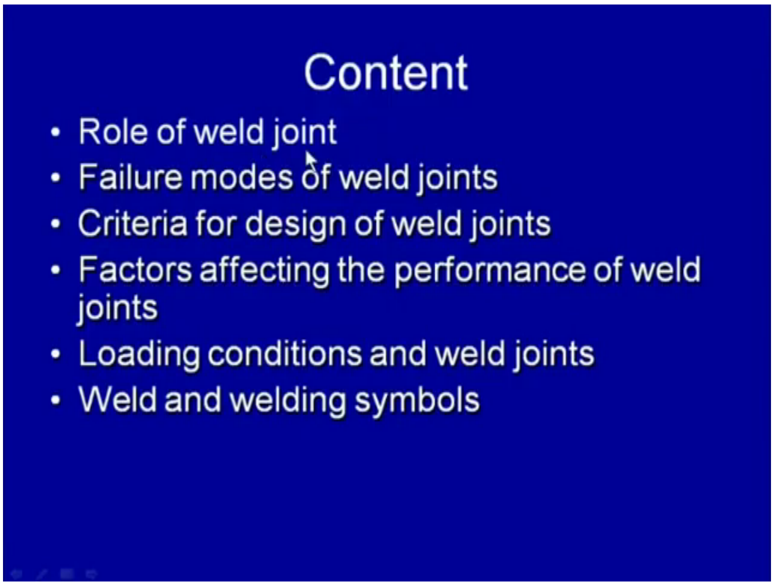
Welding Engineering
Prof. Dr. D. K. Dwivedi
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Module - 6
Design of Weld Joints
Lecture - 1
Introduction

So, in this 40 lecture series on the welding engineering this is the sixth module on the design of the weld joints. In the earlier presentations of the fifth, 5 modules we have talked about the introduction of the welding engineering, the welding power sources, the physics of arc, the welding processes and the when heat is applied for melting the faying surfaces. Then heat flow of the heat flow in the welding; and this is the sixth module in which we will be focusing on the design of the weld joint. This is the first lecture on the design of the weld joint. Here it is mainly about the introduction part of this chapter or of this module in this presentation.

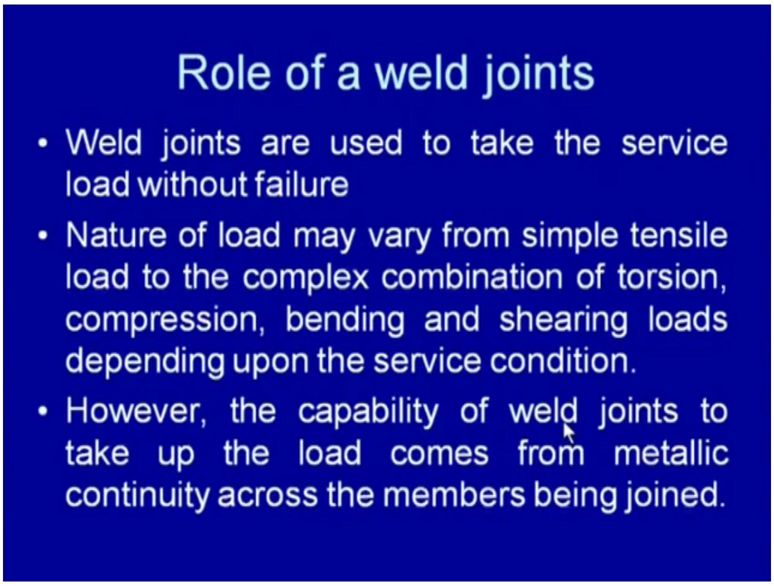
(Refer Slide Time: 01:10)



We will be talking about the role of weld joints, means what are, what we expect from a weld joint to do? Then if the failure of the weld joint is taking place, then what are the ways through which we can understand the joint has failed, so the modes of the failure of the weld joint. Then for design purpose what criteria we can apply for designing weld joints, so that it can perform successfully during the service. What are the factors that affect the performance of the weld joint will be taken up and the different loading conditions, which are normally experienced by the weld joints. How they should be designed to take care of the variety of the loads?

At the end we will also be taking up the weld and the welding symbols, which are very important especially from the fabrication point of view, because through this, through these we try to communicate to the shop floor people that what is expected and what should be developed as far as development of the weld joint is concerned? So, first we will try to see that, what we expect from a weld joint? Means, what is the role of the weld joint?

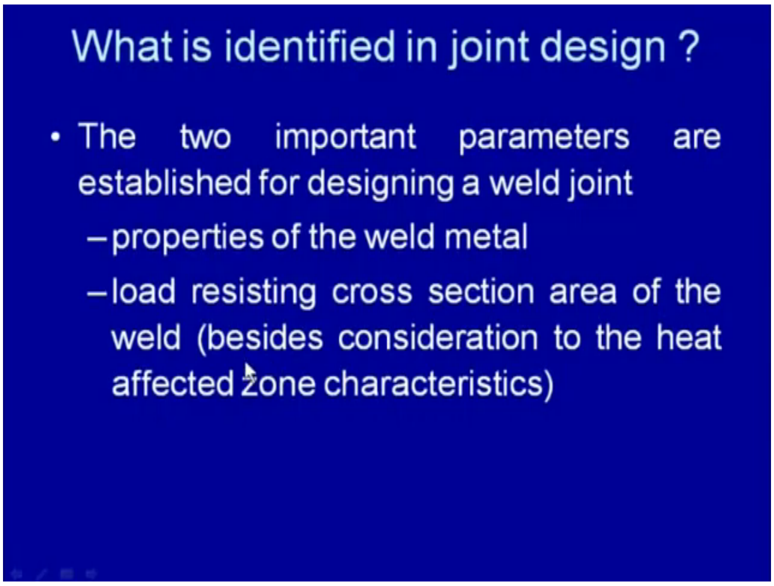
(Refer Slide Time: 02:34)



Weld joints, we know that are mainly used for connecting the two members and the when the two members are connected they are expected to be in particular position with respect to each other. It is expected that the weld joint will transfer the desired service load without failure. So, the nature of the load which under which a joint has to perform that may vary significantly from a simple tensile load to the very complex combination of the torsion compression bending shear loads, depending upon the service conditions. Means weld joint maybe expected to perform successfully under the simple tensile load or combination of the variety of loads depending up on the service conditions.

This capability to carry the service load by the weld joint would will depend upon what kind of the metallic continuity and how the metallic continuity between the two members which have been joined by the welding exists between them? So, the kind of metallic continuity, means what kind of cross sectional area of the weld joint is? What metallic properties it has, so that it can take up the desired service load.

(Refer Slide Time: 03:37)



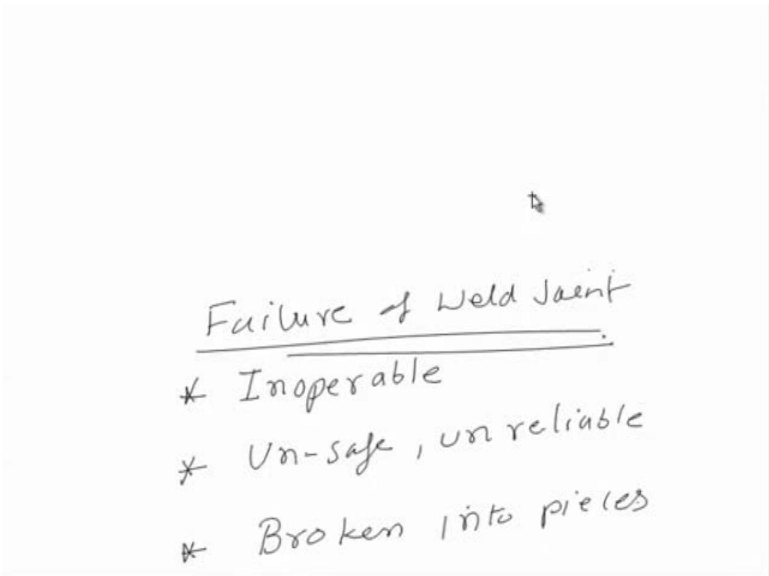
Therefore, the two important parameters are established for designing a weld joint, so that it can perform the desired function during the service; one is the properties of the weld metal. As a properties of the weld metal are established in such a way that it can sustain the service load successfully. The load resisting cross sectional area is also identified, so that it can take up the desired service load, while designing a weld joint apart from the properties of the weld metal, the load resisting cross sectional area of the weld.

We also keep in mind if any deterioration in properties of the region close to the weld joint is taking place. So, means while designing the weld joint any hardening and softening of the heat affected zone is also considered, because many times the failure instead of failure take can take place from the heat affected zone instead of the weld joint. So, that kind of failure mostly occur due to the deterioration or reduction in properties of the heat affected zone, due to the weld thermal cycle experienced by them during the welding. Therefore, weld successful sound design of the weld joint not only considers the properties of the weld metal and load resisting cross sectional area, but the any kind of property variation in any kind of variation in properties of the heat affected zone is also considered.

If the joint is not designed properly, then it can lead to the failure in number of ways. So, as far as the failure of the joint is concerned from the failure analysis point of view, any component when it becomes in operable, we can say that the system has failed or another condition. May be there when the deterioration in the given metals system becomes to deterioration in given metal system increases to such an extent that it can increase the chances of an accident or it is, it can be catastrophic. Means there is risk in application of the component, whose quality has been deteriorated has been deteriorated.

So, such an extent that accident can take place, so it is not safe to use the component, so in that case also we consider that the system has failed or third case, when we can consider the system. That system has failed when it is a it has broken into the pieces. So, typically what we say that, a weld joint or a system has failed when, so the one point one when be consider that the component has failed is…

(Refer Slide Time: 06:25)

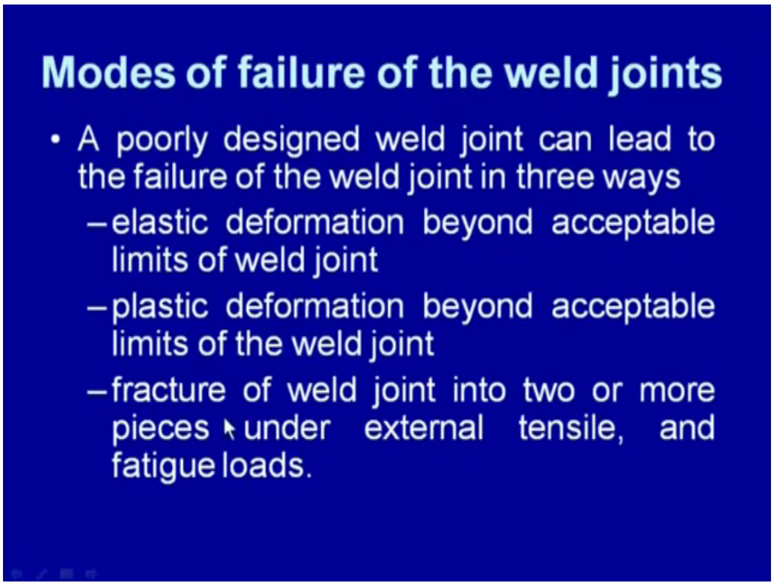


That the system of the metallic component or the weld joint is inoperable means the component is not able to perform the desired function or the use of the or the use of the component is not safe, because it has deteriorated to such an extent that it can lead to the significant possibility of the failure during the service. Means it can increase the risk of the accidents, so it is unsafe and unreliable to use it is unreliable to use the component. Then also we consider that the component has failed. Third possibility is that when the metallic system is broken into the pieces broken into the pieces.

So, these are the three possibilities, when we consider that a system of the metallic component has failed. So, these can be applied to the weld joints, also when the weld joint under the external service conditions external loading conditions deforms either elastically or plastically to such an extent; that it is not able to perform the intended function. Then we consider that the weld joint has failed the second possibility is that when the deterioration in the weld joint take place to such an extent; that it is further application is unsafe and unreliable.

Then also we can consider that joint has failed and this may be in form of the significant growth of the cracks in the weld joint or the third possibility. When in under the external loading due to or the over loading or accidental loads the component of the weld joint or the weld joint itself breaks into the pieces, so that is the third case. So, failure of the weld joint can be considered under these three conditions; one when the joint is inoperable. Means it is, it is not in position to perform the intended function it a or second its unsafe or third it is broken into the pieces.

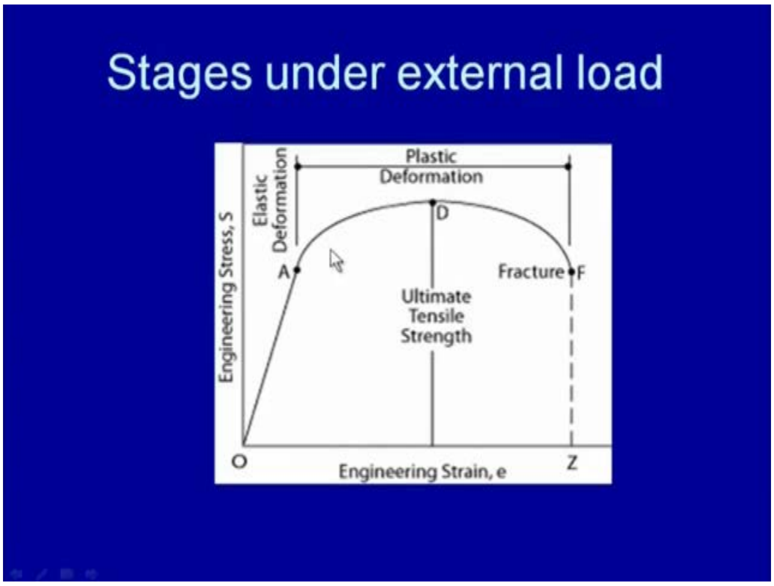
(Refer Slide Time: 08:50)



So, accordingly a poorly designed weld joint can lead to the failure of the weld joint in three ways one elastic deformation beyond the acceptable limits of the joint. So, in this case, they will not be any fracture, but the deformation of deformation takes place to elastic deformation occurs to such an extent, that it makes the system of the joint inoperable. This is the second possibility when the plastic deformation under the external loading goes beyond the acceptable limit. This can also make the system in operable or unsafe for further application.

This is a third situation where under the external loading the system of the weld joint breaks into the two or more pieces under the tensile or the fatigue loading conditions. So, these are the three ways through which failure of the weld joint can occur when one when the elastic deformation occurs beyond the acceptable limit second, when the plastic deformation goes beyond the acceptable limits. Third when the fracture of the weld joint take place. To understand this in better way we can use this typical engineering stress strain diagram say when external load is applied.

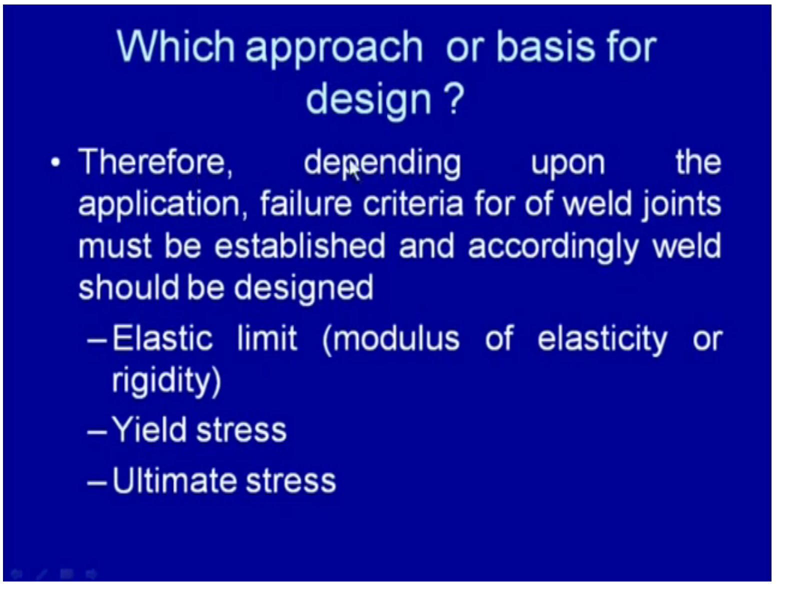
(Refer Slide Time: 10:11)



So, the application of the external load within the, within the limits applies increases the stresses within the elastic limit level. In this situation the deformation will be very limited. When the load is removed the system gets back to the original size and shape, but the application of load beyond on this limit causes the permanent or the plastic deformation. This plastic deformation may if goes beyond the acceptable limits, then also the failure of the component can take place. Third possibility when the load external load is too high to have the stresses, so that the fracture occurs, so that this is the third situation.

So, when the loading is in this range the first kind of the deformation will be occurring and when loading is in this band of the engineering stress diagram. Then the plastic deformation will be occurring means failure due to the plastic deformation will be taking place. When load goes further on the higher side then the fracture will be leading to the failure of the weld joint. So, depending upon the mode of the failure or the condition when we can we consider that the joint has failed, whether the deformation goes beyond the acceptable limits or the plastic deformation goes beyond the acceptable limits or the complete fracture of the components takes place. We need to use the different criteria or the approach for designing a weld joint.

(Refer Slide Time: 11:34)

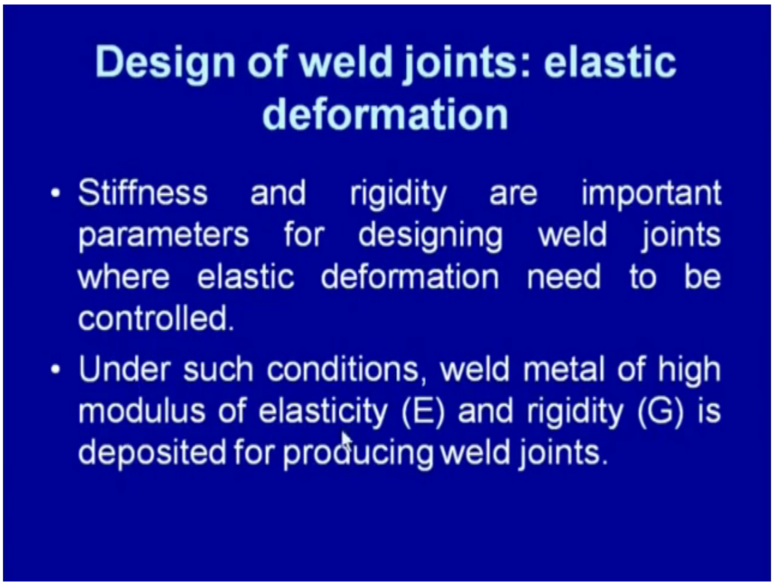


Therefore, the depending up on the application failure criteria for the weld joint must be established and accordingly weld joints should be designed. So, in some cases where minor elastic deformation is allowed within limits, then the if the failure criteria is such that the elastic deformation only within certain limits is permitted. Then the, then the weld joints should will be designed on the basis of modulus of elasticity or the rigidity.

If the criteria is that we want to have the plastic deformation within certain limit or we want to avoid the deformation. Then the yield strength yield stress criteria is used and if we want to avoid the fracture, then the ultimate stress criteria is used. So, depending up on the conditions or the way by which the failure of the weld joint can take place, we need to see whether the elastic deformation beyond the limit is a criteria.

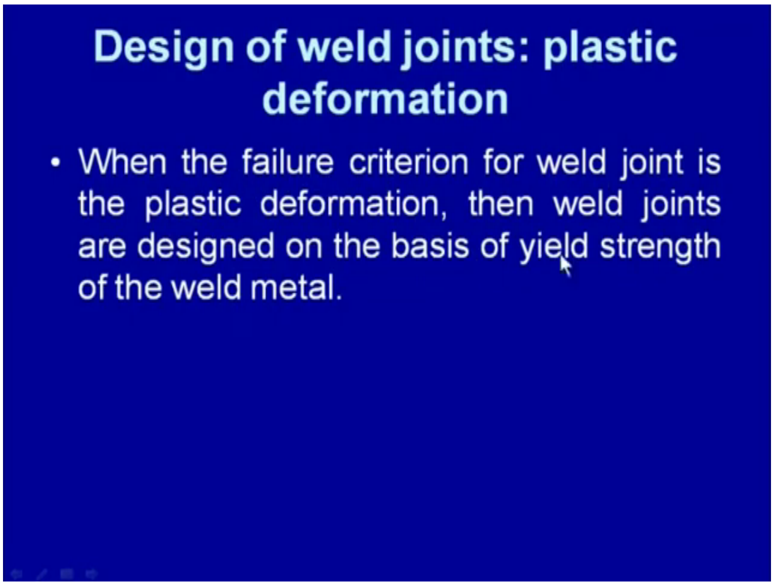
So, for this purpose modulus of elasticity or rigidity as a modulus of elasticity or rigidity is are used as a design criteria or if the plastic deformation within limits is a required means is acceptable. Then the yield stress is used or otherwise if the, if the criteria is to avoid the fracture of the weld joints, then ultimate stress is used as a design criteria, so the design of the weld joint based on the elastic deformation for this situation.

(Refer Slide Time: 13:14)



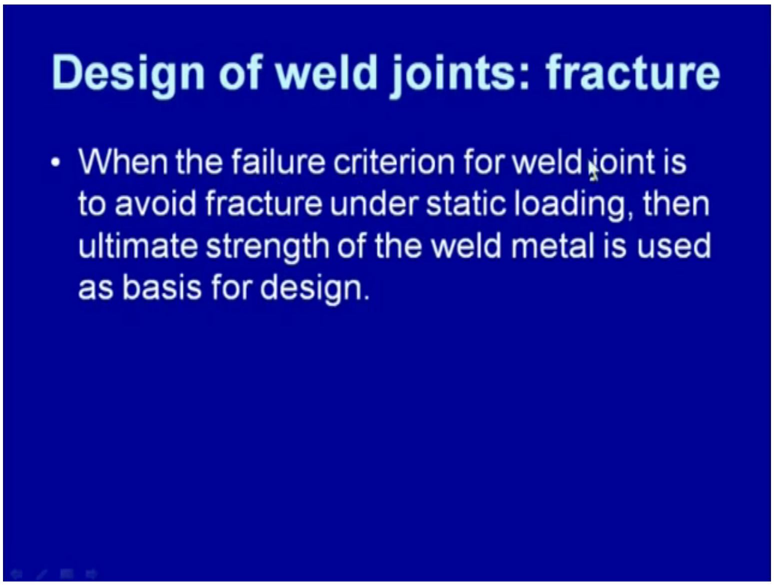
The stiffness and the rigidity are the important parameters for designing the weld joints where elastic deformation need to be controlled. So, if the if it is required to control the elastic deformation within the limits, then the stiffness and the rigidity becomes the important criteria for designing the weld joint. Under such conditions weld metal of the high modulus of elasticity and high modulus of rigidity is used for producing the weld joint. When the and the design of the weld joint, when the plastic deformation is the criteria for designing the weld joint, then when the failure criteria of the for the weld joint is the plastic deformation.

(Refer Slide Time: 13:54)



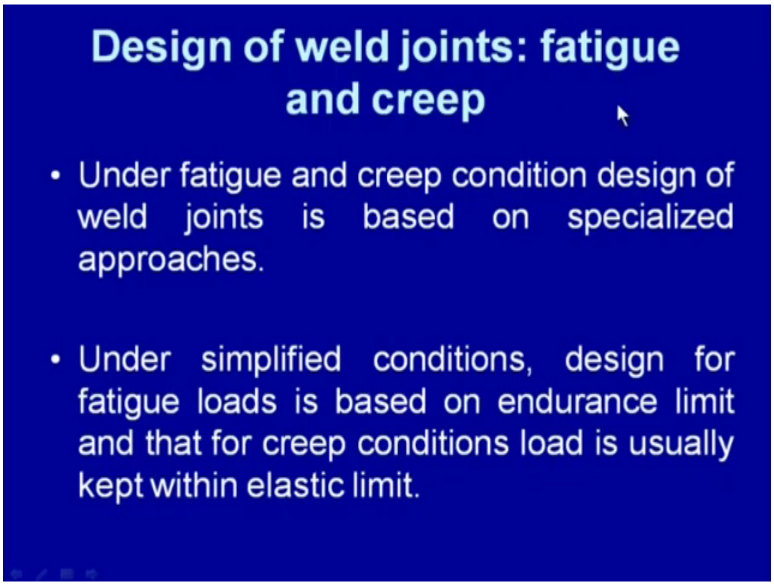
Then the weld joints are designed on the basis of the yield strength of the weld metal and the third case when the fracture is the failure criteria.

(Refer Slide Time: 14:09)



Means when the failure criteria for the weld joint is to avoid the fracture under the static loading conditions. Then the ultimate strength of the weld metal is uses as a basis for the design the, for designing the weld joints for fatigue loading and for creep conditions.

(Refer Slide Time: 14:24)

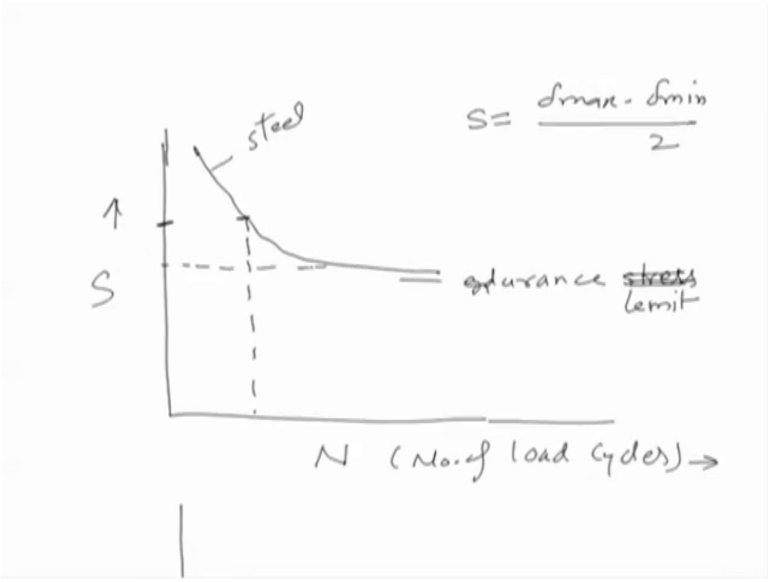


These are the very specialized properties and we need to identify the kind of the life which is expected from the weld joint during the service under the fatigue and the creep conditions design of the weld joint is based on the specialized approaches. For example, the design of the weld joint will be for the unlimited life or will be for say 10 to the power 5 number of cycles or for 10 to the power number of 6 number of load cycles.

Say for fatigue loading conditions according to that, we decide the load according to the fatigue loads. We decide whether the things means the weld joint will be designed on the basis of the endurance limit or in some other way under the simplified conditions design for the fatigue load is based on the endurance limit. So, this is the limit of the stress limit of the maximum stress or the stress amplitude below, which there is no failure of the component under the fatigue load conditions.

While the design for the creep conditions the load is usually kept within the elastic limit, but further for this case when you we need, see what is the allowable the deformation, which is which can be sued for identifying the creep life of the component? To understand this in better way, we can see this diagram here.

(Refer Slide Time: 15:59)

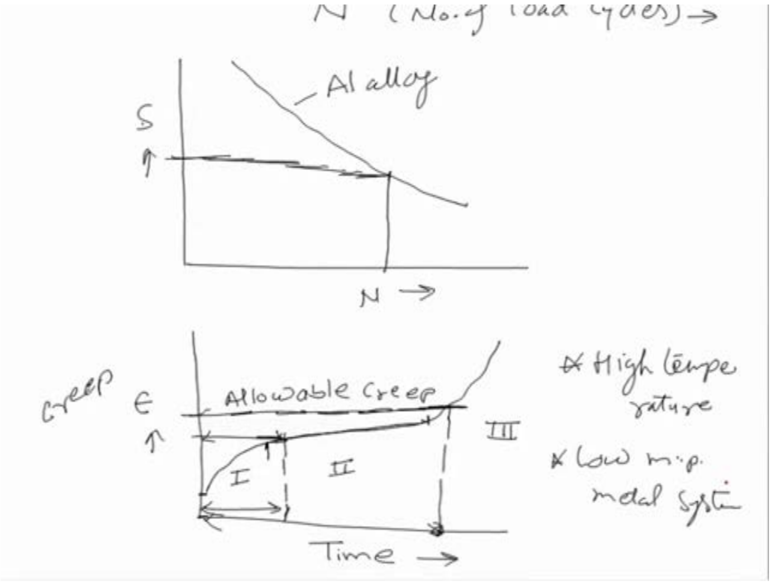


For the fatigue life basically here, basically we use the S N curve for the steels. This S N curve, this is log scale here. It shows that with the reduction in this stress amplitude the number of cycles increases and the here N stands for the number of load cycles and S is used in number of ways. It can be stress range it maximum stress or the stress amplitude it is common to use. S for the stress amplitude and then, that indicates the average of the stress range that is, so S stands for sigma max maximum stress minus minimum stress divided by 2. So, it is half of the stress range, it can be maximum stress also.

There are different ways through which this means S can be in different forms stress amplitude stress strange or the maximum stress. If we see that as the number of as the stress amplitude is decreased the number of cycles required for failure increases, so here say for this is the stress amplitude. Then this will be the number of cycles required for failure if we keep on decreasing the stress amplitude then here the number of cycles required for failure will keep on increasing. This is the limit of the stress amplitude below, which the no failure will be occurring under the fatigue load conditions.

So, this is the tip schematic diagram showing the S N curve for the steels while in case of the aluminum alloys. No such kind of the stress amplitude limit is obtained, so this limit is called endurance limit or the limit of the stress amplitude below, which there endurance limit. This is so, this is the stress amplitude below which the component can perform for the infinite number of the cycles. So, means it will the component will not fail under the fatigue conditions.

(Refer Slide Time: 18:32)



If we see the same diagram for the non ferrous metal systems S curve in the y axis and S in the y axis and N in the x axis. Then we for typical system like aluminum, we find a continuous aluminum alloys. We find a continuously decreasing trend line, so this suggest that if we keep on decreasing the stress amplitude the number of cycles required for failure. We will keep on increasing and there is no stress limit for which the life will be infinite or there would not be failure under the fatigue conditions.

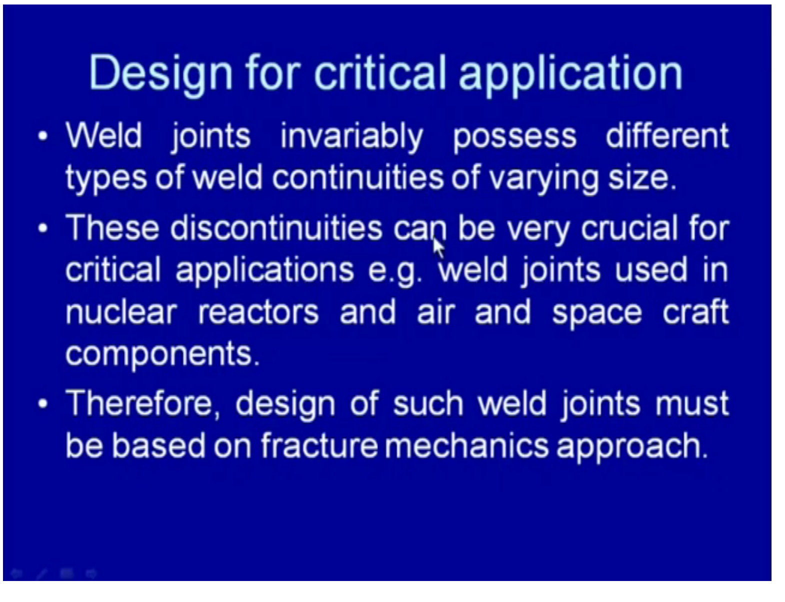
So, for designing the weld joint it becomes important that we identify the number of cycles for which life is required. So, according to that we can identify the stress amplitude which for which a weld joint can be subjected. So, whether it is so for the non ferrous metal systems, it becomes important to identify that how many cycles weld joint or the components should withstand? Based on that, we try to see the allowable stress range or the allowable stress amplitude.

While in case of the creep conditions the variation creep, we need to see the creep curve where we see in x axis, we have time and in y axis we have the creep. That is the strain creep is there in form of strain, so and this shows the typical variation in the strain like this. So, this is the first phase when the decreasing trend is observed as a function of the time in the creep. This is the study, this is the this is the portion corresponding with second stage one, stage two and stage three of the creep. In the stage one, the creep occurs at the decreasing rate. In the stage two creep occurs at the constant rate and the stage three creep takes place at the increasing rate.

So, based on the life, we try to see that the creep life is decided on the basis of the time required for reaching a particular level of the strain. So, if the allowable strain means the allowable change in dimension is this much this is the allowable limit of the creep strength. then the creep life will be given by this time value and if the allowable creep is allowable creep strain, this is the allowable creep deciding the creep life corresponding to this time value. if the allowable creep strain is on the lower side say just this much. then the failure of the component under the creep conditions will be taking place just after this much time.

So, depending upon the allowable creep value the creep life will be decided and normally the component is up subjected to the load lesser than the elastic stress limit. But even then even when the component is subjected to the stress levels below the elastic stress limit the creep means that is the creep or deformation continue to take place as a function of time. This kind of behavior is specially observed under the high temperature conditions and specially in the metal systems, which are of the low melting point.

(Refer Slide Time: 23:02)

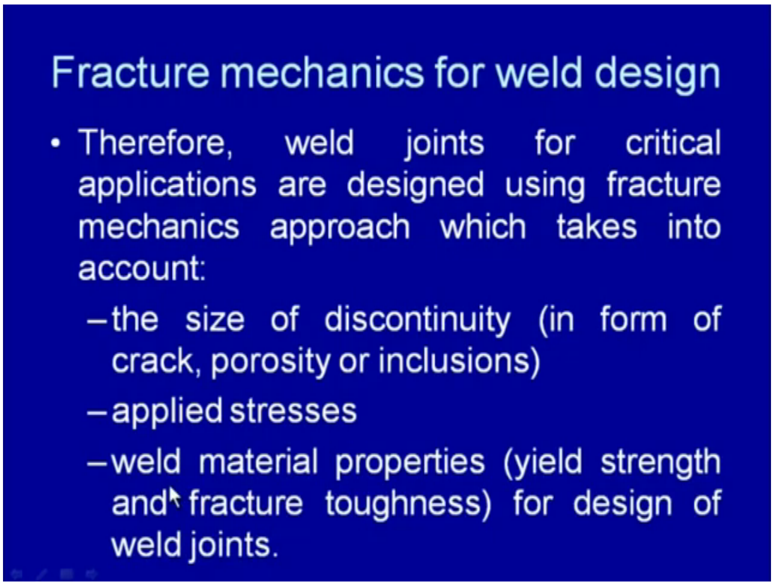


So, low melting point metal systems, this kind of behavior is normally observed. So, the creep and the fatigue are the very specialized properties in which are and for which design is based on after the thorough consideration of the working conditions. The various properties which are important and decide the life of the component or the weld joint under the fatigue and the creep conditions.

Now, we will see the design for design of the weld joint for the critical applications. We know that the weld joints are invariably produced with the discontinuities of one or other kind. However, the size of these discontinuities may vary significantly from very small in size of the few microns to the few millimeters. So, due because of the presence of these discontinuities in the weld joint, it becomes important that these discontinuities are kept in mind, when the weld joint is designed conventionally the design is not based on weld joint design is not based on the presence of these discontinuities.

Means the presence of these discontinuities is not considered in conventional design of the weld joint. Therefore, for critical applications the design of the weld joint should consider the presence of these various discontinuities, which are present in the weld joint in the different sizes. These discontinuities can be very crucial for the critical applications, specially in the case when say nuclear reactors and the air space and the aircraft component.

(Refer Slide Time: 24:57)

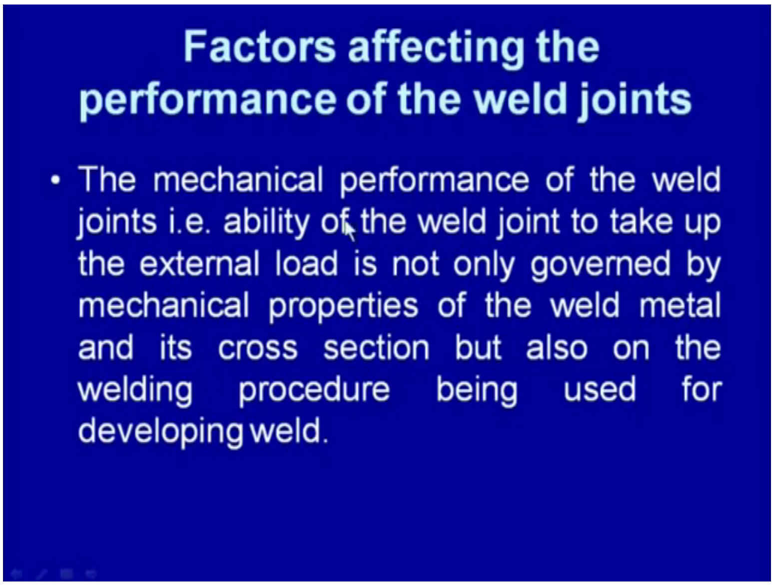


Therefore, design of the such joint must be based on the fracture mechanics approach conventional design approach of the weld joints does not consider the presence of these discontinuities, but when we consider the fracture mechanics approach for designing a weld joint. Then we take care of the presence of the discontinuities in the weld joint material properties and the external applied stresses.

Therefore, weld joint for the critical applications are designed using the fracture mechanics approach, which takes care of the size of the discontinuity, which is present in form of crack porosity or the inclusions. So, this is very important aspect that it assumes that it can take care of at the design stage that what is the size of the discontinuity that can be allowable. So, the discontinuities of the smaller size can always be tolerated. If the larger size discontinuities have been taken care of at the design stage, so means in that case the size of discontinuity forms in an important parameter in the design of weld joint, using the fracture mechanics approach.

Another important thing that it considers the applied stress for which the weld joint is to be designed and at the same time it also considers the weld material properties, like yield strength and the fracture toughness, which indicates this fracture. Toughness indicates resistance to the fracture of the material, means resistance to the crack propagation crack nucleation and its propagation for designing of the weld joint. So, that the important aspect related with the design of the weld joint using the fracture mechanics approach for critical applications is the consideration of the consideration of the size of the discontinuities present in the weld joint, which can be present in the weld joint.

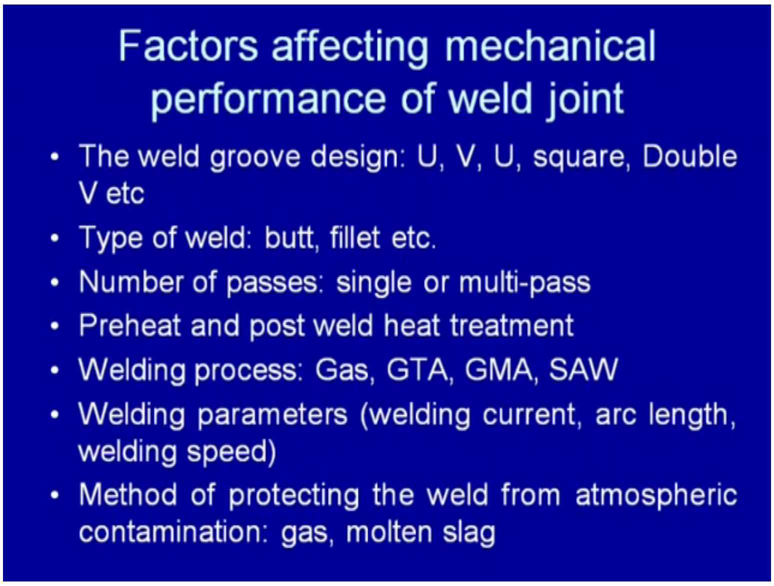
(Refer Slide Time: 27:17)



The use of the weld material properties especially those which are indicating the resistance to the fracture and the resistance to the deformation apart from this externally applied stresses are also considered in design of the weld joint. We know that the, we can we can identify that the certain properties which are desired in the weld joint. The weld cross sectional area which is to be made, but apart from these two parameters of the design of the weld joint, even if a the weld is made a properly according to the requirement of the weld joint.

The mechanical performance of the weld joint can vary significantly depending up on the procedure, which has been used for development of the weld joint. So, the mechanical performance of the weld joint that is indicating the ability of the weld joint to take up the external load in not only governed by the mechanical properties of the weld joint. Its cross sectional area, but also it depends significantly on the procedure being used for developing the weld. So, it is not sufficient to consider only the mechanical properties of the weld joint and its cross sectional area, but we need to see that very properly considered the welding procedure is established for developing the weld joint.

(Refer Slide Time: 28:43)



Because if the very carelessly welding procedure is established, then it can adversely affect the properties of the regions close to the weld region. That is the heat affected zone and deterioration in the properties of the heat affected zone can become a source of the failure in under very premature conditions. Therefore, it becomes important to see what are the other then the weld metal properties and the load resisting cross sectional area of the weld joint. What are the factors that can affect the performance specially mechanical performance of the weld joint?

The first one like the kind of weld design which is being used, so what kind of the weld groove design is being used? It is U V, single U, single V, double U, double V, square J etcetera, because these designs will be affecting the volume of the weld metal to be deposited or the amount of heat, which will be supplied during the welding. So, the minimum amount of heat weld metal will be required by the square groove design as and then the J. Thereafter, U and then V. So, similarly, single V joint will require almost double of the weld metal as compared to the double V joint especially in case of the thick plates.

So, depending up on the volume of the weld metal, which is to be deposited we will require to supply the different amount of the heat greater application of heat will be deteriorating the performance mechanical performance of the weld joint. Because higher heat input frequently causes the coarse grain structure in the heat affected zone. In the weld region which in turn deteriorates the mechanical performance of the weld joints. So, the load carrying capacity of the weld joint will be decreased. Then the type of the weld in general, but weld joints offer the greater load carrying capacity as compared to the fillet weld, because of because the fillet welds offer the inherently offer the stress razors.

Specially, in the area of the toe of the weld, so due to the higher stress consideration present in the fillet welds, the butt welds generally offers for the better mechanical performance as compared to the fillet weld. Then the number of passes in general the multi pass welds, especially in case of the thick plates welding results in the better mechanical performance as compared to the single pass weld. Because multi pass welding results in the refinement of the grain structure in the of the weld metal, which was deposited in the earlier passes. So, the bead tempering keeps on happening in case of the multi passes, multi pass welding which refines the structure and improves the mechanical properties of the weld joint preheat.

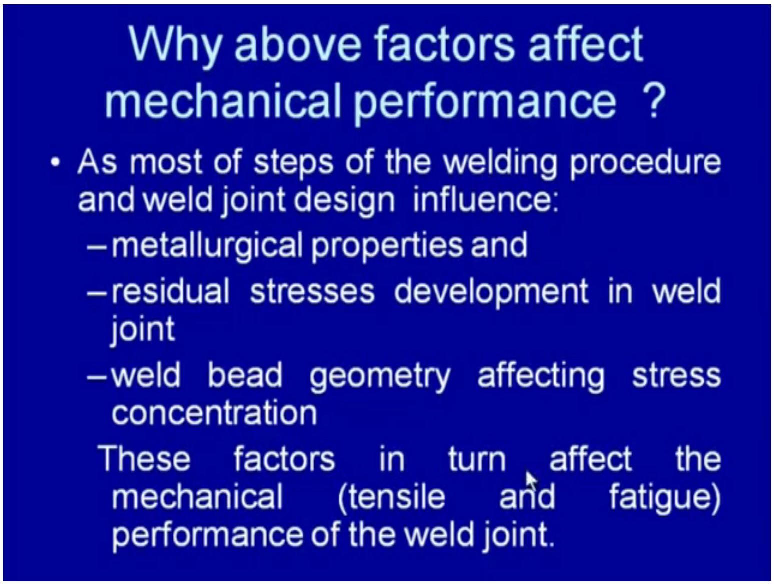
The post weld heat treatment also affects the mechanical performance of the weld joint. In general the post weld heat treatment like normalizing improves the mechanical properties and the hardening. Tempering can also be done to achieve the desired set of the properties the preheating can improve the mechanical properties. Especially in case of the hardenable steel, where otherwise there will be more cracking tendency in the heat affected zone due to the high hardenability. The welding processes like gas welding GTA welding GMAW and the SAW, the particular process affects the properties of the weld joint significantly in two ways; one is the kind of cleanliness of the weld, which is produces and the second the kind of heat input, which is used for developing the weld joint.

In general more is the but cleaner is the weld and lower is the heat input results in the best mechanical properties as compared to the other welding processes. So, if we compare these four processes GTAW offers the cleanest weld and the using and the weld is developed using the minimum heat input. That is why the best kind of mechanical properties are obtained using the GTAW weld while the SAW and the gas welding processes results in the higher heat input. The weld with the lot of inclusions and the porosity with the impurities results in the poor mechanical properties, so greater the welding parameters like the use of the current arc voltage and the welding speed.

So, we know that the combination of these welding parameters decides the net heat input. If the heat net heat input is on the higher side, then the properties of the weld joint mechanical properties of the weld joint are in general poor as compared to the case when the lower heat higher heat input is used. So, means higher net heat input in general results in the poor mechanical properties due to the lower cooling rate and the coarser grain structure. The method of protecting the weld from the atmospheric contamination, so if the very inert and gases are used using like the helium and the argon for protecting the weld pool from the, for protecting the weld pool from the atmospheric gases.

Then the properties of the weld joint will be much better than the case, when the self shielded arc is used or the shielded metal arc welding is used where the inert gas inactive gases are supplied by the thermal decomposition of the flux. So, depending up on the kind of the approach which is being used for protecting the weld pool from the atmospheric contamination different qualities of the weld and the different mechanical performance of the weld can be obtained. So, just to summarize the affect of the above factors on the mechanical performance of the weld joint, we can see the most of the above factors or the steps of the welding procedure.

(Refer Slide Time: 34:24)

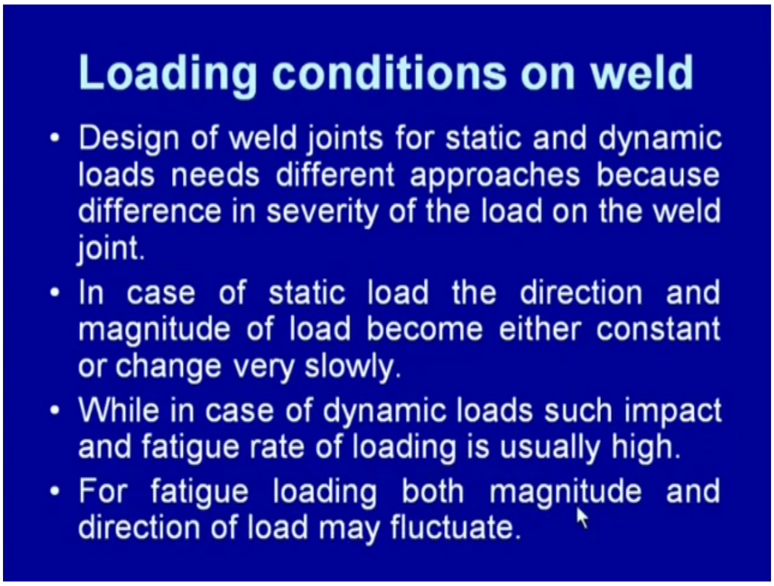


The weld joint affect the following aspect and the above factors, which have been described in the previous slide will be affecting to the metallurgical properties will be affect and the development of the residual stresses in the weld joint. The weld bead geometry which in turn will be deciding the stress concentration at the two of the weld. So, because of due to the effect of the welding procedure on these three aspects that is the metallurgical properties residual stress development.

The weld bead geometry are the mechanical performance of the weld joint is significantly affected, due to the various procedural steps, which are used for development of the weld joint. These factors in turn affect the mechanical performance under the tensile and the fatigue load conditions. Significantly, the weld joints can be subjected to the variety of the loading conditions.

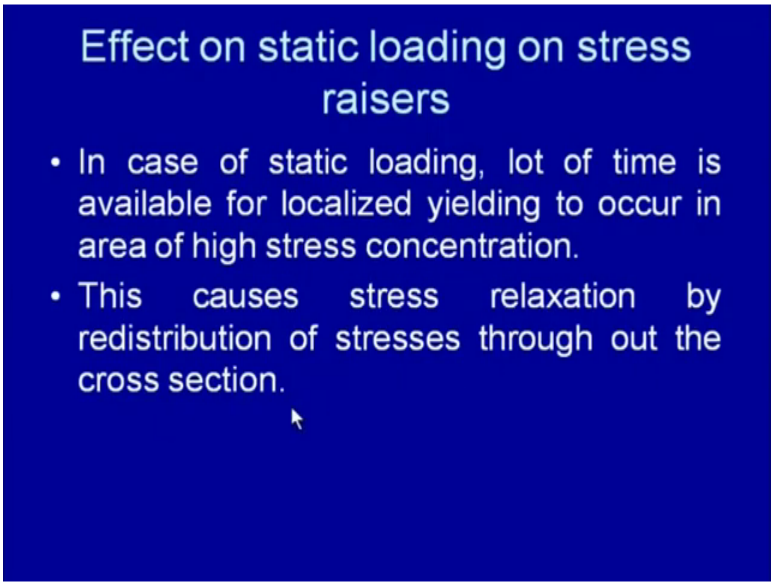
Like the design of the weld joint for a static and the dynamic loading. Accordingly, the different approaches are required for designing the weld joint, because of the difference in severity of the load on the weld joint. For a given weld joint the severity of the loading can be different for the static and the dynamic conditions with a given kind of the stress razor in the weld joint.

(Refer Slide Time: 35:28)



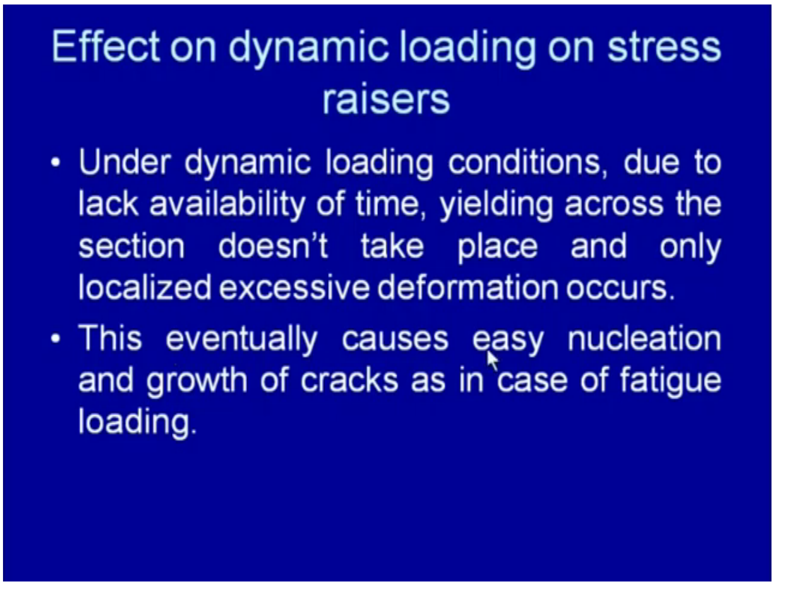
If the low if the joint is subjected to the static loading, then the severity of the stress razor will not be that high, as it can be in case of the dynamic loading. So, because of this the design of the weld joint for a static and dynamic loading, needs the different approaches because of the difference in severity of the load on the weld joint. In case of the static loading the because the in because in case of the static load, the direction and the magnitude of the load becomes either constant or it changes very slowly.

(Refer Slide Time: 36:50)



While in case of the dynamic loads such as impact and the fatigue loading the rate of load is very high. For the fatigue loading both magnitude and the direction may fluctuate significantly during the loading. So, in case of the static loading where magnitude is either constant or it changes very slowly lot of time is available for the localized yielding to occur in the areas of the high stress concentration. Because of this localized yielding possibility, this results in the stress relaxation by redistribution of the stresses throughout the cross section.

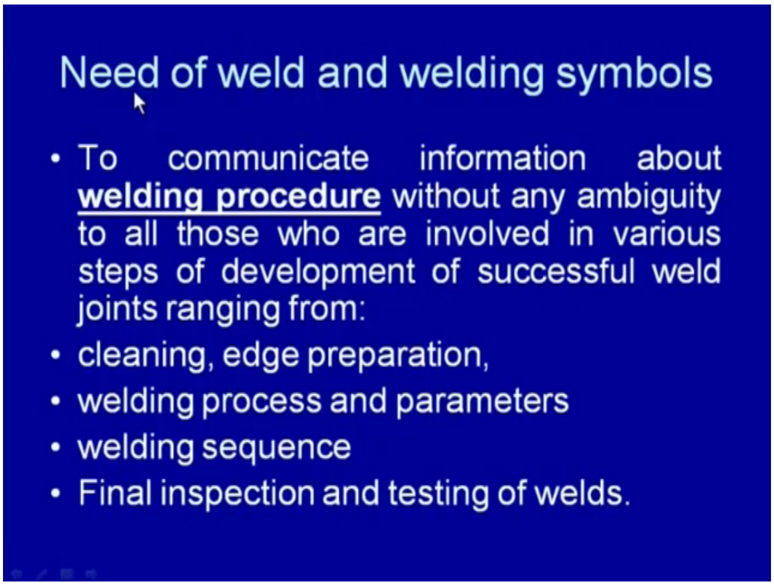
(Refer Slide Time: 37:18)



While in case of the dynamic loading conditions, due to the lack of availability of time because the rate of loading is high, the yielding across the cross section does not takes place and only localized excessive deformation occurs. This localized excessive deformation eventually causes the easy nucleation and the growth of crack as in case of the fatigue loading conditions. Means if the stress razors are present in case of the static loading, the nucleation of the crack and its growth is resisted significantly, because the yielding throughout the cross section can take place very gradually.

While this kind of yielding does not take place under the dynamic loading conditions, due to the high rate of loading. Due to the absence of such uniform loading across the cross section very localized excessive deformation is experienced, in the areas where stress razors are present. Because of this very easy nucleation and growth of crack takes place under the dynamic loading conditions.

(Refer Slide Time: 38:30)

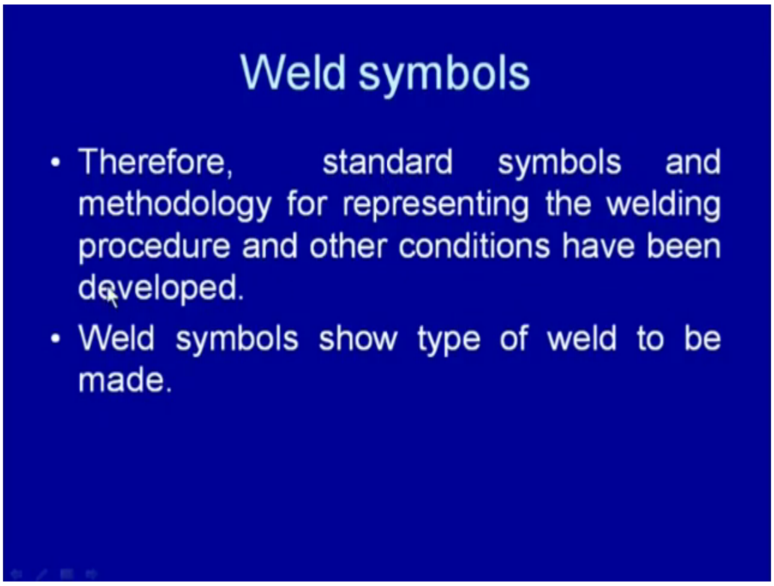


Now, we will be taking up the weld and the welding symbols. We know that if the weld joints need to be developed in the shop floor, then it is required that the desired information is provided to the shop floor people without ambiguity. So, that they can develop, they can use the suitable type of the edge preparation and they can use the suitable the welding process and develop the weld joint in the required sizes.

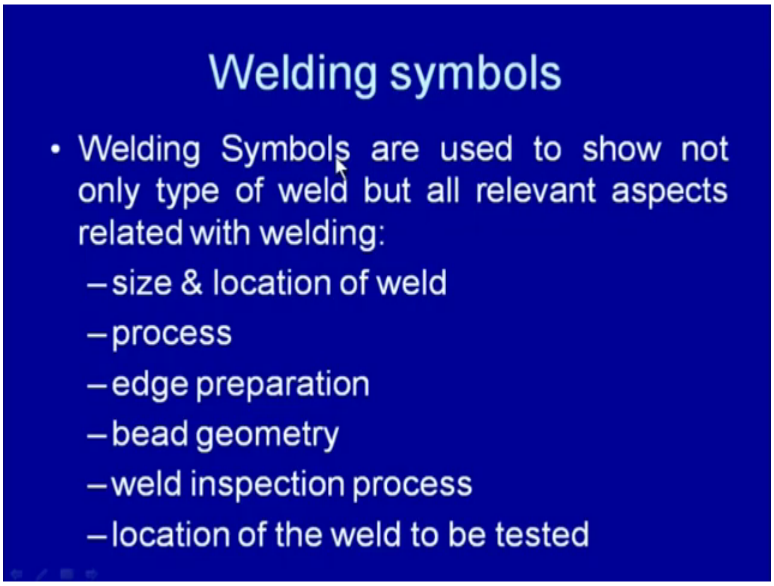
The lengths at the desired location and in order to communicate the information about the welding procedure without any ambiguity to all those people, who are involved in various stages of the development of the weld joint. It is important that they are given a proper information in respect of the cleaning procedure to be used kind of the edge preparation to be used. The welding process and parameters that are to be used welding sequence and the kind of inspection and the type of inspection of the weld joint to be used.

For this purpose very standard procedure of the weld symbols are used. We can see here there the we use the two types of the symbols one is weld symbol. Another is welding symbol weld symbol mainly indicates, what type of the weld is to be made? While the welding symbol shows all relevant information including the type of weld, welding process, the location of the weld number of weld pitch of the welds size of the weld groove angles etcetera. So, the weld symbols are important, but the welding symbols give the complete information about the location and all relevant information.

(Refer Slide Time: 40:19)



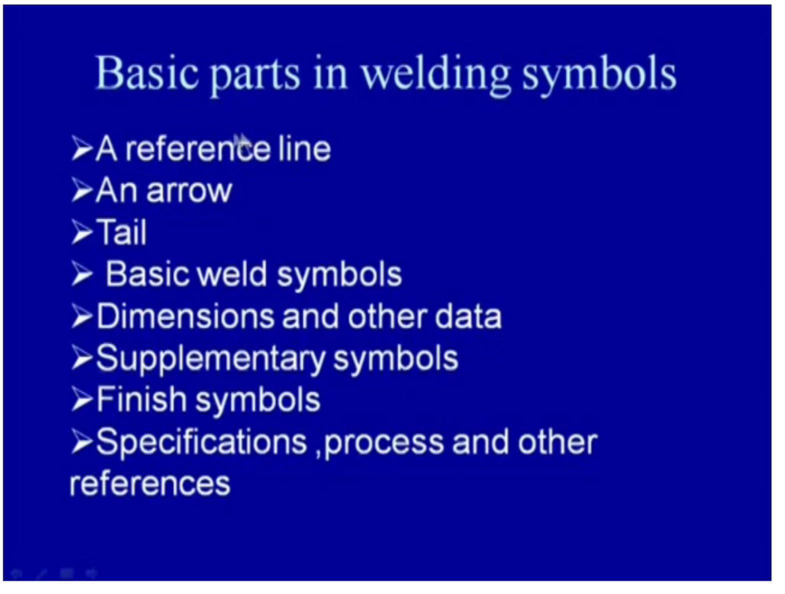
(Refer Slide Time: 40:35)



Therefore, standard symbols and the methodology for representing the welding procedure and other conditions have been developed welding weld symbols, show the type of the weld which is to be made.

The welding symbols are used to show not only the type of weld, which is to be made. But all the relevant aspects related with the welding, such as the size and the location where weld is to be made. The welding process to be used the what type of edge preparation is to be used like square groove v groove. Their corresponding angles and the type of weld geometry to be obtained the kind of finish, which is to be obtained the welding inspection processes to be used. The locations which are locations, which are to be inspected and the areas where will be weld will be made. The weld whether weld will be made in the field or in the shop floor, so all relevant information's related with the development of the welding is provided through the welding symbols.

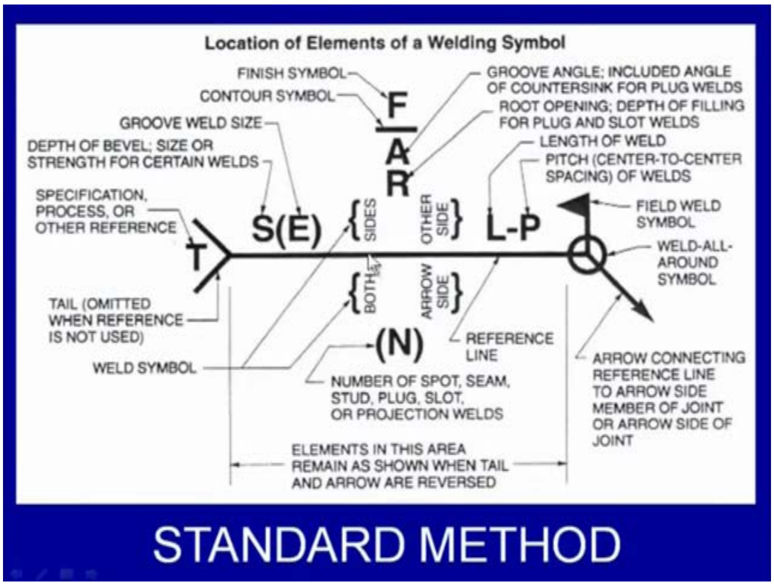
(Refer Slide Time: 41:32)



The important parts which are there, which are used to show the very suspects related with the welding symbols are one reference line, which is basically a horizontal line, and then an arrow line which indicates where weld is to be made. And then there is a tail which indicates that what type of weld is to be made like the full penetration weld, partial penetration, partial penetration weld or the which type of the welding process is to be used, and what are the specification at the parameters of the welding which are to be used then.

Apart from this shows a basic welding symbols, which will be showing the type of weld which is to be made and the dimensions of the weld and the pitch of the weld; means the welding and dimensions and other data related with the weld to be made, then the supplementary information like the kind of the control kind of finish groove angle and the pitch location where weld is to be made and finish symbols the specification of process. The other references are provided with the help of the weld symbol. This diagram shows schematically, the various elements which are shown with the help of the standard.

(Refer Slide Time: 42:46)



Weld symbol method and here we can say we have one horizontal line this is called reference line. Then we have one arrow line; this arrow line shows that the location where weld is to be made this circle at the junction of the reference line. The arrow line shows the all around weld is to be made. Then this flag indicates that the weld is to be made in the field. Then here, this then in both the sides depending upon the location where weld is to be made.

The below the reference line the information is given regarding the weld to be made in the arrow side and the above the reference line show the information about the weld, which are to be made on the opposite side of the arrow. That is the other side where weld is to be made. Here if we see, in both the sides we have the information about the size of the weld which is to be made. So, here we will be basically giving information about that basic weld symbol, which will be made here this is basic weld symbol, which will be made for the arrow side weld.

Here basic weld symbol will be made for other side weld and in both the sides means before the weld symbol in the left side will be mentioning about the size of the weld to be made. The pitch of the weld to be made and then here this l and p indicates the length of the weld, which is to be made and this p shows the pitch of the weld. Means center to center spacing of the weld and then the other information like the means just bellow this the weld symbol.

We have the number spots seams stud etcetera that are to be made. Then we have tail where specification about the process. The kind of weld which is to be made and some other special information regarding the inspection, if required then that will be provided. Here this s indicates the size of the in the left side of the weld symbol. We will be having the kind of size of the weld, which is to be made or the strength for the certain weld is mentioned. Then the groove weld size is made in bracket and these are the different characteristics of the weld like the top one indicates the finish symbol.

Like it will be the machined or the ground finished, then the contour this straight line shows that the flat means all that weld reinforcement is removed. So, the weld contour symbol is there and then we have this r for the root opening or this is for the root opening or the depth of the filling for the plug and the slot weld. Here a stands for the groove angle, which is to be used, so this is how the different information are provided with the help of the weld symbol. So, in the next presentation with the help of suitable example we will try to see that, how the welding symbol can be effectively used to give the information to the shop floor people for development of the weld joint?

So, in this presentation now I will try to conclude things which have been covered. So, far in this presentation mainly we have talked about the different modes of the failure for the weld joint. The way by which the criteria that can be used for designing the weld joints and we have also seen that what precaution can be taken for designing the weld joint for the critical applications. We have also at the end of this presentations saw that what are the weld symbols. The welding symbols and how these can be presented to communicate, the information for the shop floor to the shop floor people for development of the weld joint.

So, thank you for your attention.