

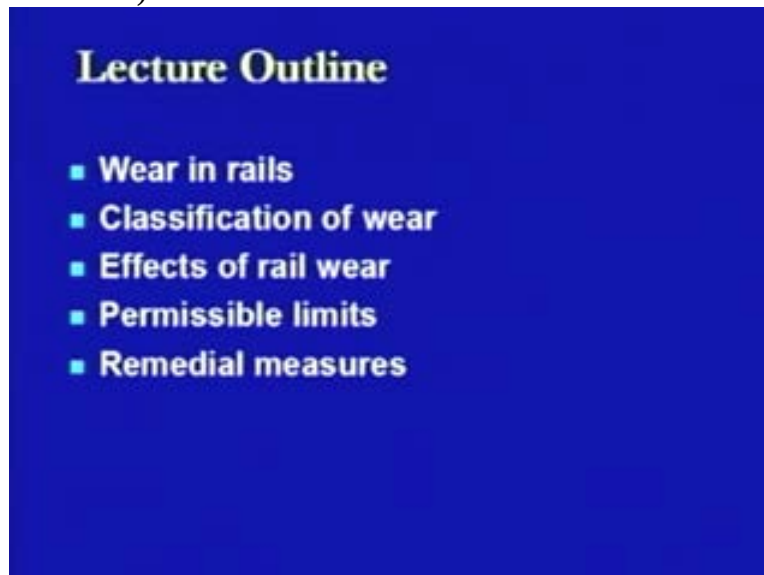
Transport Engineering-II
Dr Rajat Rastogi
Department of Civil Engineering
Indian Institute of Technology - Roorkee

Lecture - 9
Wears and Failures in Rails

Dear students, we are again in the course material of transportation engineering 2. So far we have discussed about the different aspects of railway engineering; we have looked at the permanent way, we have looked at the history of the Indian railways, we have looked at the stresses, we have looked at the resistances being offered by the track, the tractive efforts or the holding powers required for the locomotives. We have also looked at the rail sections; the type of the rail sections and then the specific aspect related to rails, that is, creep.

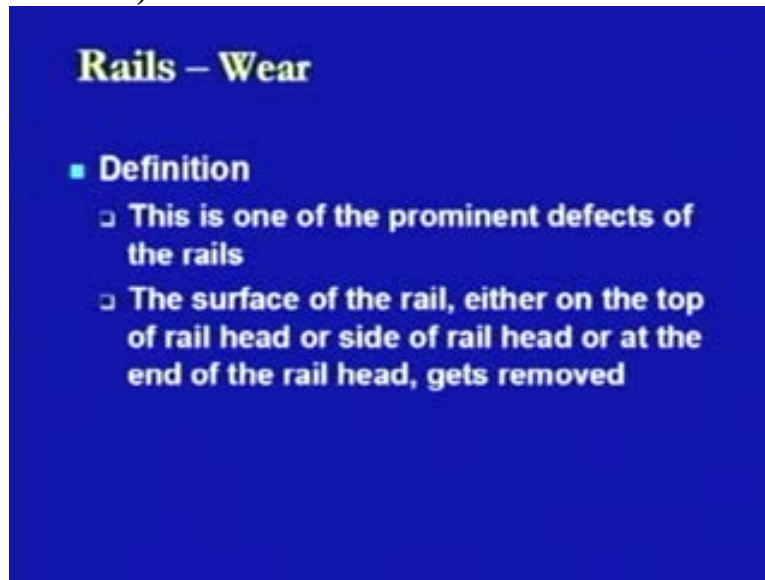
In today's lecture we will be looking at some of the more specific features of the rail that is wears and failures in rails. Wears and failures in rails basically are sort of a condition where we are moving towards a situation where the rail sections cannot be further used even after removal or renewal. It means we have to just change the section and place another section so as to make the section further more usable. In the case of this wears and failures of the rails, the lecture has been outlined using different subtitles like wear in rails, the classification of wear, the effects of rail wear, the permissible limits and some of the remedial measures of removing or eliminating or reducing the wears or the failures.

(Refer Slide Time: 02:04)



Now we will be starting first of all with the rail wear. Now how we define wear, wear is one of the prominent defects of the rails. In this case the surface of the rail either on the top of the rail head or side of the rail head or at the end of the rail head gets removed

(Refer Slide Time: 02:30)



Rails – Wear

- **Definition**
 - **This is one of the prominent defects of the rails**
 - **The surface of the rail, either on the top of rail head or side of rail head or at the end of the rail head, gets removed**

So in this case what is happening is that there are some sections of any part of the rail, most of the time these are the things which are happening at the rail head. In the case of the rail head there are 3 locations where the 3 things wear can happen. One is at the top of the surface, another is on the side of the head and third case is the end of the head. So in all these cases if there is any removal of the surf material or if there is any breakage of the material then that is what is termed as the wear of the rail section. So that is why if any such sort of the thing is happening in any of the locations of the rail then that is termed as the defect in the rail section. So in this case there are certain reasons which cause this wears and they may increase the wear because of those actions or they may be normal in the cases.

(Refer Slide Time: 07:30)



Rails – Wear

- **Major Reasons**
 - **Abnormally heavy loads**
 - **Fast train speeds**
 - **Concentrated stresses exceeding elastic limit**
 - **Gap at joints**
 - **Slipping, skidding or striking of wheel flanges on curves**

So, the first one is the abnormally heavy load. What happens is that all the rail sections have been designed for certain axle loads. We have seen that there is a relationship between the axle loads and the sectional load of a rail section. So when any heavy load is coming from the top other than this axle load which is being defined then in that case there are all chances that more of the stresses will be induced. If heavy stresses are inducing in rail section and if this phenomenon becomes a continuous phenomenon, means these abnormally heavy loads are coming again and come in repeatedly on the same rail section then those rails will not be able to sustain those stresses which have been induced at that location. So in that case there are all chances that some of the material may go away from that section at which that load is being applied.

Another one is the fast train speeds. Nowadays we are increasing the speed of the trains and therefore we are having the high speed tracks. Now in case the high speed tracks are not being provided with the whole specification as required so as to provide those high speeds and we try to provide the high speeds with the normal section of the track. Then in that case what we have found is that these high speeds have their speed augmenting effect as we have seen in the case of stresses or we have seen in the case of resistances offered to that by the track. So because of those reasons there are all chances that the wear of the section or the rail may take place.

Further, there are concentrated stresses which are exceeding the elastic limit of the section. In the case of the rail sections we have seen that there are certain permissible limits related to different type of stresses which are coming on that rail section. They are related to the lateral stresses, they are related to the vertical stresses or the loads which are coming from the top, they are related to the thermal stresses and likewise. So in that case, that sense if the stresses which are getting concentrated because of the loads which are coming from the top they become so heavy that they are exceeding the elastic limit of the rail section. Then in that case also the wear of the rail section may take place. So this is another reason because of which the wearing of the section may take place.

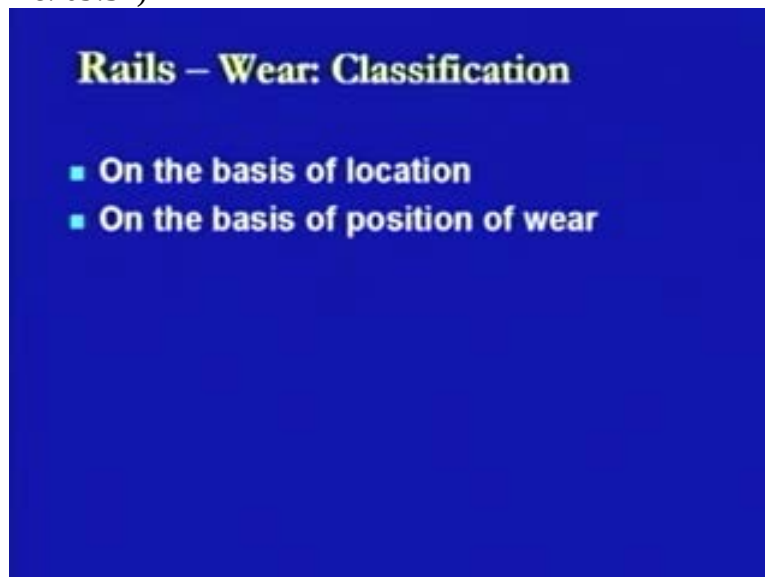
Then gap at the joints is one of the reasons. We have seen in the previous lecture where we have discussed the creep of the rails. Under the percussion theory what we have found is that if the gap at the joint is increasing then the impact which will be created by the wheel on that rail which is provided at the forward direction will be heavy. So if this gap is more, if there is a loosening effect at the joint then all those cases there will be a higher striking at the rail end of that rail section which is provided in the forward direction and that is the case of the wear at the rail end.

Another reason which may contribute towards the wear is slipping, skidding or striking of wheel flanges on the curves. In the case of the curves there is an oscillating effect which will get induced because of the rigidity of the wheel base. Now, because of this rigidity of the wheel base the forward axle, or the backward, or the trailing axle they are not following the same path as being provided by the curve. Therefore, what happens is that there will be a movement of the forward wheel with no connectivity for some short period of a time and then it will strike the outer rail section. Now when it strikes the outer rail section it will be striking at the side of the rail head. Now as soon as it strikes at the

outer rail section the diameter of the wheel will increase. Now if the diameter of the wheel is increasing it means it is coming out of the equilibrium condition.

In the similar condition, in the case of the trailing axle it will be trying to strike at the inner side of the curve and therefore there will be a strike on the rails head side on the inner side of the curve because of the trailing axle. Now in these cases because there is a longer distances which is to be traveled on the outer curve or there is a shorter distance which needs to be traveled on the inner curve, what will happen is that as soon as the outer curve outer wheel is having a higher diameter, they will try to come back, it will try to slip and there will be a slipping and skidding action which will be happening to the trailing and to the forward axle. So these are the two things which will be different in nature but they will be having at a different axle ends and because of these types of a differential sort of movements which are happening ,that is, slipping, skidding and striking of the wheel section we found that there are chances of wear on the rail heads side. This is one of the major reasons of that type of wear.

(Refer Slide Time: 09:52)



Now we come to the classification of the wears. The classification can be done on the basis of location, on the basis of position of wear. These are the two things on the basis of which we can classify them. So, we will be starting with the first type of the classification that is based on location. Now what happens is there are certain specific location along the track which induces the wear of the rail section. We will look at all those locations, we will look at all those situations which may create that or which may induce the wearing of the rail sections. The very first thing is in the case of the sharp curves. In the case of the sharp curve what happens is that there is an application of centrifugal force in the outward direction.

(Refer Slide Time: 18:08)

Rails – Wear: Classification

- **Based on location**
 - **On sharp curves – due to centrifugal force**
 - **On steep gradients – due to extra effort**
 - **On approaches to stations – due to braking or acceleration**
 - **In tunnels and coastal areas – due to humidity and weather effect**
 - **On weak foundations – due to heavy loads**

Now when this application of centrifugal force in the outward direction as I have discussed just before what will happen is there is a lateral movement of axle base in the outward direction. Now in the straights section the front and the wear axles they are just following each other. The path remains the same but as in this case the path is not the same. Therefore, what will happen is the 3 types of actions as we have discussed previously the slipping, the skidding and the striking of the wheel, all the 3 things will be happening. Now the slipping and skidding will happen at the top surface of the rail head and therefore it may cause the wearing at the top surface of the rail head whereas striking of the wheel because of the flanges which will be hitting at the rail section will be at the side of the rail head. Therefore, in this type of case the wearing will be on the side of the rail head. So the two types of things may happen because of the same reason in the case of the sharp curves.

Now if the curvature is quite sharp then these types of action which will be happening will be more in gravity. So we have to look at what is the radius being provided and if the radius is flat enough then that actions will be very low and therefore there were low rate of wearing of the sections taking place. Another aspect is or another location where the wear will be happening is because of the steep gradient. In the case of the steep gradients as we have seen in the case of creep also if there is a movement of the train or the rolling stock in the upward direction or there is a movement of the rolling stock in the downward direction both of these are going to create an effect in the opposite directions to each other.

Now on these steep gradient whether we are going up or we are coming down some extra effort is required. When we are going up, the extra effort is required in terms of pulling whereas when we are coming down the extra effort is required in terms of stopping. So in both the cases when we are trying to provide this type of an extra effort, the force will be acting at top surface of the rail head and when this force is acting at the top surface of the rail head and there is a sort of a rubbing action which is taking place then in that case the

train is going up, then there can be disturbing action may be in terms of slippages also. Then we are coming down it may be in terms of skidding of the surfaces then the heavy energy will be dissipated at that location where this type of phenomena will be happening. Now when there is a heavy amount of energy which is being released at this location then this is one of the reason which will cause the flow of the metal which is provided at that section or generally this is the case related to rail heads, that is, this top surface of the rail. So in this case the top surface of the rail will start losing some of the metal and there will be a flow of metal. So this is one type of wear which may happen because of steep gradients.

Then another one is the approaches to stations. In the case of approaches to stations mainly the platform area conditions where you can see the station limit condition where the heavy application of brakes can be there or there may be another condition where the train is standing and then it has to start, so there is an application of accelerating force in this case. In both of the cases whether we are talking about the braking effort or we are talking about the acceleration effort, the force will be acting on top surface of the rail section and when this force is acting at the top surface of the rail section it may stimulate the wearing or it may cause the wearing of the top surface of the rail section. So this is another reason or another location or the case due to which the wear of the surface may take place.

Then we come to another specific condition. These two are the specific condition; one relates to the tunnels and another relates to coastal areas. In both of the cases what we found is that in case of the tunnel because of its longevity and enclosed area certain amount of humidity is maintained. Now in this section if the rail section is being laid and it remains continuously under the humid condition then obviously there will be some sort of wearing will start taking place. One such sort of thing is the corrosive effect of that humidity and the degradation of the material of the rail section which finally terminates into or which finally results into the wearing of that rail section.

In the case of the coastal areas or even in the case of the desert areas where the rail sections have been provided what happens is that it has a two different things which will be happening; one is the humidity in the case of coastal areas. Now this humidity again has its effect in terms of it is bringing along with it certain salts and when these salts get deposited on the rail sections they have their own chemical reaction and these chemical reaction slowly and slowly if prolong for a long period of time will be having its effect in terms of reducing the life span of the rail section. So that is a sort of weather effect which is there in the case of tunnel effect or in the case of coastal areas.

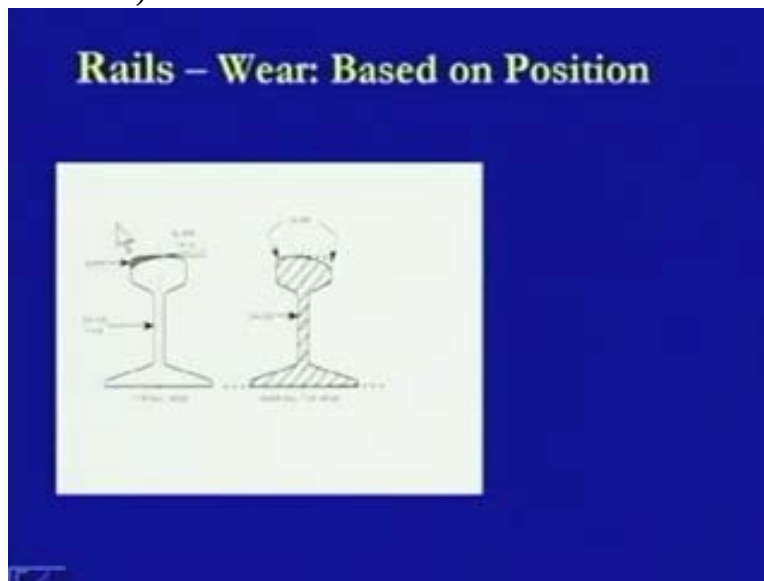
Now another thing which I was just discussing was with respect to the desert area as well as the coastal area. In both of these cases there is a fine particle condition that is sand. This sand when it moves along with the wind it will get deposited on the rail sections and when there is movement of the wheel on the rail section then this sand which has just come along with wind it has a grinding effect. So with this grinding effect what we found is that that rail section will start having corrugations or there will be some spotting which will be taking place at different locations of the material will be coming out at some

specific locations and that is another way of wearing of the rail sections and obviously in this type of condition there are also chances that it may also result in the corrugation of rail sections and finally it can be termed as the roaring rails because of the noise being created by the rails with the movement of the wheels at the top of it .

Then the next reason in the case of the location is the weak foundations. Now the foundation is the ultimate point which is going to take the whole of the load which is coming from the top. Now if the foundations are weak enough then in that case they will not be able to sustain the loads which are coming from the top and there are going to be deformations in the overall structure. Now when the deformations are going to be induced, they have the further effect in terms of the track irregularities. Now these track irregularities will further induce stresses. So this is a sort of a chain reaction which will be caused because of one reason. So as soon as the stresses are being induced because of the track irregularities then wherever these stresses are being induced because of any of the motion that is longitudinal or lateral movements which are taking place on the rail sections with respect to the movement of the wheels or the rolling stock. Then in that case the wear will taking place on either on the top of the rail section or at the side of the rail head. So this is another reason which may cause the wear. So these are some of the locations due to which the wear of the rail section may take place and as we have seen that not necessarily each and every reason may be causing the wear at the same point it may cause wear at different locations also, at different points also of the same rail section.

Now coming to another thing in this case the wear is on the basis of position. What we found is that in this case we can see that there is some wear which has taken place at this location in this place.

(Refer Slide Time: 19:54)

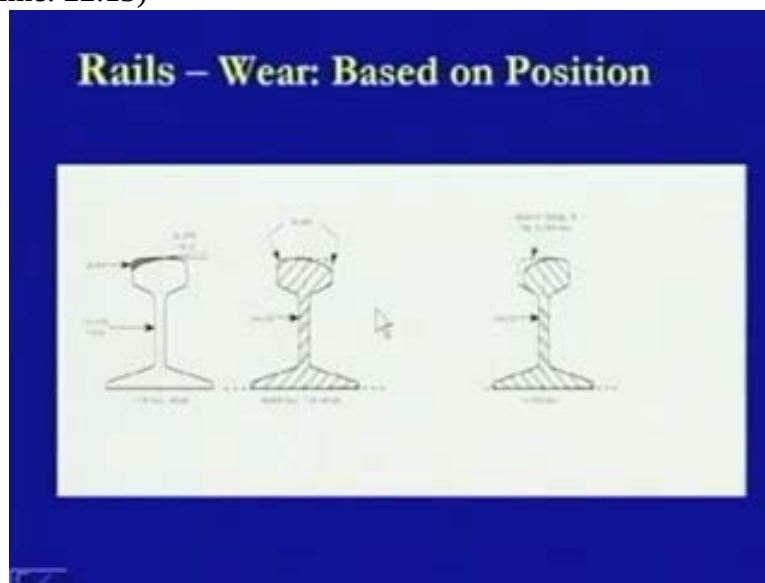


Now there is a slope which is provided at this surface which is 1 in 20. Now in this case of a slope and if there is a continuous movement of the wheels at this section there is

burning of this section taking place. Now when this burning of the section taking place it means as I have just discussed this is one of the cases where heavy amount of energy is getting dissipated or there that is being created then it tries to remove the material it tries to flow the material from this location and therefore this is the total amount by which it has got eroded. So we are left with this section like this. So this is the section which will be left at this location like this. So there is a sort of a tilting, this one and this one type of wear in the case of the base of basis of position.

This is another case. Now here this is a gauge case gauge phase means that the gauge is being provided from this side. Now when the gauge is being provided from this side then it is happening on this gauge side that is another rail is being placed on this side and this how this is a track. What can be done is that this is a case of top of the rail wear. This is another case in this one. This is the inner rail section where the gauge phase is being provided here and then this bar is taking place like this. It is getting tilted in this direction slowly and slowly. So what we found is that this is the actual shape which has been there here like this but this there is a deformation in this shape also at this location and this is total tilting of this one this is another condition of above which is taking place and this is may be because of heavy loads which have coming and the striking of those heavy loads at the top surface. Then there is another condition of the outer rail in this outer rail the wear is happening at the inside of the outer rail like this one and this is the gauge phase.

(Refer Slide Time: 22:13)



What we found is that not only the top surface is being affected; in this case the side is also being affected. So initially this was the original shape like this. Now instead of that original shape the wear has been so heavy that it has also eaten up the material from the top as well as it has also eaten material from the side of this one and we are left only with this much section.

Then further on the basis of position what we can look at is that the wear can be at the top of the rail head. The wear may be at the side of the rail head or wear may be at the end of the rail head. So we are looking at all these 3 types of locations and all these 3 type of conditions due to which the wear is happening. Now in the case of the top of the rail head what type of conditions may get created we are looking at those. The very first one is the flow of metal as we have just seen in the previous diagrams where what we have found is that there is some elimination or removal of the material from the top surface that is nothing but the flow of metal which has taken place.

(Refer Slide Time: 28:36)



Now this flow of metal is going to be there because of the energy, because of the heat which is being generated at the certain locations. Now these locations may be the locations where the slipping or the skidding of the two surfaces are taking place. That the wheels are skidding, oscillating at the top surface. Another case may be the applications of the brakes are there or there is an application of heavy tractive effort at certain locations or there is a section which is being used for a very heavy or a high speed. In all these conditions it is going to be a higher energy condition and therefore the flow of metal may take place.

Then another case is recurring impact of heavy axle load because we are talking about the top of the rail head. Therefore, what may happen is that there are heavy axle loads which are coming again and again and they are creating an impact condition at the top or there is a rubbing action which is going on at the top of the rail head because of the successive movement of the rolling stock at that section. Not necessarily that we are talking about the condition where there is a curve, we may be talking about the section which is straight enough but still the heavy loads are coming from the top so in that case it may be happening that some of the material may get wear out from the top of the rail head because of this reason.

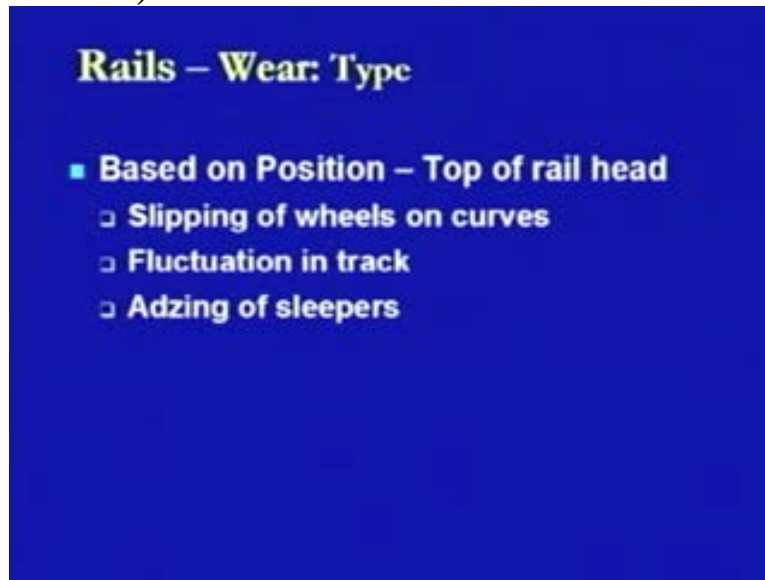
Then the next point is that there can be an abrasive or corrosive condition which may get induced. Abrasive or corrosive conditions are the 2 different conditions. In the case of the abrasive condition what happens is that there is it is required that there should be some abrasive charge which help in the removal of the material due to the rubbing action of different things taking place. Now when we have different type of material which are rubbing each other then in that case what happens is that if as we have seen in the case of coastal areas or in the case of desert areas, in both of these cases the matter there is a sand which comes between the rubbing action will induce that abrasive action further and this is one of the reason due to which the wearing of the top of the rail section may take place further. In the case of corrosive condition it is more related towards the effect of weather as well as chemicals. So in this case what is happening is that along with the weather condition where the humidity is there the salts are also acting or breaking with the minerals which have been provided in the rail section and that is how the corrosive effect may take place. Now this corrosive effect not necessarily may only take place at the top of this surface, it may also take place at some other location.

Then skidding is another case. In the case of the skidding as soon as there is a train rolling stock which is moving at a higher speed and there is a sudden application of the brakes then there is going to be some skidding being caused in that rolling stock and as soon as this is skidding is being caused there will be a heavy amount of energy which will be dissipated at the point of contact or the wheel in the rail section and this heavy amount of energy which is coming will burn the head of the rail section and if we are standing very near to such type of rail section, if you see you will found that fumes coming out that location probably at certain point of a time you have observed while traveling in the train also that there is a some smell which is coming from the track or from the train that is related to the burning of the section. So that is because of these effects on rail.

Then improper super elevation or centrifugal force is another reason which may cause the wearing on the top of the rail head. If there is an improper super elevation then there are unbalanced forces which will be induced on the inner and the outer rail sections and when this unbalanced forces are there then obviously there will be more of the stress at one location as compared to the another location and therefore there will be a relative sort wearing taking place at the two of the rail section at the same location and this is obviously related with the centrifugal force. So, these are some of the cases due to which in the case of the top of the rail head the wearing is taking place.

Now we will be looking at another aspect, that is, some of the other reasons which may be there is the slipping of wheels on the curves. In the case of this one what we have seen is that as the trailing section or the trailing axles are not following the forward axles then in that case what happens is that the wheels which are moving on the trailing conditions tries to slip down so that they can move extra distance, that is, the distance which is the differential distance between the outer rail and the inner rail on the curves.

(Refer Slide Time: 30:15)



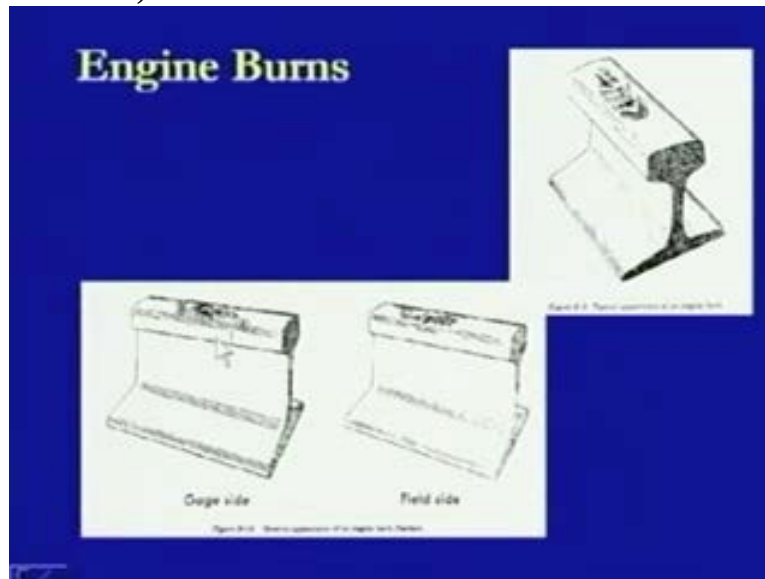
So this is the slipping of the wheels and again the slipping of the wheels takes place at the top of the rail head and that is why this is related to the wear at the top of the rail head. Then fluctuations in the track is another reason. As soon as there is fluctuation, that is, fluctuation in the track is going to create surface irregularities and because of these things what will happen is that the contact between the wheel and the rail will not remain continuous. When this contact is not remaining continuous there will be some point at which there is a striking behavior and because of this striking behavior the wearing at the top of the rail section may take place. It will result in the removal of the material in terms of chips, or in terms of flakes, or in terms of further removal of material.

Adzing of sleeper is another reason. We have seen in the case of coning of wheels that if you are not providing the adzing of the sleepers that means we are not providing the seat in which the rail section can be set it at angle of 120 then what will happen is that there will be concentration of the loads at the top of the surface where there is a point of contact between the wheel and the rail section and due to this reason there will be a sort of a striking behavior, that is, sort of an indentation behavior which will take place at that point of contact. So the wear will start taking place from that location. So that is why adzing of the sleepers must be provided so that there is connectivity between the wheel and the rail surface throughout their width.

So we will be looking at another one type of failure here, one type of wear here. This is termed as engine burn. So in this diagram what we can see is that there is a burning of the top most surface of the rail section because of the engine. This is the specific to those locations where the engines will be stopping on the rail sections like in the case of the platforms. On that platform at the end of the platform where the engine will be stopping we can find this type of burning of rail section head. Then this is another two diagrams where again the burning of the rail section because of the engine has been shown. Here what we can see is that this type of burning which has taken place and there are some of

the numbers which have been attached here like there is a number A which is being placed on this side or there is a number B which is being placed on this side.

(Refer Slide Time: 31:50)



Similarly, in another case what is being this is another type of the burn which is to be taken place in this case. This is the field side and this is the gauge side. On the gauge side what we are seeing is on this side again there are some sort of a metal loss which is there whereas here what we found is that there is a type of a some wearing or the cracking taking place at this location and this is category C by which it is being designated. So there are certain designating numbers by which all these type of wears or failures which are being observed in the rail sections can be categorized.

Now in the case of the flow of the metal where we can see in this case what is happening is that as I just mentioned previously that this metal is coming out of its location because of the heavy energy or the thermal stresses being induced at this location.

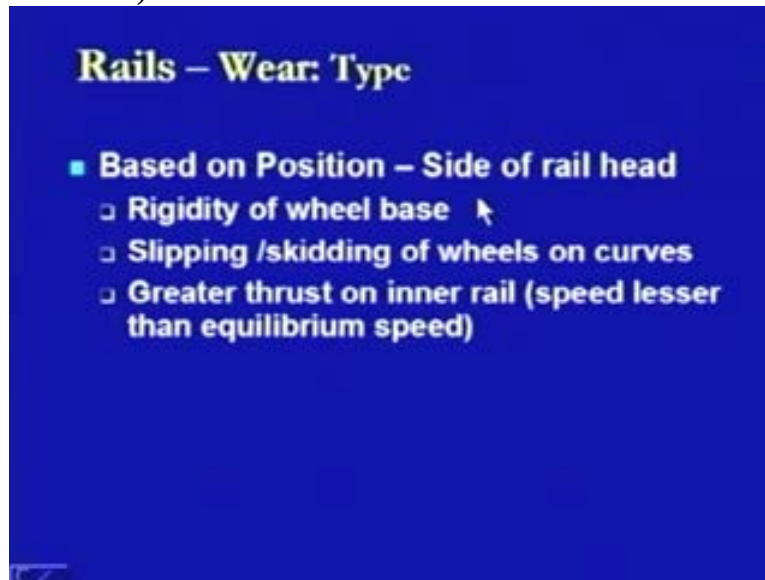
(Refer Slide Time: 33:03)



Now as the energy is being dissipated because of the contact what is happening is that this metal starts flowing down. So, what we can say is that this is the normal shape of this rail head like this is the side of the rail head on this side. So, on this side also it should go like this only but whereas what we are finding at this is crosscutting like this so there is a sort of canopy which has been created at this one and this metal is coming out of the surface in this direction at this level. So this is the flow of the metal and in this case again there is a categorization of this flow as A, B and C on the basis of the location and on the basis of the type of the things which are happening. We will be looking at all these abbreviations little later what does it mean as A, B or C. Then further when we come to the wear of the rail sections another case is based on the position is side of the rail head.

Now what are the reasons due to which this is happening is one is the rigidity of the wheel base. Again and again we have been discussing about the rigidity of the wheel base and because of this rigidity of the wheel base there is a sort of differential movement of the trailing and the leading axles.

(Refer Slide Time: 37:10)



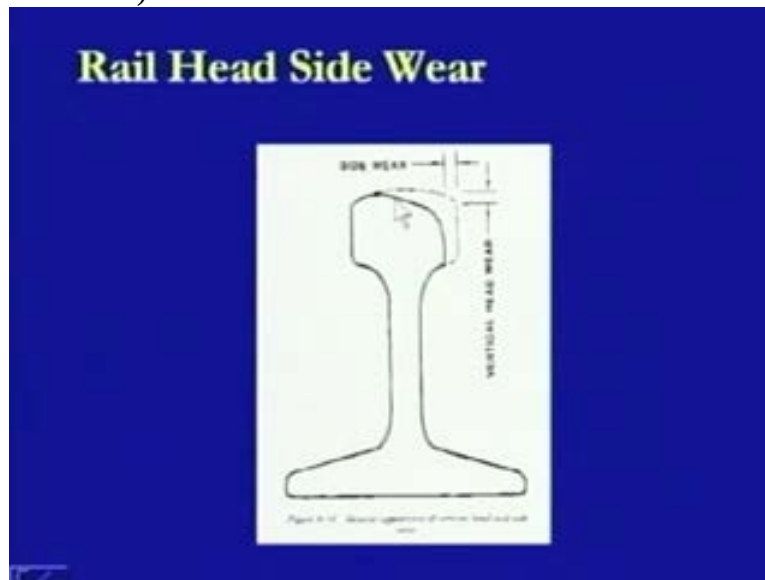
Now when there is a differential movement of this trailing and leading axle then it transforms into the striking of the wheel flange on the inner side of the outer rail as well as on the inner side of the inner rail at the leading section or at the trailing section respectively. Now due to this reason there is going to be the wear on side of the rail head. So this is one of the reasons. Another thing is that if we look at the lateral oscillation or the lateral space which is being induced in any of the rail section then because of the rigidity the whole of the bogie will be shifting towards either the outer side or the inner side and in that case there will be a wear on the rails head. This is on the side of the rail head basically.

Then slipping and skidding of the wheels on the curves. Now in the case of this slipping or skidding of the wheels on the curves what happens is that if the slipping is taking place, slipping is related so as to bring the base of the bogie to the equilibrium condition. Now in the case of the curves as we have seen that if there is leading axle which is going in the outward direction or there is a trailing axle which is coming in the inner direction then there is a change of the diameter of the wheel. Now if there is a change in the diameter of the wheel then it tries to adjust itself in the equilibrium condition. At the same time it is also trying to adjust itself so that total amount of movement which is taking place on the outer wheel and the total amount of movement which is taking place on the inner rail in these 2 conditions which is different by certain amount it has to move in the same fashion. It should not happen that the one wheel is lagging behind and the other wheel is moving in the forward direction. So therefore, this is one other phenomena in which the wheel will try to slip to the equilibrium condition towards the average diameter of the wheel and this slipping will cause the wear of the side of the rail head.

Then there is a greater thrust on the inner rail because of the speeds which are lesser than the equilibrium speed. Now what is happening in this case is if you are talking again of the curves the curve are designed for certain speed and if we have that equilibrium speed then the equilibrium super elevation will be provided that not on all the trains are moving

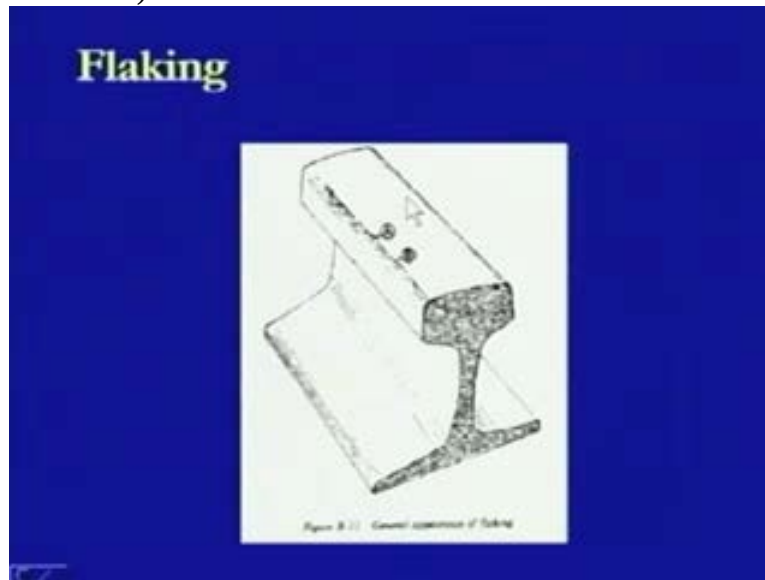
at the same speed there will be some things which are super fast category trains, there are some trains which are mail or express trains and there are some trains which are passenger trains. Then further there is categorizations even in the super fast category where the super fast trains may be further have given in categories Shatabdi or Rajdhani. So what is happening is that there is a difference in the movement or difference in the speed of the train with respect to the equilibrium speed for which at track section or a super elevation has been designed. In that case what is going to happen if the speed is lesser than the equilibrium speed there is going to be more thrust on the inner rail and that will be in terms of the rubbing of the wheel flange on the inner side of the rail head and therefore there will be more wear on the inner side of the rail head in this case. So what we can see in this diagram this is one of the diagram where the side wear has got affected and this is the normal section like this as we can see in this diagram and therefore what is happening is that there are 2 type of things which are happening in this same section one is there is a side wear by this much amount.

(Refer Slide Time: 38:27)



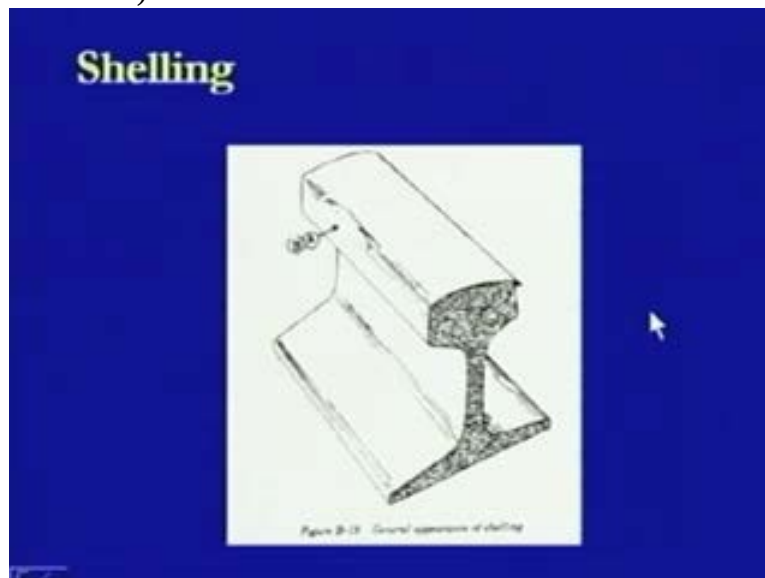
Thus this is the total amount by which the rail sections has reduced and at the same time if this is going down therefore there is also this much amount by which this rail section will go vertically downwards. So these are the two types of wears which are happening at this location. Then there is another case which is termed as flaking. In the case of flaking this is also happening generally on the side of the rail section.

(Refer Slide Time: 39:10)



What we found is that along this section of the rail head there will be some chips which will be coming out or material will be coming out in the form of flakes and that is what is a flaking. So chipping sort of a condition will be happening at this location because of striking of the wheel flanges on this side because the wheel flange is not going up to the full depth of this rail section head. In that case having some depth up to this much level and this is the area in which that striking will be taking place. So, when this striking from the lateral direction is taking place like this then this is going to create an effect on this side of a rail head. Again these things can be categorized based on the location based on the type of the wear as A, B or likewise.

(Refer Slide Time: 40:15)



Then another further condition which can get induced is shelling. In the case of the shelling this is the category of wear as compared to the flakes where the flakes were coming from this section in the longitudinal direction like this whereas in the case of shelling it is the removal of the mass from a certain location. So what we found is that this much amount of mass has got removed from this location and it has fallen down. So this is what is a shelling talking place. The shelling may be in term of like at this location if we look at this side what is happening is that there is some material which has come out of this location whereas the head of the rail section remains like this. So there is again a sort of a canopy got created at this location. So this is another type of failure which can be there in this one because of shelling and this is being categorized as C whereas here the two types of failures are taking place they are being categorized as A and B.

Now another case is on the base of position is for the end of the rail head. In the case of end of the rail head there are some of the reasons again we may found that there are some repetition of some of the reasons because we are talking about the rail head.

(Refer Slide Time: 44:38)



One that condition is the loose fish plates of the fish bolts. If the fish plates and fish bolts are loose in condition then obviously there is relative movement of the two rail sections and when the relative movement of the two rail section is taking place then there is a striking behavior of the wheel on the rail head and because of this striking behavior wheel there is a wear which is taking place at the end of the rail head. Then another case is that there are heavy loads which are coming at higher speed. Obviously, in this case also it is also related again if the impact which is going to be transferred at the end of the rail head where the striking will be there and if more are the loads and more are the speeds then it is going to create a higher effect.

Then the another point which we have already discussed is the effect of wide joints and openings, because of this reason there is more connectivity or more contact between the wheel and the forward rail end and this is going to create the problem for the end of the

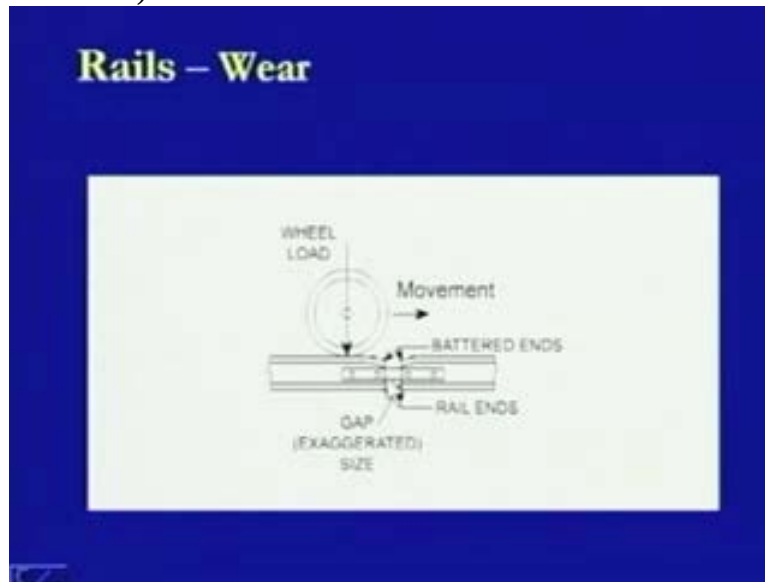
forward rail and the wearing will take place at that location. Then another aspect which is being observed is the difference in the rail height at the joint. If the two rail sections are not being provided at the same level or because of certain maintenance problems they have now being placed at different levels then there are two things which may happen.

If the train is coming from the higher level and then the wheel moves on the lower level there will be a hogging effect at this location and because of this hogging effect the rail section will start bending downwards whereas in the case of the wheel which is coming from a lower level section of the rail and it tries to negotiate the higher level section of the rail which is being jointed at certain point then there will be some force which will be transferred at the forward section which is at a higher level and due to this force there will be a movement in the forward direction in the rail section because the horizontal component of that force. So this is the 2 things which can happen because of the difference in the rail height at joint and because of these 2 things which are happening the striking which will be taking place at the end of the rail section may be because in the case of hogging or in the case of forward movement, the end is going to suffer and there will be some wear at the section.

Then bad condition of vehicle spring is another case. It will not be able to take up the motion in the vertical direction and motion in the vertical direction and when it is not taking those motions then it is more of a rigid condition which is being created and due to that reason again there can be wear. Then poor maintenance of course, all these all things are related with the poor maintenance of the track and if the track is not being maintained finally it is going to create more effect on the ends of the rails as compared to other conditions.

Now this is the case where the rail end is being shown and as we have discussed whether there are two rail sections are at a different level or there is a movement of the wheel in this direction, what we found is that if that gap is either more or the rail section are at different set level.

(Refer Slide Time: 44:54)



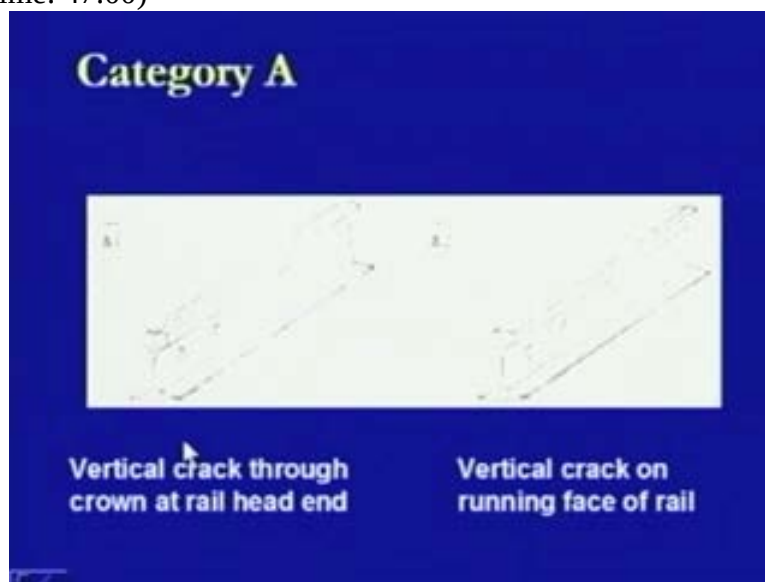
This is hogging taking place, that is, this end of the rail section it has gone down and this also termed as battered end of the rail section. So this is also the battered end of the rail section and this is also the battered end of the rail section whereas at the bottom it remains at the same level. So this is one type of condition which gets created. Now we will be looking at some of rail failures in the case of rail failures there as I have discussed that there are certain categories. Category A says that there are cracks in the head of the rail. So instead of writing all of the things like cracks in the head of the rail in the terminology of rail failures it will be designated as A. Similarly, if the B is designation for a solitary cracks in the web or the flange of the rail then C is transverse parallel to rail cross section cracks, D is horizontal cracks in the web, E is pieces of head web and flange broken off at the rail end, F is the portion of the rail broken off, G is breaks through sections of rail. then we have some more further like H cracks and breaks through the welds, J is the portion absent from the rail head, K is the piece of rail broken away through web and head or flange likewise it goes up to U. So there are different categories by which we can describe all these fractures or the rail failures.

(Refer Slide Time: 46:46)

Rail Failures	
Category	Description of Fracture
H	Cracks and breaks through welds
J	Portions absent from railhead
K	Piece of rail broken away though web and head/flange
U	

Now in this diagram we are trying to show the vertical crack which is being induced through the head. Here the crack is being induced actually here likewise, this is the vertical direction crack which is going and it is propagating in this longitudinal direction.

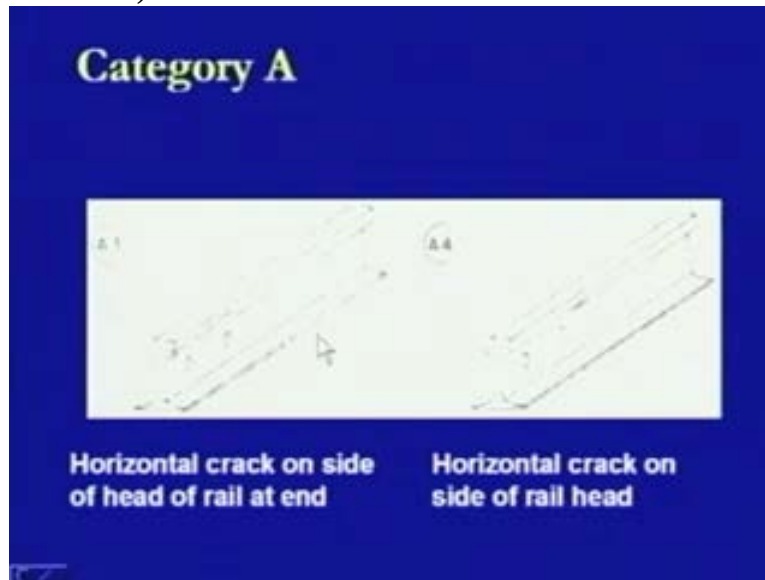
(Refer Slide Time: 47:00)



So this is little less visible but in this case what is happening is it is starting at this end of the rail and is propagate along the length of the rail whereas the another case is that in this case it is happening from this side where it is being jointed or another case is that it is happening in some mid block condition where the running phase of the rail is in the vertical direction likewise in this case. Then it may also happen in the horizontal direction instead of this vertical direction this is happening horizontally like this and then this is propagating along this section on the side where the fish plates and the fish bolts

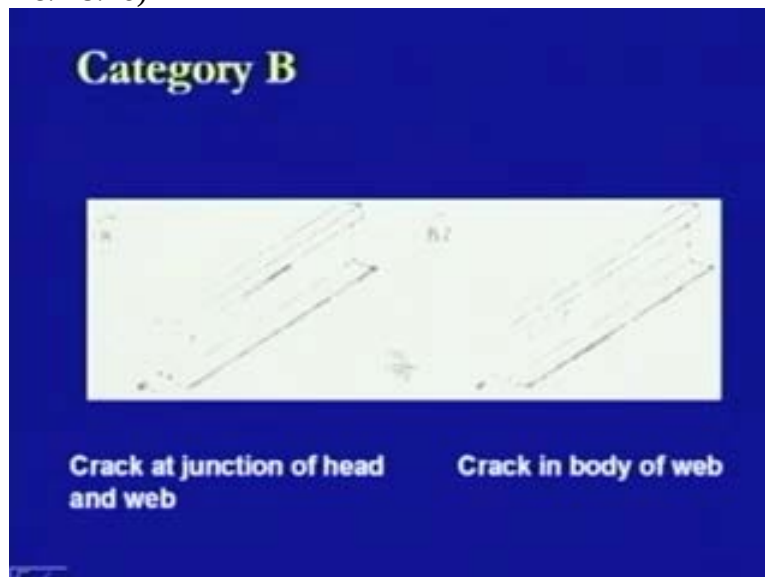
had been provided, that is, at the end of the rail section or there may also happen in the mid block condition where at this section there is a horizontal crack being got induced and it is taking shape in this area on this side of the rail.

(Refer Slide Time: 47:41)



Then further this is at the junction, this one, this is another sort of a crack which is at the junction of this head of the rail with this web of the rail section. So this is another type of a crack which can happen.

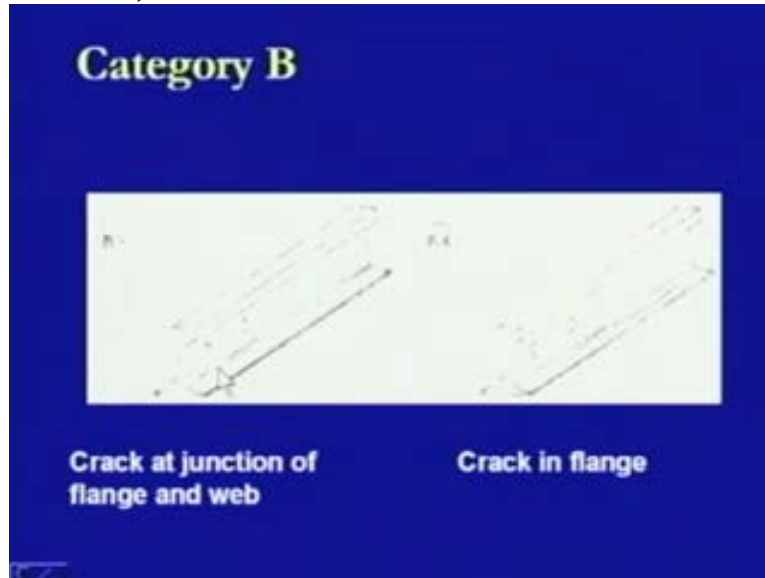
(Refer Slide Time: 48:16)



There is a crack which can also happen in the body of the web. So this is the web section and in this web section there is a crack got induced here. So this is another type of crack and although these type of a crack they are categorized as B. Then further in the case of B

category what we found that the same type of crack as we have seen at the top can also happen at the bottom where the web is connecting at the foot. So when the web and the foot they are being connected at this location also the cracks can get induced.

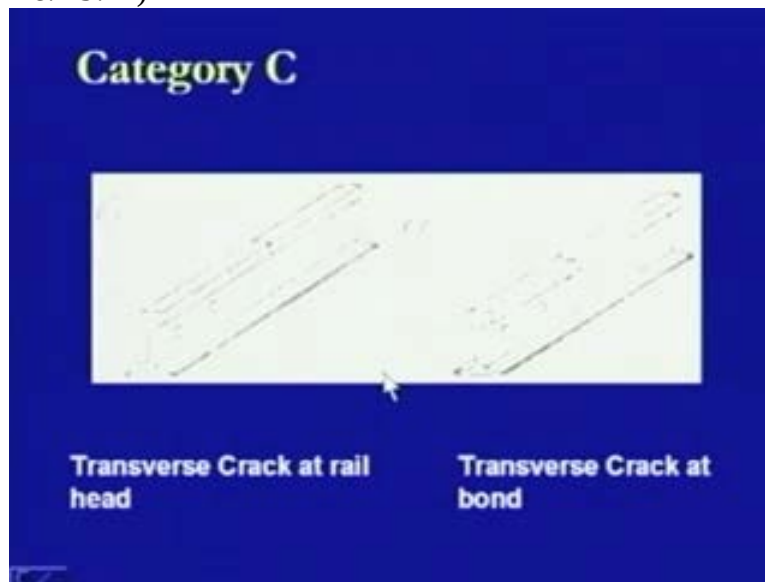
(Refer Slide Time: 48:50)



Similarly, the cracks can also get induced in this flange of the foot that is this section which is there and this section likewise that this is another sort of a crack which is there that is known as crack in flange again categorized as B.

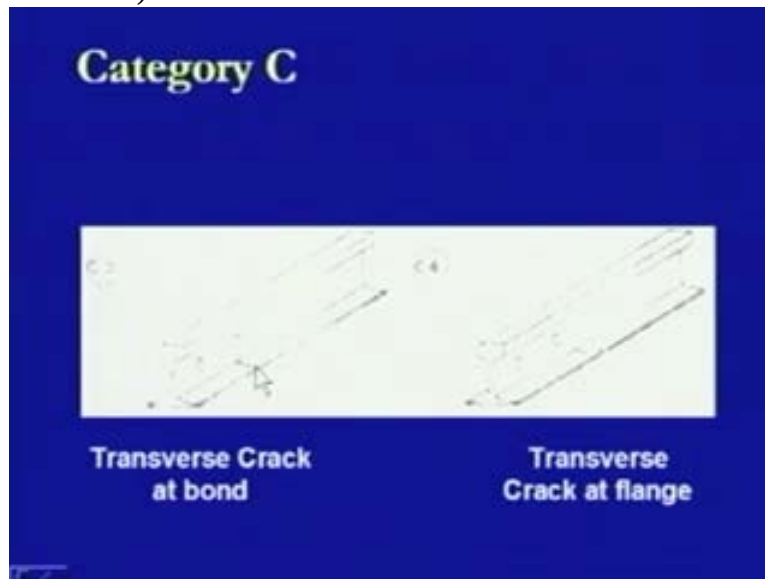
Then we have some other categories like in the case of C this is transverse crack here. This is the crack which has got induced at this location. So this is going in the transverse direction that is why its termed as like this and at times this can also propagate towards the body of the web. So this is coming from this side, goes along the side of the rail head and then comes through the joint and starts going down.

(Refer Slide Time: 49:22)



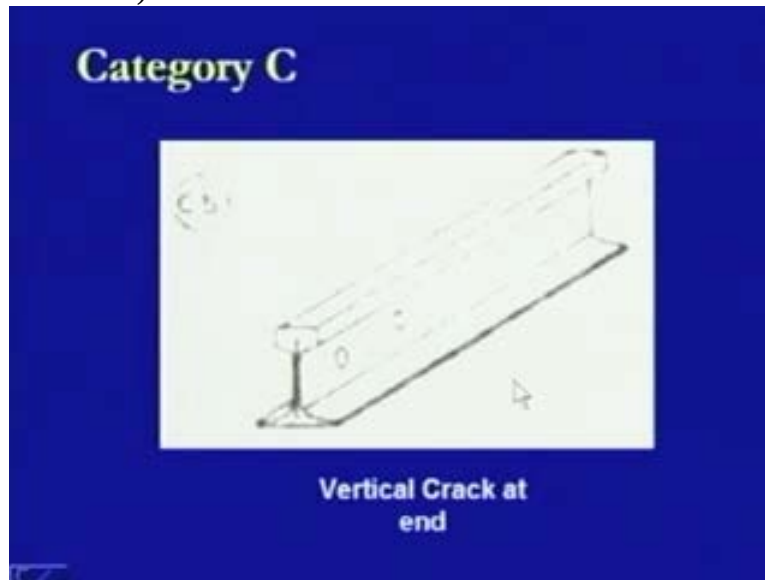
Then the same thing can also happen from the bottom. Here it is happening from the bottom and it is going towards this fish bolt hole. So it means that there are more of stresses which have been induced in this point and therefore it is getting cracked in this location like this.

(Refer Slide Time: 49:52)



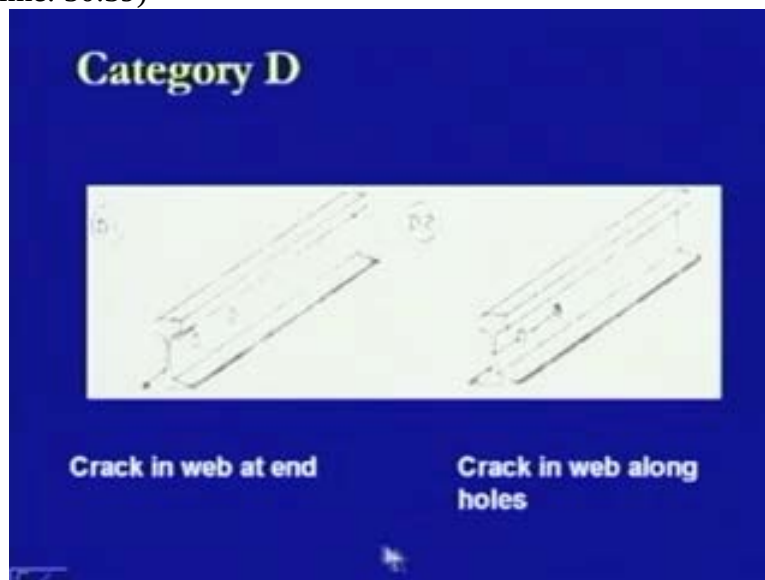
Then it may be the transverse crack, may be in the angle instead of perpendicular condition, this is another form. Then there is a vertical crack at the end where we found that this vertical crack is propagating along the web in the vertical direction and its moves from the head to the foot.

(Refer Slide Time: 50:19)



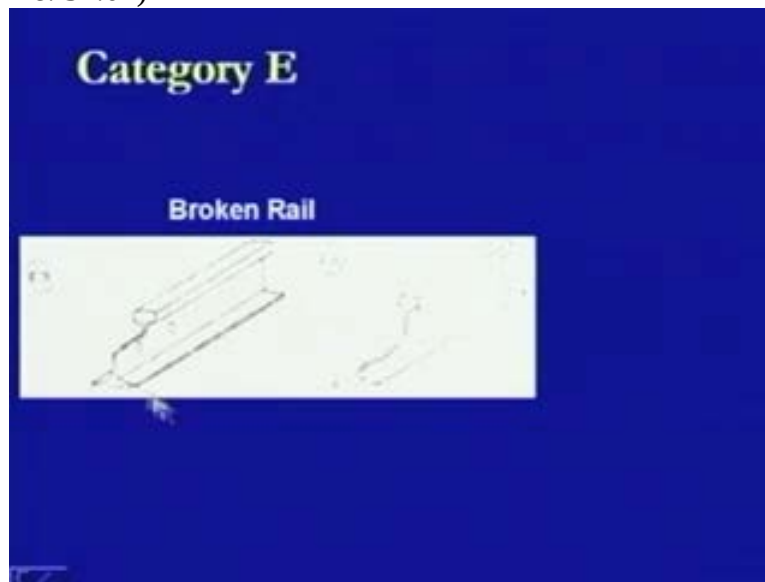
So this is how it is going in this way. This is another vertical crack which is there. Then there is a crack at the end of the web. Here this one, this is crack which is taking place whereas there is a crack which is going along the holes of the bolts.

(Refer Slide Time: 50:39)



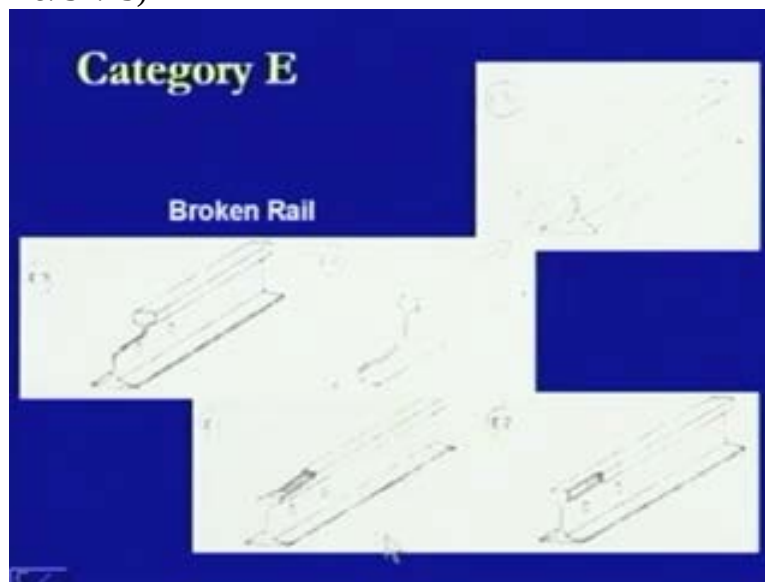
So this is another, this is related to more concentration of stresses in this location. Now some category E where the broken conditions are there, we see that this is how the whole of the rail section is broken down, then this is the distance by which it has gone out and still we found that there are holes.

(Refer Slide Time: 51:02)



So this material has gone away whereas in this case the it has gone in such a way that even this holes are also not now here and it means that the fish plates are also gone out. In this case though the head has remained intact but what we found as that its bottom has gone down away. So this is broken and this is bottom shape this is like this. This is broken down.

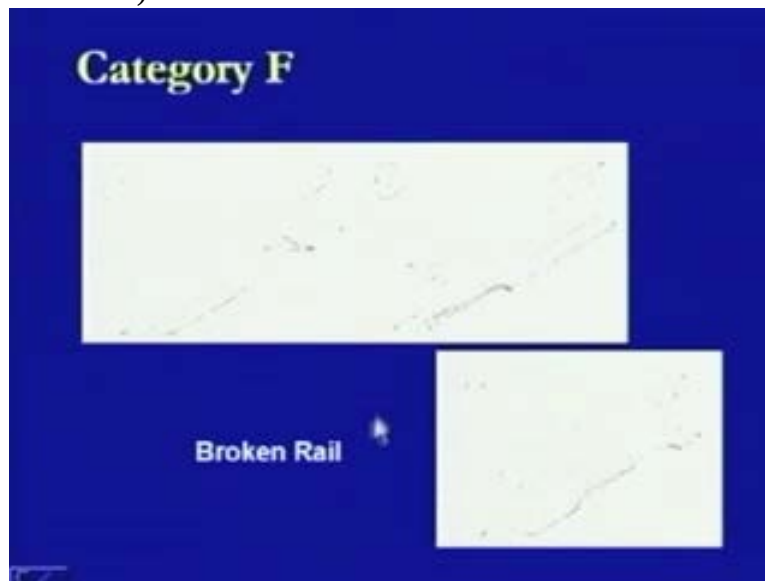
(Refer Slide Time: 51:43)



It is broken that the web and the foot remains intact but in this case the portion of the top of the rail has gone away. So this is another condition of broken rails. In this case what is happening is that the one side of the rail section head remains intact but the other side of the rail section has gone away. So this is another type of a broken rail. Then this is

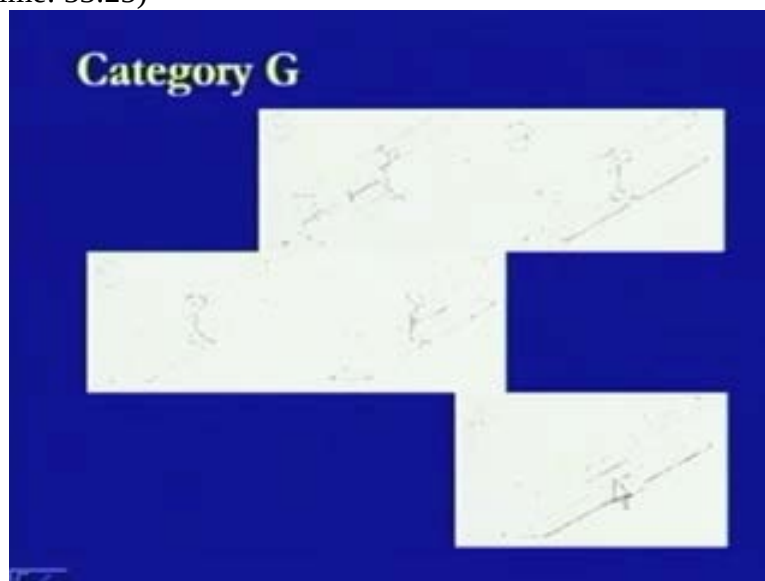
another way where the flange of this section has gone away. In this case again it is a little less visible, what is happening that in the center this material has gone away like this.

(Refer Slide Time: 52:29)



So it is a sort of an arch which is being created at this level. Then this is another case where instead of staring from the end this is from the mid block section of this rails and it is broken in this form. Then this is the vertical split of the rail section up to the point up to which the fish plates have been provided. It remains like this and after that it is breaking down and this category.

(Refer Slide Time: 53:25)



It has broken down here at this level as well as it is getting broken down in the web condition. Then there is a propagation of this broken web and this also getting the

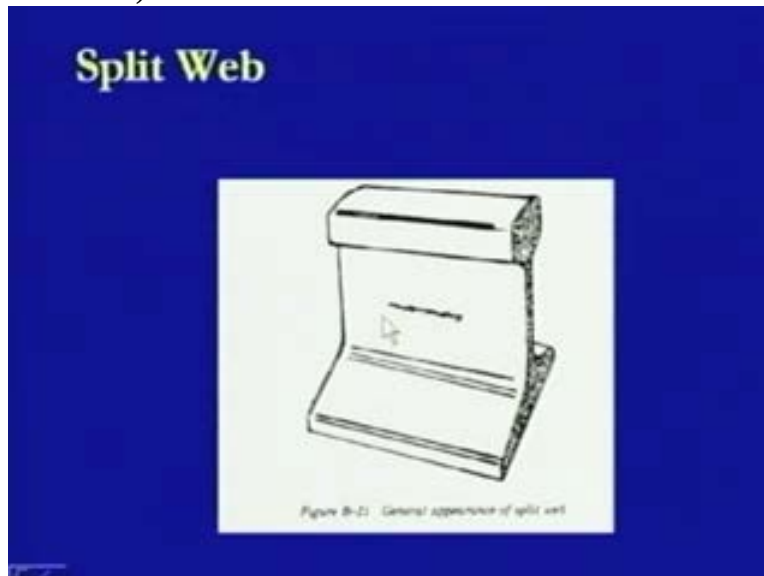
transverse web as well as the vertical crack at this location. So this is transverse crack and vertical crack. Again here, it is borne apart in two parts at this location. Then in this case there is a bar by which it is being joined and there has been some flow by which it is being tried to remain intact. This is horizontal split head condition where what we found is that the material is worn away in this shape. Then there is a split in the web like this. Then there are different types of the transverse effects which are happening. That this is one defect on this side this is another defect.

(Refer Slide Time: 53:37)



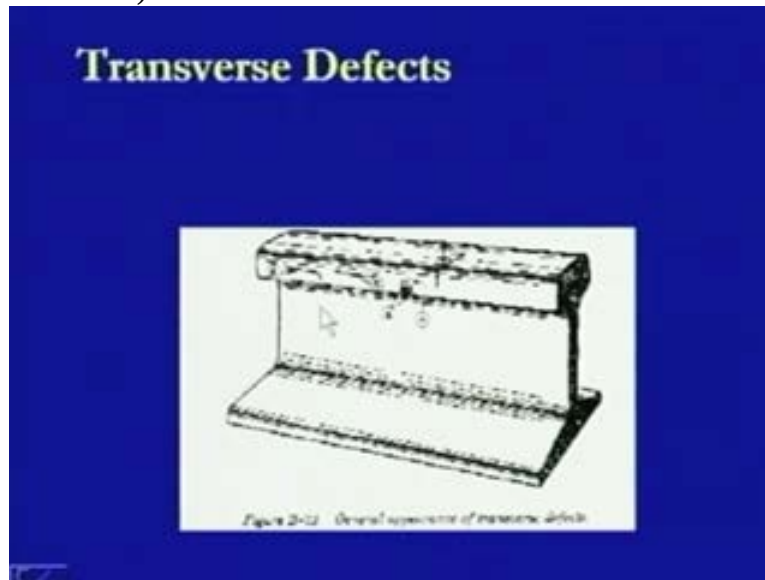
and

(Refer Slide Time: 53:47)



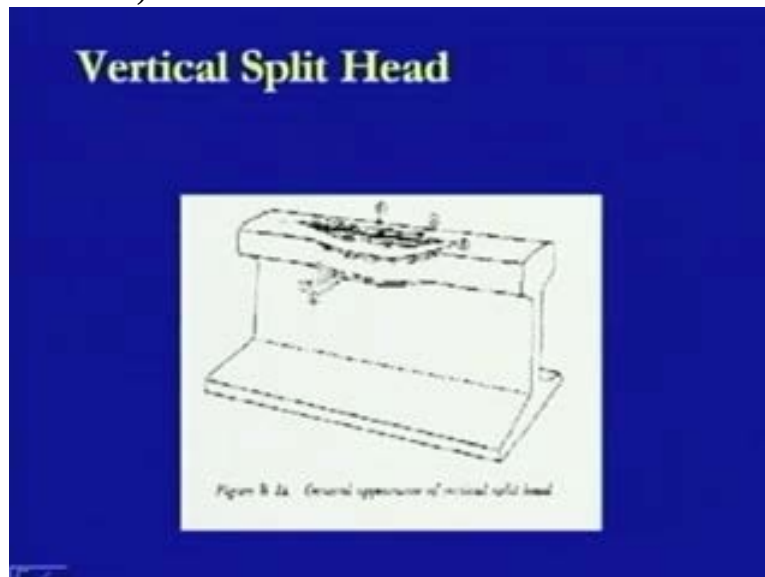
and

(Refer Slide Time: 53:53)



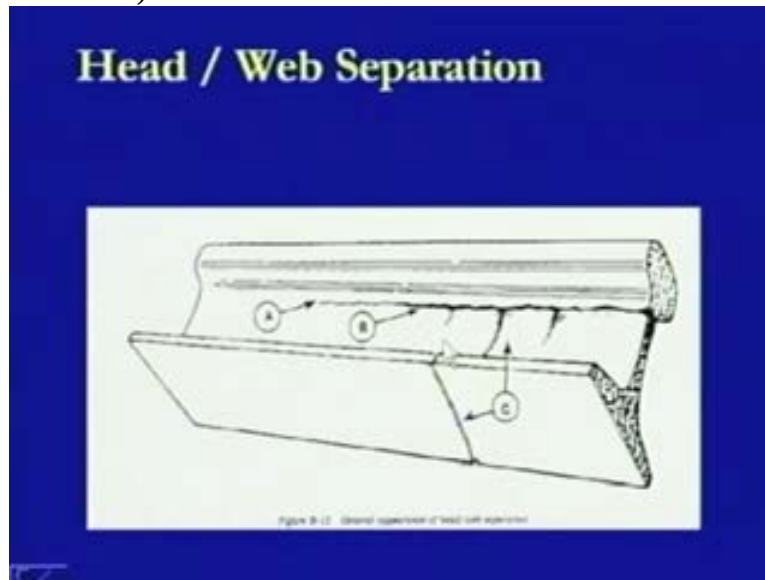
this is one defect which is there, then from the bottom side there is another defect. Likewise, so many defects can be there. This is vertical split head condition where this whole of the section has gone down and it is getting deformed in the downward direction and at the same time at this location there is the crack getting propagated.

(Refer Slide Time: 54:11)



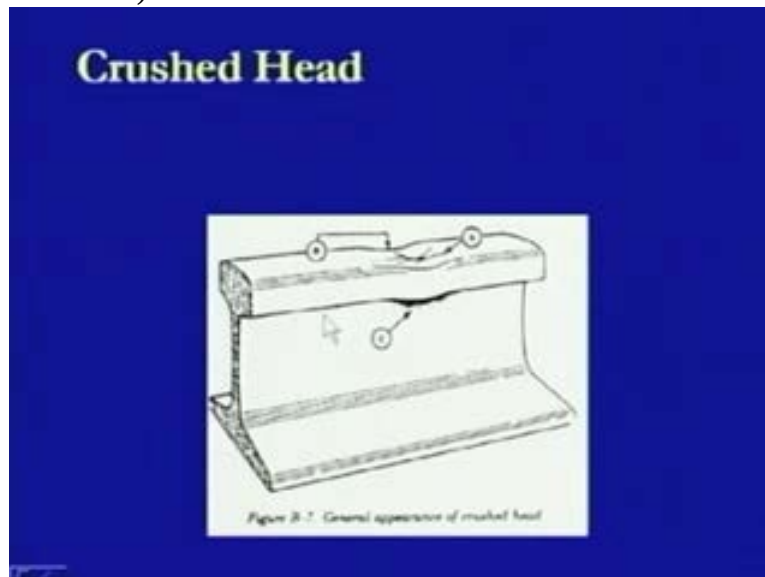
This is another condition where the head or the webs are getting separated. This is head; this is web section what we found that this is getting separated at this location. At the same time there are some cracks which are getting propagated to the foot also and this is how it is just cracking the whole of this section.

(Refer Slide Time: 54:25)



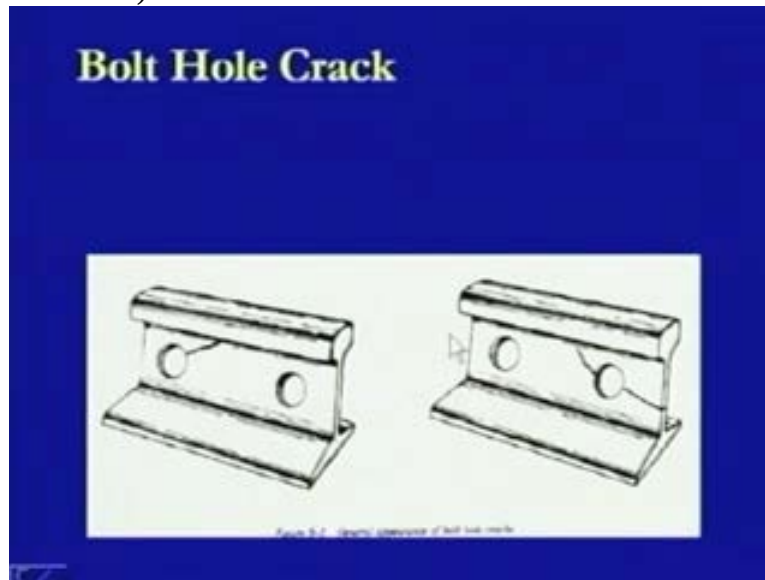
Slowly and slowly we will find that this section has got away and only this section along with this one will remain. Then this is another case of the crushed head where what we have found that it has gone sink and down like this where there are some cracks which are propagating in different directions.

(Refer Slide Time: 54:54)



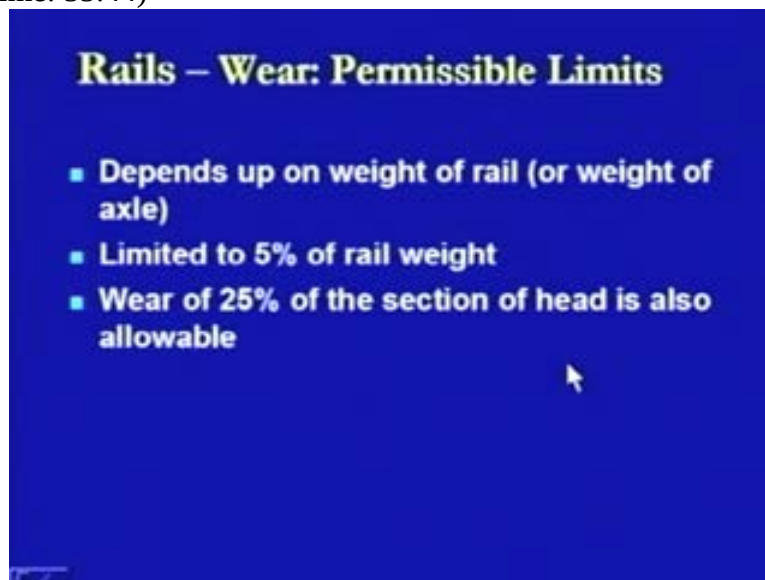
Then there is a crack which is coming from this hole towards the connectivity of the web with the rail head. This is one type of another crack and there is a crack which is going towards the end of this one.

(Refer Slide Time: 55:05)



So if it propagates we can lose this of material in this direction. Now coming to the permissible limits of the rail wear, thus depends on the weight of the rail or the weight of the axle.

(Refer Slide Time: 55:44)



So in this case what we found is that it is limited to the 5 percent of the rail weight. This is permissible limit of the wear and the wear of 25 percent of the section of the head is also allowable. Then certain prevention of the wear; we can prevent the wear by the better maintenance of the track. If we remove the number of joints then we can remove the end wear, the use of heavier and higher UTS rail sections will help in reducing the wear of the rail sections or the head of the rail sections.

(Refer Slide Time: 57:02)



The use of bearing plates at the bottom of the rail section, that is, below the foot will help in just dispersing the stresses to a wider area and this is at the same time we should also go for this adzing of the sleeper so that that can set it easily. Lubricating the gauge face is another way by which the wear can be prevented. Using check rails on the sharp curves. The check rails are the rails which are provided inside of the main rail section and it helps in the controlling the lateral oscillation of the rail of the rolling stock. So this is another way by which we can prevent the wear because it will be reducing the striking of the wheel flanges on the side of the rail. The track renewal is another way of preventing the wear. We should do it periodically wherever there is a maintenance required should be renewed. Further, what we can do is that we can interchange the inner and outer rails because in the case of the rail both the phases of the rail are not being used simultaneously when there is an operation of the rolling stock.

(Refer Slide Time: 58:22)

Rails – Wear: Prevention

- Interchanging inner and outer rails
- Using special alloy steel
- Regular maintenance of rail joints
- Welding or dehogging of battered ends
- Maintenance of correct gauge
- Application of heavy mineral oil in case of corrosion of rail metal under adverse atmospheric conditions

So if the inner side of the rail sections have got wear out, there what we can do is that the outer rail can be made inner rail and inner rail can be made outer rail and by this can change the gauge phase of the rail section. Using special alloy steel is another way by which we can resist the wear, regular maintenance of the rail joints means they should be made stiff and they should be maintained, lubricated and level difference should not be there. Everything has to be checked at the joint. Welding is another way by which we can reduce the number of joints and then dehogging of the battered ends is by which we can reduce the wear, but dehogging is not an easy job as we have seen in the previous lecture. Maintenance of correct gauge is another way. Then application of heavy mineral oil in case of corrosion of rail metal under adverse atmospheric conditions or some other ways by which we can prevent the rail wear.

So this is in short about the different type of wears which can take place on the rail sections. We have seen the types of wears because of the location as well as because of the position of the wear that is on the surface of the rail head, on the side of the rail head and at the end of the rail head and we have also seen the preventive measures by which the wear can be reduced. So we are stopping at this level.

Good bye.