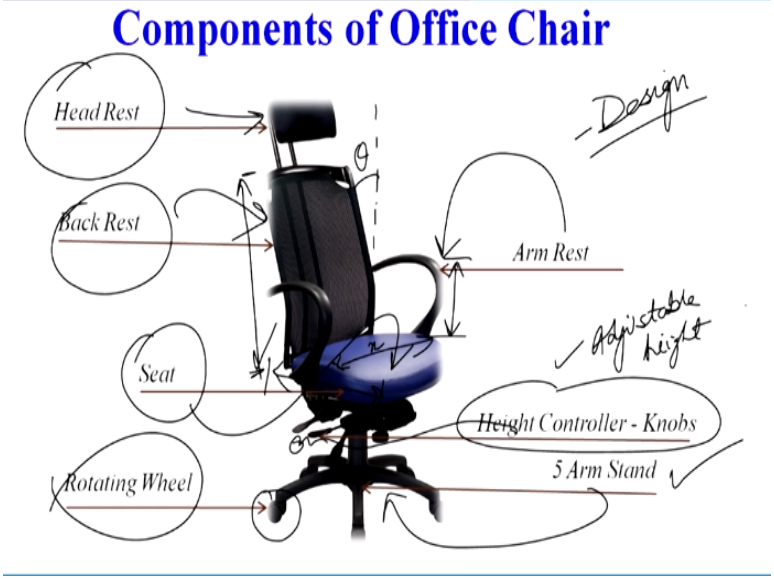
But the long exposure, the prolonged exposure or the prolonged interface between the chair and the operator will definitely have different characteristics as compared to a short time interaction between the 2. Therefore, here we can see the operator having different postures, different postures on the chair and therefore the importance of this chair becomes much more where we can see this is the kind of a chair that we want to design and we can see the person is changing different postures.

(Refer Slide Time: 15:21)

Components of Office Chair

Now we will quickly have a look at the components of the office chair.

(Refer Slide Time: 15:27)



This is 1 design of office chair. So these are the arm rest, because we will be using these terms. So we will just have a glimpse of that. This is the head rest, arm rest, seat, this is the seat. Then there is a height control knob here and then the 5 arm stand, rotating wheels here you can see. These are some of the parts. There can be other parts also. One is here I have left this is the back rest.

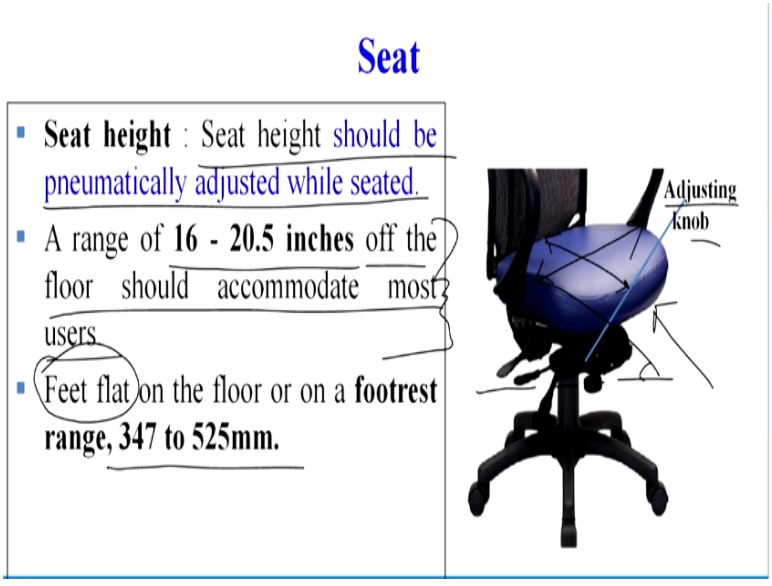
So these are all the components of office chair or the parts of an office chair and we need to design each one of them so the design for each one of them will require a basic understanding of

the various principles that we have already covered. For example, this suppose, we drop a vertical from here what must be this angle theta. Whether it must be adjustable, if it is adjustable up to what height or what angle it must go so that is one thing.

We have to decide what is this thickness or x, what has to be this length between the back rest and the front part of the chair, so what has to be this height? All these parameters have to be decided. Now how we will decide these parameters as engineers or as managers or a scientist it is our duty to design good equipment for our workers. Now suppose a chair has to be designed how we will decide this parameter. This height is there.

This angle theta is there. Then this height is also equally important. Then whether to go for a 5 arm stand or 3 arm stand that is also very, very important. Whether we need to give the adjustable height or it can be a common height that is also important, that is also equally important. So 1 by 1 we will try to understand most of these parameters.

(Refer Slide Time: 17:35)



So what is seat? Now this is a seat. There is an adjusting knob here. So seat height. Seat height should be pneumatically adjusted while seated. So we must be able to control the height of the seat. A range of 16 to 20.5 inches off the floor should accommodate most users. So this is an important guideline for the height of the chair. A range of 16 to 20.5 inches of the floor should accommodate most users. Feet flat on the floor or on a footrest range, 347 to 525 mm.

So this is we have to ensure that the feet are flat while we are sitting on this seat. So seat must be such that the feet are flat on the floor or on a foot rest. Now coming down to the seat material there are different types and just I will go back to this the design of a seat. There are other parameters also that we need to look for where 1 can be this width then this dimension also and this angle also is important as particular to the horizontal.

So all these parameters are very, very important and we will see if possible to cover some of these in our subsequent slides or what are the guidelines related to the angle of the seat or the curvature of the seat we will try to cover, but important point is that when we are designing ergonomic chair, seat is one of the most important parameters that must be given do consideration.

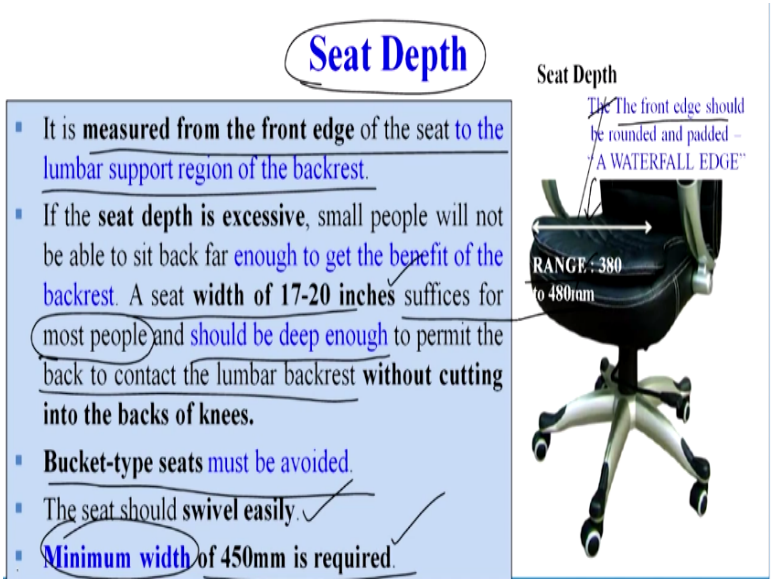
(Refer Slide Time: 19:18)

And for seat material also is very, very important. It can be made up of leather. It can be a wire mesh, it can be a cushion, or normally we have a cushion covered by a cloth. Then again this is again example of a leather. So we have different types of materials that are available when we are designing a chair for the office going professionals. So we can choose. Now different type of materials will have their pros and cons.

Leather will have its own advantages, but will have its own limitations also. Similarly, a wire mesh will have its advantages, but may have the limitations also. Now depending upon the kind of an environment that we are offering to our workers we also need to design the material or select the material as per the working environment. So there can be number of examples where leather is not advisable.

So you need to go for a wire mesh type. In many cases a cushion may be advisable. For example, most of the cinema halls when we go to watch a movie, we will get the seats with cushion in those cases or in most of the cinema halls. Now this is again I have already told in the previous slides that we will further see the important parameter of seat depth.

(Refer Slide Time: 20:42)



The seat depth, the front edge should be rounded and padded a waterfall edge this is it is given, the front edge. The front edge must be rounded and padded. So let us see regarding seat depth what are the important parameters? One guideline is already given regarding the front edge it must be rounded and padded. Now seat depth it is measured from the front edge of the seat to the lumbar support region of the backrest.

So this is giving us an example of sorry definition of the seat depth how we will call it as a, or what is basically the seat depth. If the seat depth is excessive, small people will not be able to sit back far enough to get the benefit of the back rest. So this we can see. We can very easily

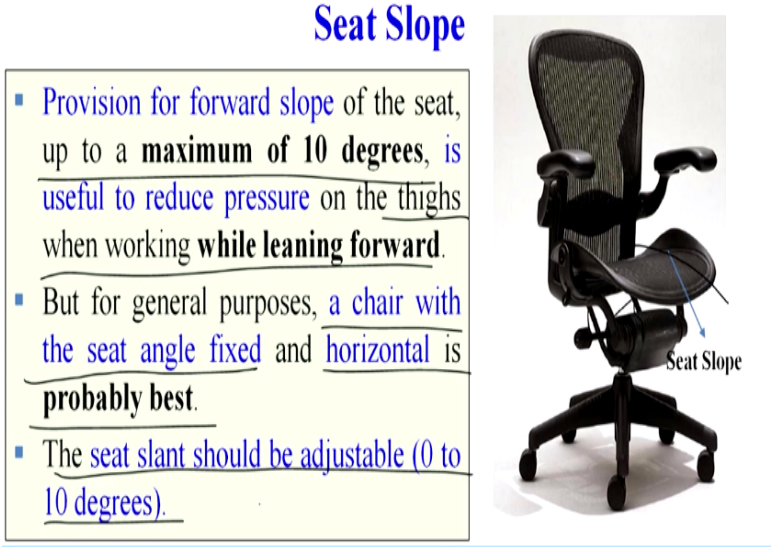
experience what is written here. So it is not something which we need to understand. We can experience that if the seat depth is excessive from here to the last part.

This is white portion is giving the indication of sitters from the beginning to the end. So when the seat depth is large or it is excessive small people will not be able to sit back far enough to get the benefit of the back rest. So they may not be able to touch or you can imagine a child sitting on a chair. His back may not be touching the back rest. A seat width, this is the width 17 to 20 inches suffices for most people and should be deep enough to permit the back to contact the lumbar back rest without cutting into the backs of the knees.

So these are the important guidelines may be this may also vary based on the anthropometric data for different regions when this is based on the design for average. So whatever we are saying if you see is suffices for most people. So this is designing for the average people. So in many cases if the anthropometric data suggest otherwise this is the value of the seat depth and the other parameter we have seen is the width have to be chased accordingly. Or the values may change for the seat depth and the width.

So width also is given range and similarly the range is given for the seat depth also. Bucket-type seats must be avoided cause a problem in the back. The seat should swivel easily. So swiveling of seat is important and we must ensure that we can swivel the seat. Minimum width of 450 mm is required. So we can see that the width is also specified so the minimum value is given of 450 mm. So this slide is giving us an idea that we must design for the average people, the seat depth and the seat width so that it becomes comfortable for a person to be seated on the ergonomically designed chair. Now, seat slope.

(Refer Slide Time: 23:59)

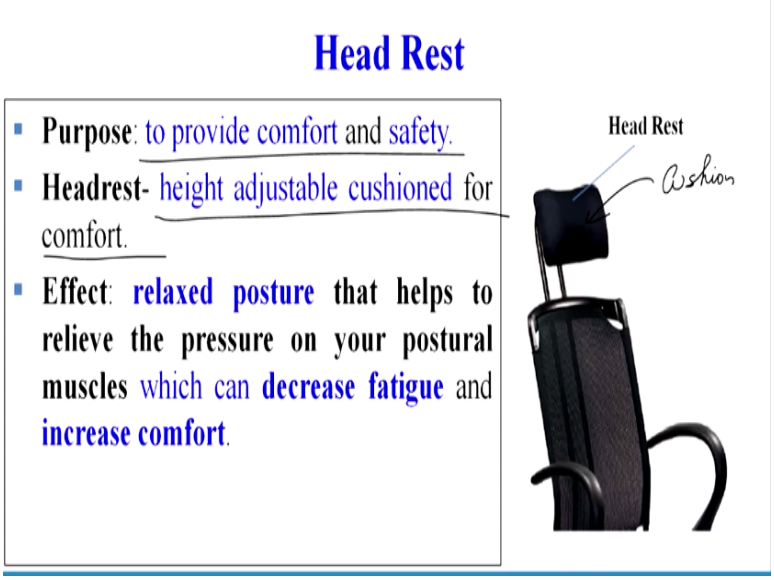


This is a slope we can see, seat slope. Provision of forward slope of the seat up to a maximum of 10 degrees is useful to reduce the pressure on the thighs when working while leaning forward. So when we are working on a system sitting on a chair so there may be pressure points under the thighs. So those pressure points in the highest to be avoided and for that reason a slope of 10 degree can be given or a maximum of 10 degree slope can be given on the seat.

But for general purposes chair with the seat angle fixed and horizontal is probably best. So in many cases as I have already told depending upon the requirement the kind of work being done by the operator we can design the chair or we can customize the chair as per the requirement. So in many cases we may design a chair with a seat angle fixed and horizontal is probably the best. So we can always keep the seat horizontal also instead of giving it an angle of 10 degrees.

The seat slant should be adjustable. So this slant should also or the angle should be adjustable between 0 to 10 degrees.

(Refer Slide Time: 25:10)



Now, head rest. What is the purpose? The purpose is to provide comfort and safety. Headrest must be height adjustable cushioned for comfort. So it must have a cushioning effect here, must have a cushion and it must be adjustable as per the height of the person. Relaxed posture that helps to relieve the pressure on your postural muscles, which can decrease fatigue and increase comfort.

And sometimes while stretching we can place the head on the head rest and relax for sometime because you have already seen that a person changes lot of postures, or sitting postures in an hour. So if we multiply it by 8 hours we can see that the person may have to relax also. So head rest will definitely reduce the fatigue. Now this is a back rest which is also very, very important.

(Refer Slide Time: 26:00)

The back rest must be large enough to cover the entire width of the back, a minimum of 12 inches is recommended for width. So 12 inches is recommended minimum that is a minimum value. Back rest seat pan angle. The angle between the seat pan and chair back should be adjustable when the user is seated with thighs parallel to the floor and legs properly supported vertically. So we can say that the angle must be adjustable we must give the flexibility.

This angle permits the user to sit slightly forward, straight up or recline back depending on the type of computing performed, support needed, and comfort desired. So depending upon the comfort desired or the support required for the back, this must help the operator to fix up the angle as per his requirement. If he wants to sit slightly forward, he must be able to do it. If he wants to sit straight up must be possible, if you want to recline back that must also be possible. So, back rest is important.

(Refer Slide Time: 27:04)

Foot rest must be adjustable does not restrict the leg movement easily. They must be removed if you do not want to use the foot rest as wide as your hips, large enough for the soles of both feet has a nonskid surface made of anti-skidding material, anti-fatigue material. So this is 1 example of the foot rest which is given here and this can be integrated with the design of the chair also. Then we can have an arm rest.

(Refer Slide Time: 27:33)

Arm rest users report enhanced performance including less fatigue, increased comfort, and better endurance with sustained computing. So you can see the advantages of using a arm rest, less fatigue, increased comfort, better endurance with sustained computing. So you are continuously

persistently the person can work if adequate arm rests are provided. Arm rests should be placed at least 18.5 inches apart and made of soft and padded material.

So just general guideline is given between the distance. Arm rest should be placed at least 18.5 inches apart and obviously they must be soft because they have to support the arms and are made by the padded material. An ergonomically designed arm rest should be adjustable vertically and not impair circulation due to direct pressure to contact areas but distribute that load over the broad areas comfortably.

So we must have or must follow these guidelines so they should be adjustable vertically and not impair circulation due to direct pressure to contact areas, but distribute that load over the broad areas comfortably. So the load must be distributed to the broad areas. So it must not be at a point that a load is acting as we have seen the pressure points under the thigh. Now those points must be avoided and the load must be distributed over the wide area. So may be if the arm (()) (29:08) if I am placing my hand on the arm rest like this so the load must be distributed over a wide range of area.

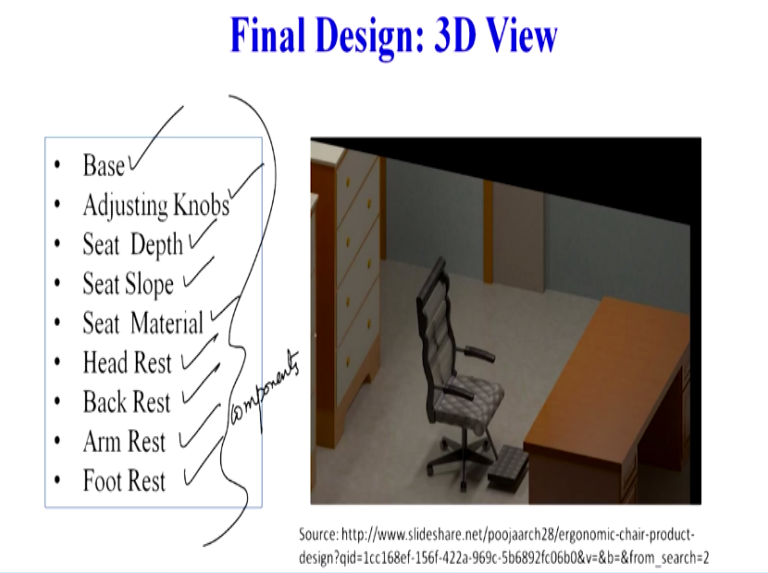
(Refer Slide Time: 29:18)

So the base an ergonomically designed chair has a solid, safe, and stable 5-post chair base. It should be made of strong materials to support up to 5 times the body weight. So this is important. It must be able to support up to 5 times the body and this is a very, very general statement strong

material. So what are strong materials? We must know so it can be made up of metals. There are different types of metals which can easily be casted or forced into these types of shapes or it can be even made up of some plastics.

Some plastics may be usually we use thermosets, thermoplastics in this case. So they can be made in plastic or it can be made in a combination of metal and a plastic. There can be a strong metallic core inside. Then it is covered by a plastic outside or encapsulated in a plastic. The chair base should also be equipped with quality casters to easily or to permit easy maneuvering on office floor surfaces. So the casters is given here. So we may have a flexibility of using the casters also so that you can maneuver the chair from 1 place to another place easily.

(Refer Slide Time: 30:34)



So this is the final design or the 3D view. So we can say that the base has to be designed, adjustable knobs, seat depth, seat slope, seat material, head rest, back rest, arm rest, foot rest. So if we take into account all these components of a chair and design them properly keeping in mind the standard guidelines as per the anthropometric data for a particular geographical reason of the world.

I think the chair that will be designed keeping in mind all these parameters will be ergonomically designed as well as it will provide comfortable working environment or working conditions for the worker. So with this, we conclude the today's session and in next session we will try to take

another case study in which some important part or some important man-machine interaction will be discussed and highlighted and we will try to see that how ergonomic design can help in improving the productivity of the system.