Transportation Engineering-II
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Lecture-7
Rails

Dear students, I welcome you back to the lecture series of course material on transportation engineering 2. In the previous lectures we have already discussed about the elementary sides of various cases like what are the permanent ways, what are the specifications, the gauges being used on the Indian railways, the resistances offered by the tracks under stresses or the bending moments etcetera being caused in the different components of the track. Now we are starting with another aspect of the railways that is the components of tracks. In today's lecture we will be covering the aspects related to rails. The some of the aspects which will not be covered today will be covered in the subsequent lectures. In the rails we will be taking the functions of the rails, the type of rail sections, the selection of rail sections, the length of rail, the test conducted on rails and rail deformation or defects. These are the things which we will be taking up in today's lecture.

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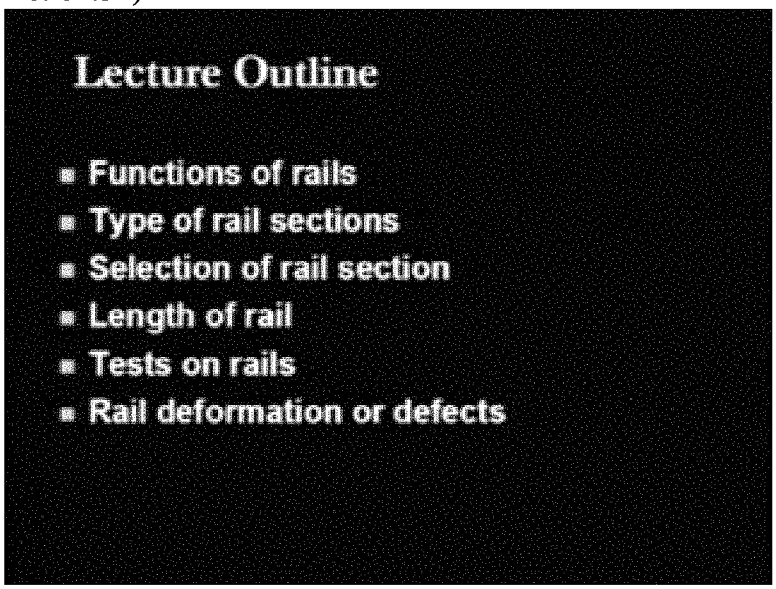

So starting with the functions of the rails, the rails are provided so as to have a continuous and leveled surface on the track. Rail is a surface which provides the surface for the movement of wheels. If this is not continuous and if it is not leveled then obviously it is going to create some disasters or hazardous conditions as we have seen in the case of the stresses or the moments which can be induced in any of the components of the tracks in the previous lectures.

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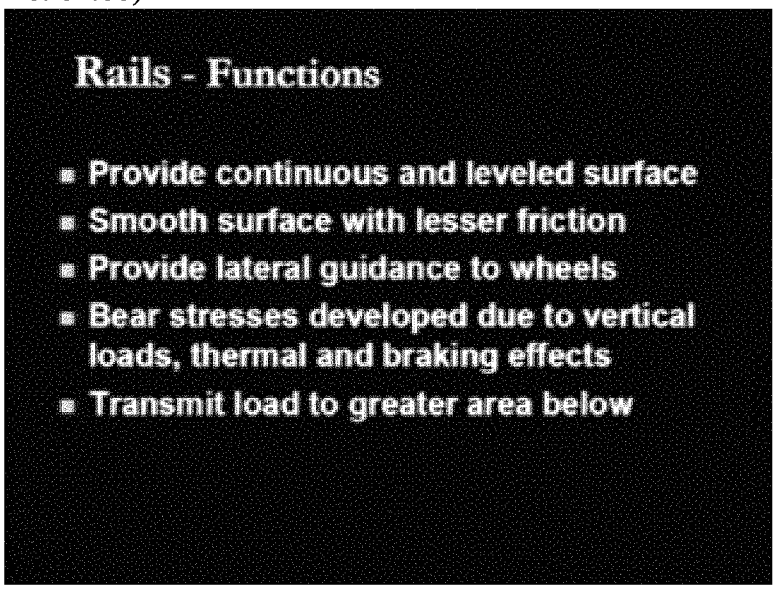

Another thing is that it should require to have a smooth surface so that the frictions are as low as possible. Then it also provides the lateral guidance to the wheels. In the case of the wheels as we have seen may be in the coning of the wheels or any other diagram where the interaction of the wheel with the rail is being shown, what we find is that flanges are provided on the inner side of the rail section to the wheels. So that when there is a lateral movement of the wheel in any outward or inner direction then the wheels are not going away from the rail section. So that is how the rail sections are providing lateral guidance to the wheels. If this lateral guidance to the wheels is not available then there will be a derailment condition because of the slippage of the wheels over the rail sections. Further it bears stresses which are developed due to vertical loads, thermal loads or breaking effects.

In the previous lectures we have seen that there are stresses which are caused because of different reasons. All those stresses needs to be counteracted or to be taken care of. The rail is one of that system which has to bear the stresses which are coming directly from the wheels to it. So that is why whatever types of stresses are being developed because of any of the reasons they should be able to bear them without failure. further they should be able to transmit those stresses loads which are coming from the top that is from the wheels with the lower areas to a greater area below. If they are not transferring the load to a greater area below then because of the concentrated load conditions or the pressures being induced at any of one location there will be chances that there is a permanent sort of a deformation get created at that location and if there is any permanent deformation which is getting created at the location finally it is going to culminate into surface irregularities and the failure of the track. Now we are looking at some of the requirements of the rails sections.

The very first thing is the composition of the steel should be proper. Whatever is the material which needs to be mixed so as to form that rail section, in whatever proportions they needs to be mixed, in whatever grades they need to be mixed that should be proper

then only the proper strength properties of that rail section will be achieved otherwise there will remain certain sort of defects in it.

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Another thing is that the rail sections should be economical in nature. When we say it should be economical in nature we have to look at three components along with economy. It should not happen that we provide a so small rail section that it is not in a position to take up the loads which are coming from the top or it is not in a position to sustain or to provide the guidance to the wheel system. The three aspects which needs to be taken care are strength durability and stiffness. We cannot compensate or we cannot remove or we cannot eliminate, we cannot reduce any of the aspects related to these three things. The strength which is required should be there. It should be durable, it means whatever are the effects of the temperatures or other corrosive effects because of the location of the rail sections being provided in certain areas, they should be able to sustain all such type of actions and they should be stiff as far as possible so that they can sustain the type of load which are coming from different locations from different direction in eccentric condition.

If any of these three aspects are not taken care of or there is something being left in the design procedure then it is going to culminate, it is going to finally reach the failure condition of that rail section. So we have to get the economy along with reserving these three things, that is, the strength durability and stiffness. Another important thing in the design of rail section is that its CG should be as near as possible to the center of the height. Now if the CG is very near to the center of the height then it will help in balancing of the tensile and compressive stresses. If this balancing of the stresses is not there and any of the stresses removed then it is going to create its effects in terms of the different types of defects which can get induced into the rail sections. So as to remove that type of effect getting induced in we have to make sure and ensure that the CG is coming very near to the center of the height. Now this is one of the rail section which is being shown here

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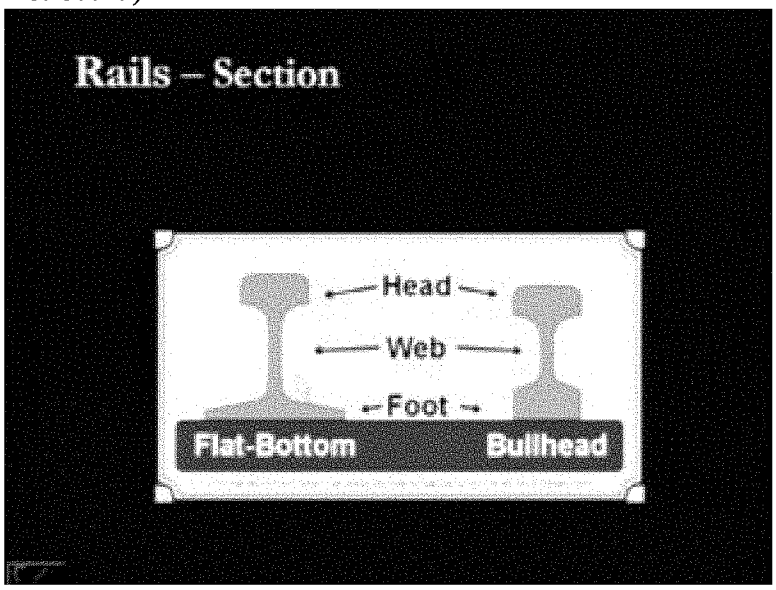

Here this rail section has three components. This component is known as the head, this is known as web and this is the foot. This is another sort of a rail section where again this is head, this is web and this is foot. This section where we are having a larger foot area is known as flat-bottom condition whereas in this case where it is not having a larger area it is quite similar to what is being provided at the top that is the head. It is termed as the bull headed condition or the double headed condition. So what we can see is in this case that we have to design this area, we have to design this web area as well as the foot area.

So when are talking about the strength it means the head should be sufficiently large enough so as to take the loads which are coming from the top and dissipate them, web should also have its sufficient strength so that because of the lateral loads which are coming from this direction this should not break down because it is a thinner area and foot should be able to provide the loads to a wider area which is possible basically in this section because this is the total width which is available through which the same amount of load will get dissipated where as in this case this area is so small. Now keeping in mind this aspect we can look further the balanced distribution of material is to be done in head web and foot. This is another important thing.

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What is the total amount of the material which is to be put in these three sections? As we have seen the head is the section which is taking directly the total loads which are coming from the top. Therefore it has to be a little wider. The web is to be designed in such that it is stiff in nature and foot should be able to sustain the twisting conditions as well as should be able to distribute to the load a larger area and looking at these three aspects of these three sections the distribution of the material has to be done. Next thing is that we have to look at the economical and balanced distribution of metal where the head should be able to have adequate depth so that the vertical wear if any is there is not creating an effect by which we have to remove that rail section very frequently. Another thing is that it should be wide enough so that the running surfaces whatever running surfaces of wheels are there they should have sufficient movement over the top of that and a lateral stiffness obviously has to be there because of the flanges are getting the side of the rail head and when they are hitting the side of the rail head then their stiffness has to be there. If it is not there then it will break down at the point of contact of the head with the web.

Another thing related to the rail section is the height. It should have the sufficient vertical stiffness and strength. Looking at the total amount of the loads which are coming in the lateral direction we have to look at what are the bending conditions which will be created and on the basis of this height those bending values can be computed. So we look at their stiffness and their strength aspect and design it. Further, in the case of the web the thickness has to be designed because it has to resist the lateral loads which are coming from the top in terms of the flanjuction and at the same time the rigidity, flexural rigidity has to be there. So this is the design aspect of the web.

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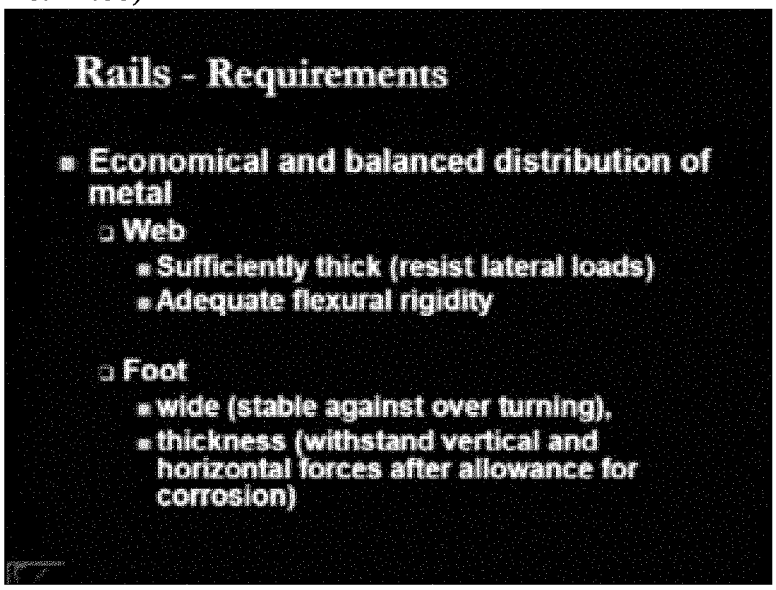

In the case of the foot because it is a point at which it is being connected with the sleeper it should be stable enough and so as to have that stability it should remain wide in nature. So if it is wide there will not be any overturning of that material of that component. The next thing is the thickness. Now thickness is too provided because there are stresses which are induced at this level of connectivity. The foot is connected to the sleeper using fastening. If it is not thick enough then it will breakdown very easily and there will be a failure of the system. In this regime it should be able to withstand the vertical and horizontal forces after given allowances for different type of durability aspects like corrosion and effects of corrosion which can reduce the size of the section.

The next thing is we are talking about the fishing angles where the design of the bottom of the rail head and the top of the rails foot, they have to be designed in such a way that whatever fishing plates are provided at the side they get fit in.

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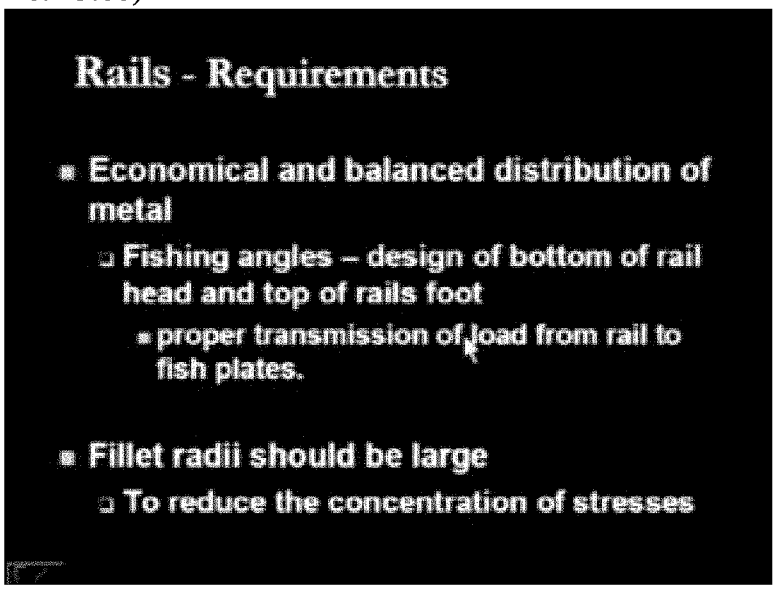

If they are not getting fitting in then there will remain some gap between the fishing plates and the web of the rail section and because of that there will not be proper transmission of load from rail to the fish plates. So the location at which the head is connected to the web or the foot is connected to the web at that point whatever curvature have been provided at that level the fishing angles have to be designed in that form so that the proper connectivity is maintained.

Another point is then the fillet radii should be large so that the concentration of stresses can be reduced. Now looking at the extended sections; what are the types of sections which are available to us so that we can use them.

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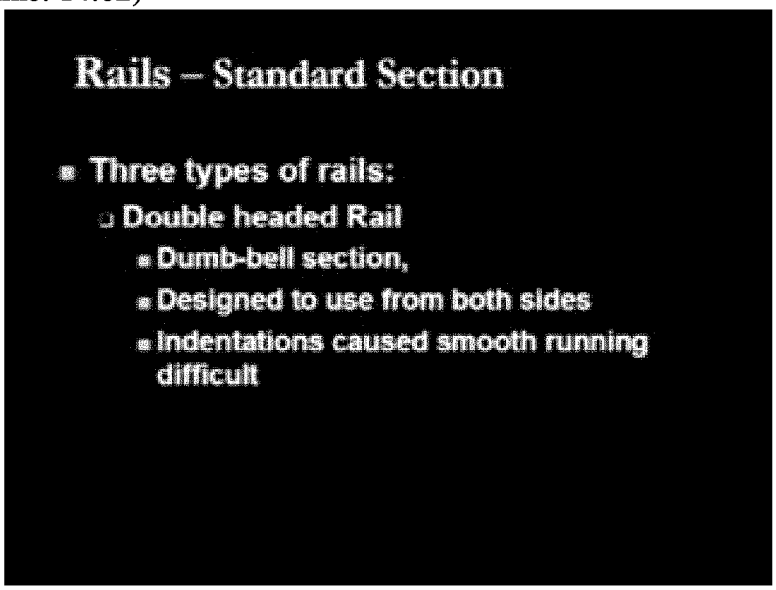

There are three types of rail sections one is double headed section. This double headed rail section is also known as dumb-bell section. This is a sort of exercising equipment dumb-bell where there is a thinner section in the center which is holding the hand and then there is thicker section on both the sides which are same in nature. It means they are having the same sort of dimensions. So it is designed to use from both the sides. The philosophy behind designing of that type of section was that if there is wear and tear at the top surface of the rail head then we can just make it opposite, that is, make the top bottom and make bottom top so that we can use it from the other side, but what was observed that because of the load conditions and because of the connectivity of the bottom of that rail section with the sleeper through fastenings some indentations are caused in that level and if you are turning it towards the up side then this indentations will create surface irregularities and therefore running of the wheels will become difficult. It will not be smooth in nature.

Then another type of rail section which was used looking at these aspects was bull headed rail. In the case of bull headed rail the head was made a little more thicker and stronger as compared to the previous one where the both head and foot were of same section and it means some more material is being added to the top of the head.

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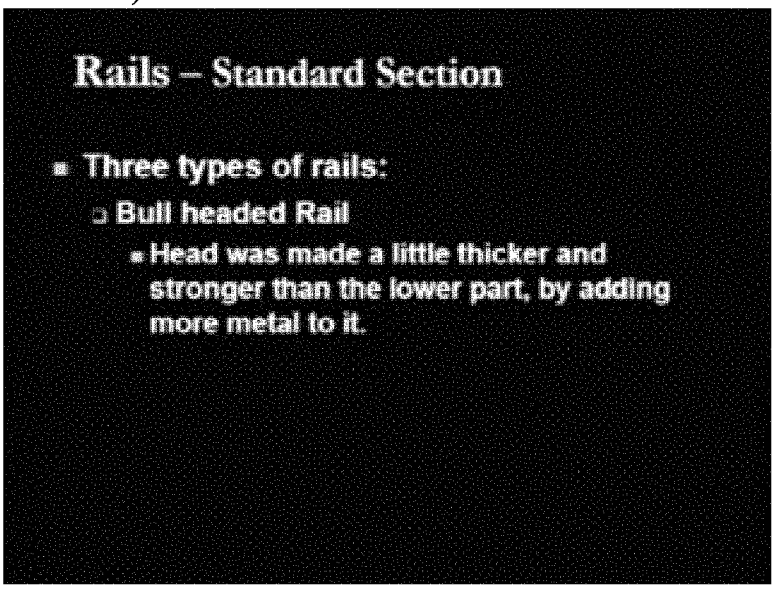

The philosophy here was that even if there is some wear and tear in this case it will remain as such and will remain in continuous reuse.

Finally the third type of rail section which came was the flat footed rail. The flat footed rail is also known as Vignole's rail after the name of its inventor Vignole.

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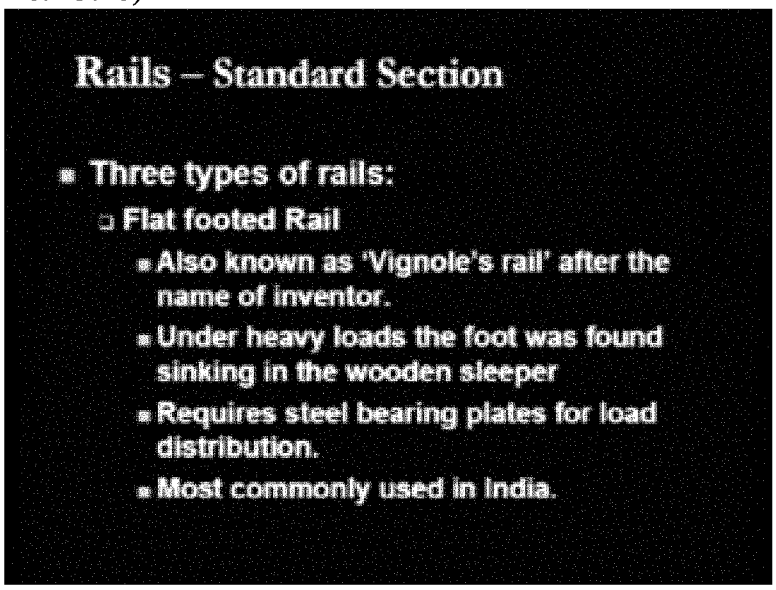

Under heavy loads in this case the foot is found sinking in the wooden sleeper that was the case of the previous too one because the sections which was being provided at the bottom, that is, as the foot where of a smaller section and if the heavy loads were coming at the top then they were going inside of the sleepers. Initially the wooden sleepers have been used and so it was found that they were penetrating the wooden sleeper whereas now if we have the flat footed rails then this is not the case. Another thing is that they were requiring the bearing plates for load distribution, but in this case of the flat footed rail because larger area is available therefore generally the bearing plates may not be required and they are now most commonly used in India. These are the comparative sort of a diagram which is being shown here.

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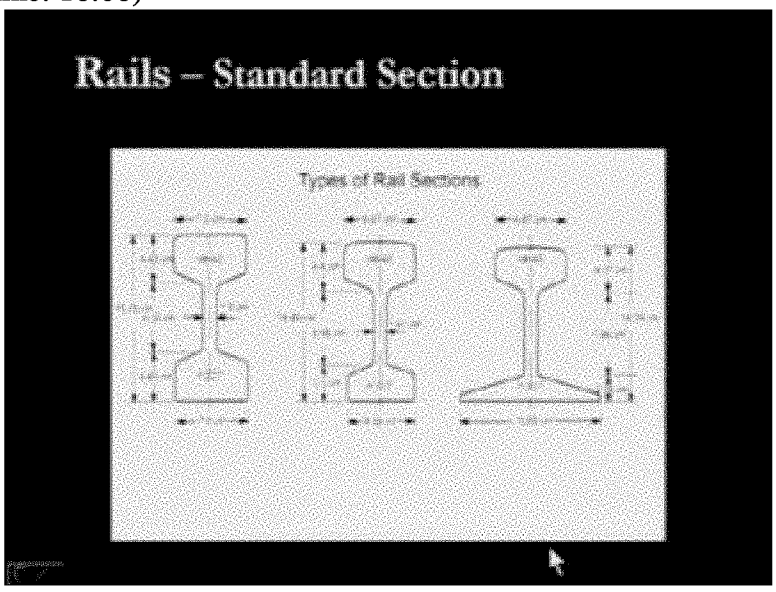

This is double headed rail section where this section and this section they are of similar nature. It is a little higher than the another rail section which is bull headed rail section where it has a sort of a bull head, that is, it is more stronger, bigger as compared to this foot section and this is a flat footed rail section where this top section is more or less sort of a similar condition as this one with some sort of thickness or depth of the section being reduced, but what we see is that the foot is being enlarged by a big amount. Instead of 6. 35 centimeter as a foot being provided here it is more than double of that one and this is 13.65 centimeters in size at this level.

So the merits of the flat footed rails are; they are easy to fix, they are more economical, they have greater strength and stiffness, they provide more lateral stability, there is no requirement of keys or chairs which are required in the previous two cases that is the bull headed and double headed rail section.

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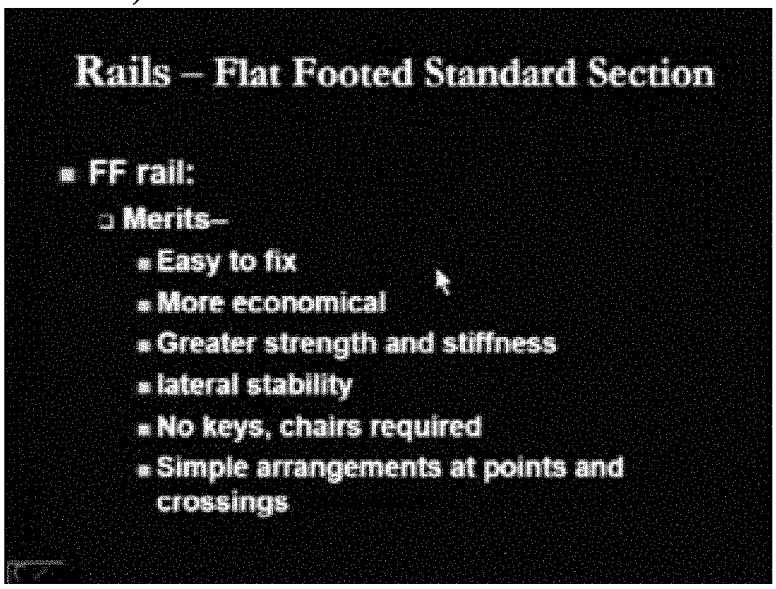

The simple arrangements are there at the points and crossings by which the directions of the movement of the train can be made. We will be looking at the points and crossings in some other lecture.

There are of course some of the demerits related to the flat footed rails. There is a demerit in terms of the loosening of the fittings because of the thinner sections there are chances that fittings get loosened out and there are some problems related to the strength straightening of the bent rails.

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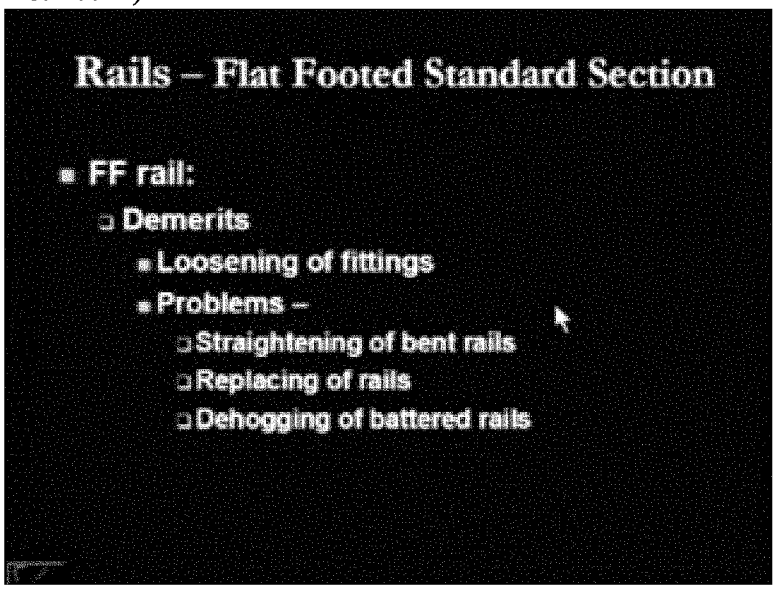

If the rails have got bent due to some of the reason then it becomes a little difficult so as to make them straight. There are all chances that at the bottom some breakage may take place. Then at the time of replacing of the rails the problem is because they are not being seated in the chair. So therefore, we take out the chair and replace it but here they have been nailed down to the sleepers and because they have been nailed down to the sleeper so all the fittings have to be taken out and then only these rails can be replaced. Then the next thing is that dehogging of battered rail conditions because at the point of joint of 2 rail sections there are chances that the battering of the rail may take place. Battering of the rail means, it is taking a nose dive at that location because of the impact of the wheels. Now if that is going down at that location then it is to be brought back to its normal level condition that is what is termed as dehogging and it is little difficult condition in the case of the flat footed rail.

Now we come to the standard sections or designations which have been used in Indian railways or otherwise. Now there are types of rail sections which have been used because the British were the people who started the railways in our country.

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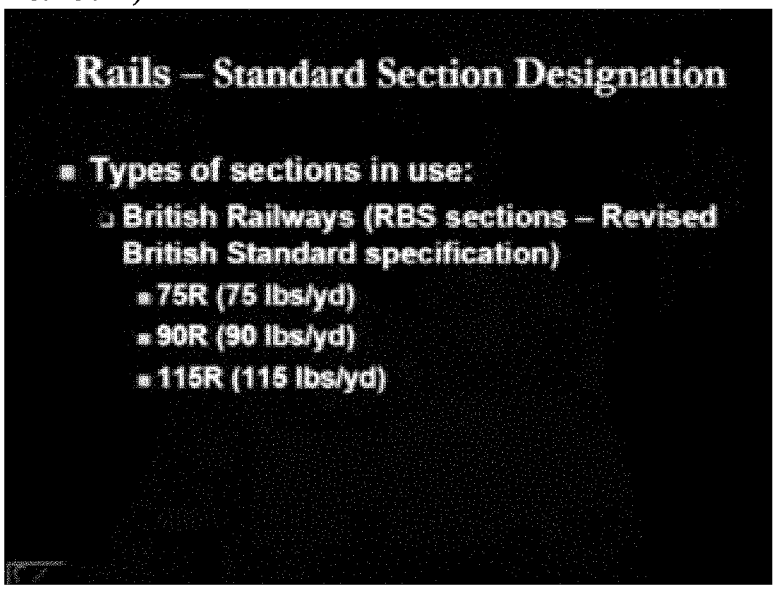

So they used their own standards as I have told you in one of the previous lectures and that is why we had the specifications from the British that is RBS sections or revised British standard specifications and in that case the rail sections were designated as 75 R, 90 R, 115 R likewise and this 75 R means this 75 pounds per yard section, 90 R means 90 pounds per yard section, 115 means 115 pounds per yard section.

Later on we had revision of all these and we are now having in Indian railways our Indian specification where in we are using again the rail sections being designated in terms of the weight per unit length but that is being taken as SI unit and here now we have two rail sections one is 60 kg per meter rail section another one is 52 kg per meter rail section.

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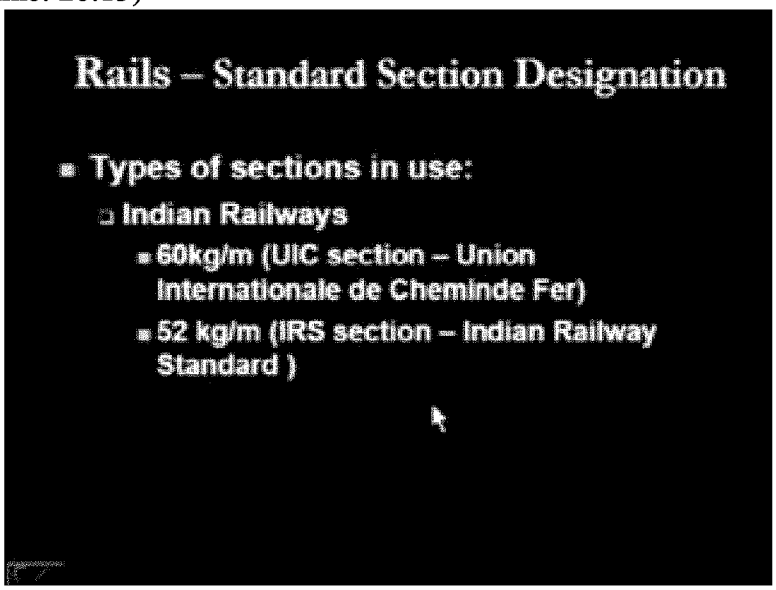

The 60 kg per meter rail section is also termed as UIC section which is term which comes from France and it is the union interationale de cheminde fer, this is what is the terminology stands for UIC section whereas 52 kg per meter rail section is IRS section which is Indian railway standard section. Then the next type of the rail section which is in use on meter gauge or narrow gauge, they stand with still we are continuing with those standards specifications which came from British and they are 60 R section means 60 pound per yard rail section, 75 R section and 90 R section as specified before. Similarly, in the case of rail sections for the narrow gauge it is 50 R rail section means it is 50 pounds per yard rail section. So these are the standard sections which are in use and this is how they are designated in Indian railways.

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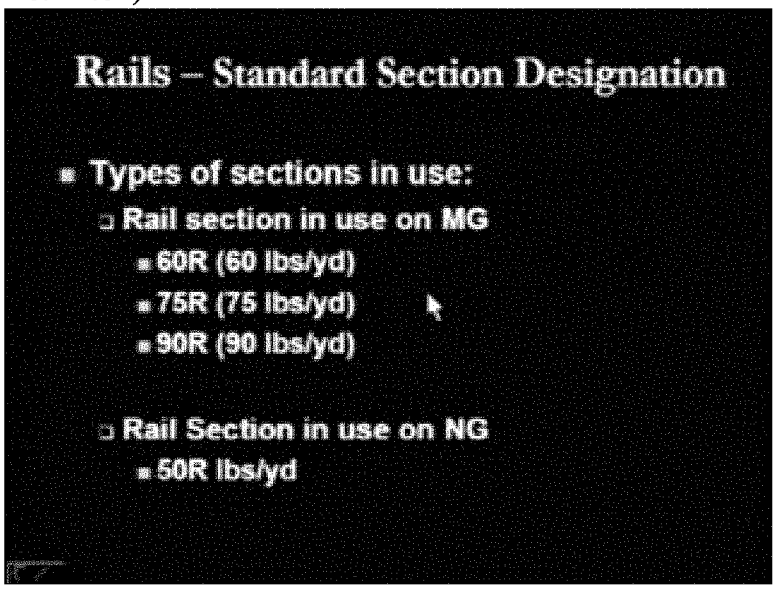

Now if we have to make a comparison of the different type of the rail sections which are available to us then that comparison can be made on the basis of different factors like strength. Strength means we have look at the load taking capacity of that section, whether it is in a position to take much amount of load as we have seen in the comparative diagram.

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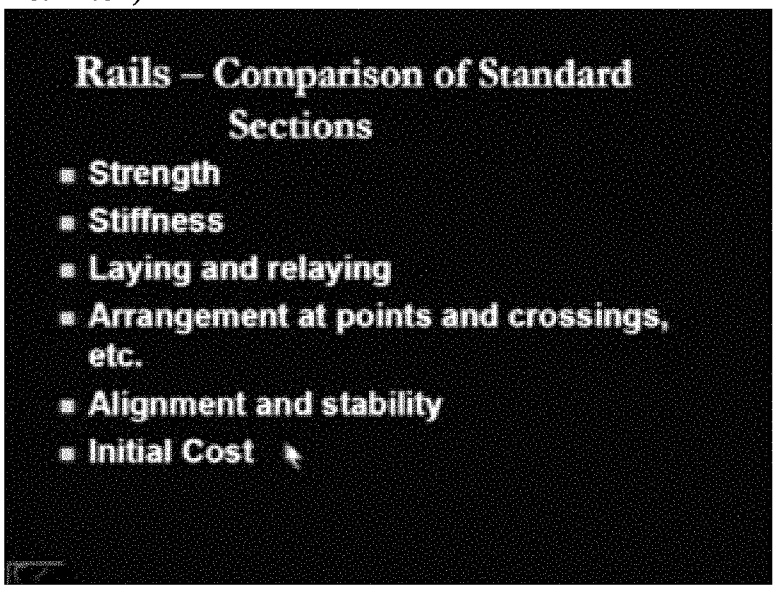

What we have found is that the head of the bull headed rail section or doubled headed rail section has been little more wider or thicker as compared to the head of the flat footed rail section. So in that sense probably those have little more strength but as far as the base is concerned then other one, that is the flat footed rail section has some more strength. Stiffness is defined in terms of the size of the web and the material or the thickness being provided on the web. So it a little comparing condition but along with the fixation of that rail section with the sleeper that stiffness can be increased. So it also depends on the fastening which is being provided along with the rail section.

Then laying and relaying of the rail section as we have seen during a little smaller comparison as we have done previously between the three types of the rail sections and we have seen the merits and demerits of the flat footed rail section. The laying and relaying is a little difficult condition in the flat footed rail section because the fastenings are directly being inserting in that rail section or they are taking sort of you can say, they are just fixing it in a much more higher condition as compared to the previous two cases where they are being placed in a chair. So you just take out a chair and the rail is being taken out.

Arrangements at points and crossings is another important aspect for the comparison because so as to make a change in direction we have to look at this aspect; alignment and stability. Stability is much more in the case of a flat footed rail sections and because of that there chances of having a better alignment condition in this one. Initial costing is another aspect because cost is the prime factor of starting with any of the thing whether it is a laying or relaying of any component or the track. Further we can make that comparison on the basis of the rigidity of the system, the rail sections, how rigid they are when they are taking up the loads and then whether it is possible to make the inspection of those one.

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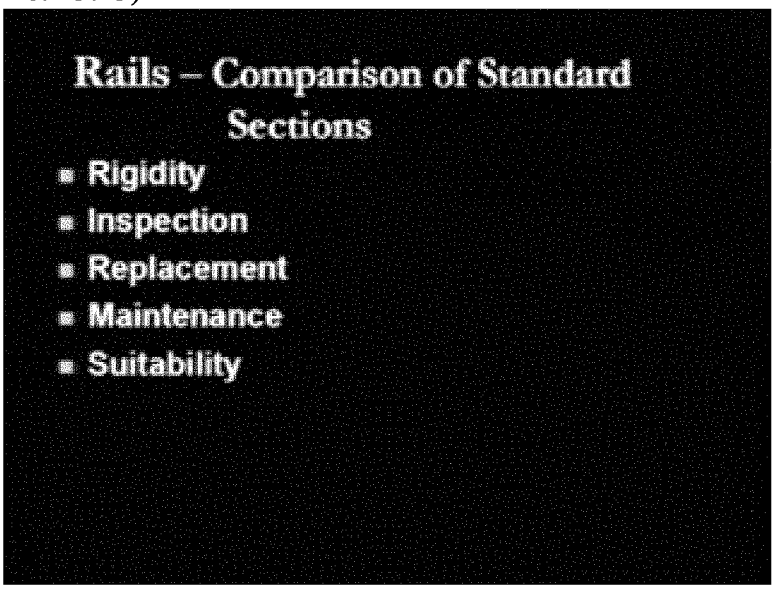

What is the ease of the inspection or what is the periodicity with which the impaction inspection needs to be met? So we have to look at these two aspects whether replacement is to be taken in the form whether it is possible to make the replacement in an easier way or it take it is a quite difficult to replace the thing. The maintenance aspect is taken in the form at what is the periodicity with which the maintenance is to be done whether the periodic maintenance is required at the level of weekly or fortnightly condition or it is to be done at monthly basis or more than that. Suitability is another aspect that what are the locations where those rail sections can be easily used. So whether that suitability is available to all the rail sections or not, we have to take care of that.

Now coming to the next point is the selection of the section. Now there are different factors which need to be taken care of in the selection. The very first thing is what of the axle loads which are coming from the top.

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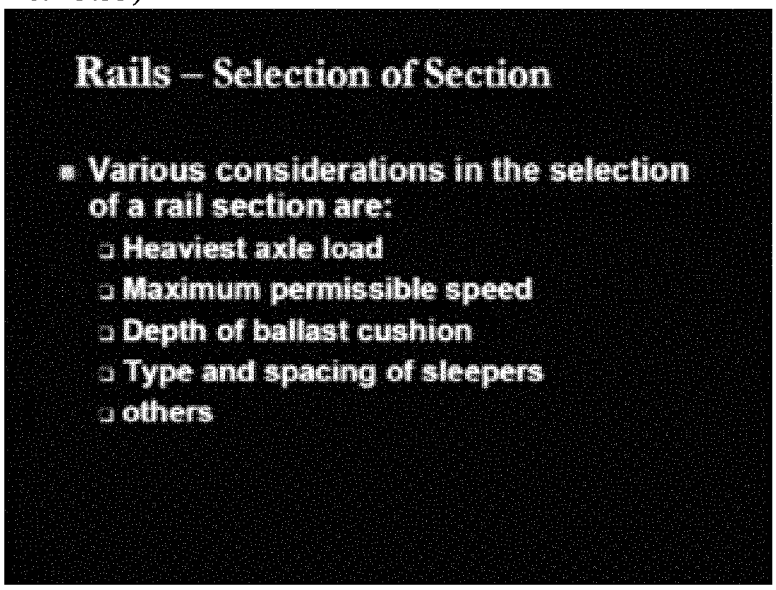

Depending upon the heaviest axle load we have to use the type of the rail section and there are certain relationship between the axle load and the type of the section. We will be looking at that one. The maximum permissible speed is another aspect. If we have to provide higher speed we require a better higher level of a rail section. Then what is the depth of ballast cushion? If the depth of the ballast cushion is lesser, then obviously a bigger rail section is to be provided. Then type and spacing of sleepers, that is the another aspect. If the sleepers are of inferior type or they are having lesser of spacing so that now these sleepers will be having more loads which are coming at that one, then also it is going to create some effect at the type of the rail sections and this type of relationships we have seen when we have seen the specification of permanent wheels. This is the permanent type or way of the root then what is depth of the ballast cushion to be provided? What is the sleeper density to be provided? Similarly, what is the rail section which needs to be provided?

Now here the relationship is being given as I was talking that the axle load can be related to the sectional weight of the rail, that is, in what kg per meter rail section is available to us and the relationship is that the maximum axle load is 560 multiplied with the sectional weight of rail in kg per meter.

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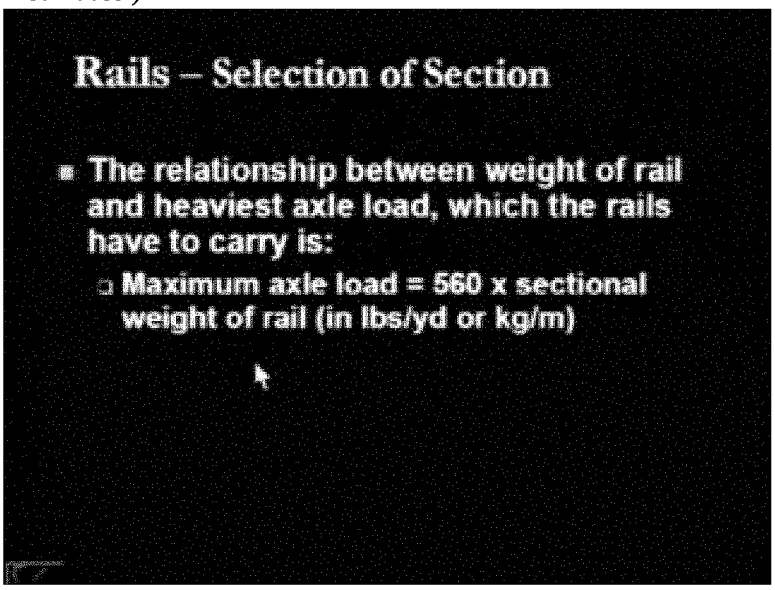

So if we are talking about the 52 kg per meter rail or if we are talking about the 60 kg per meter rail then that will get multiplied with 560 and it will give you the value of the maximum axle load which it can sustain. So we can transform this axle load into tones and that is how the axle load of the locomotive will be defined. So what type of locomotive is to be used will be defined in this form or if we have the locomotive and we have to see that what type of rail section is to be provided then using that axle load of the locomotive we can find out the sectional weight of the rail so it is a vice-versa condition.

Now another thing is that how we specify any rail, so what is the brand of that rail? Now there are different ways of doing it but we are using some way that is it is defined in some form of this line which is being shown here and this will be engraved on the rail section.

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It is IR - 90 R - TISCO - II 1985 - basic BASSEMER. Now what does it mean it means IR is for Indian railways, 90 R means it is 90 pound per yard rail section being used here. It may be 60, it may be 75 R. Then TISCO means this is a company which has manufactured this rail section, II is for the month in which it is being manufactured, 1985 is the year in which it was manufactured and basic BASSEMER is the manufacturing process by which that rail section has been manufactured. So this has been the previous way of defining it.

Now there has been little different modification in this one and what we have is this IRS- 52 kg- 710- TISCO- II 1991 arrow OB; what it stands for is that it is Indian railway standards specification IRS, 52 kg is the rail section as 52 kg per meter.
1710 is the grade of the rail. There is II grades of the rail one is the 710 another is 880 grade. TISCO is again the name of the company, II is again stands for the month and next one is 1991 is for year and it says it is being processed by the process OB. OB is the short form of again a sort of BASSEMER ordinary BASSEMER process of steel making. So whatever are the abbreviations available those abbreviations will be used instead of giving the whole beginning of that one. Similarly, in the case of this 52 kg per meter rail section, instead of this one as an alternative it may be 60 UIC rail section, this can be given at this level. So this is the thing that will be engraved and each and every rail section which is manufactured by any of the company and this tells us that what was year in which it was manufactured and accordingly the replacement requirements can be ascertained.

So another aspect related to rails is the length of the rail sections. The rails are manufactured in different length. In the case of the broad gauge it is 12.8 meters and the case of meter gauge and narrow gauge it is 11.89 meters.

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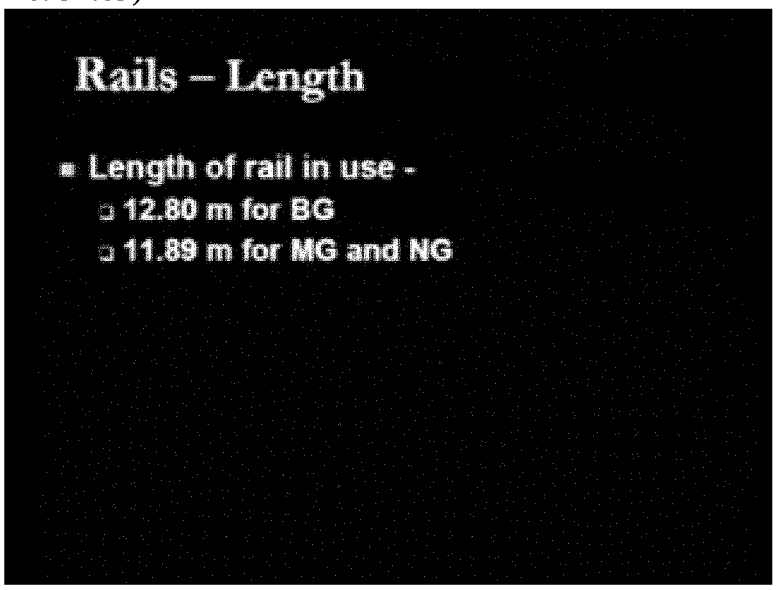

So this is length of rail sections which is used. Now this is restricted, we are not having the bigger rail section because of certain reasons. The one is that ease of manufacturing. We can easily manufacture smaller rail sections as compared to the large long rail sections

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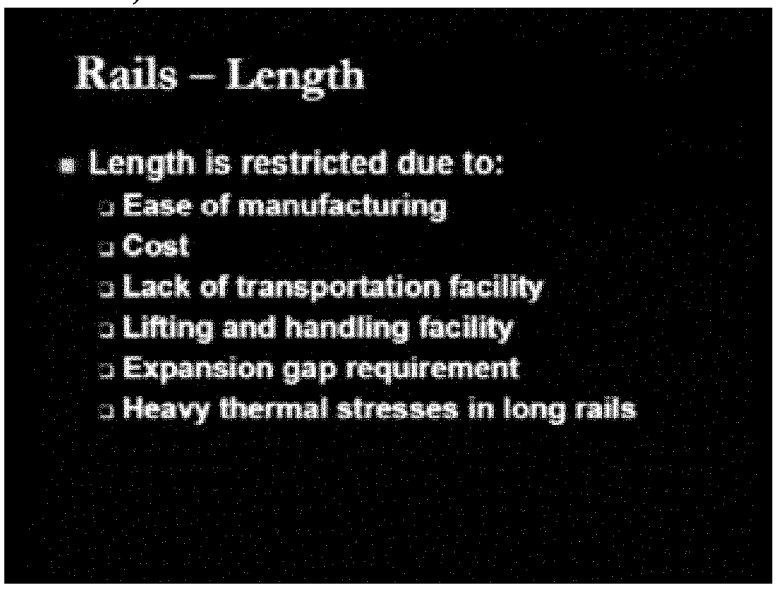

Another aspect is the cost of manufacturing the bigger rail sections. It is quite large as compared to the smaller rail sections. Then there is a lack of transportation facility of such big rail sections. We require a big wheel base on which those can be transported. Lifting and handling facilities are again of specific nature because it becomes a heavy weight condition. So therefore, it will not be available at each and every place. So it is better to have a smaller rail sections as compared to the bigger rail section.

Then if the rail section length is increasing it is going to also create an effect on the gap requirements to be provided between the two rail sections which have jointed at one level. Now because of that change in the temperature there will contraction and expansion of the rail section and if the length of the rail section is more then there is going to be proportionate increase in the movement in that direction may be in terms of expansion. So it means a larger gap is to be provided between the two rail sections and if the larger gap is being provided between two rail sections it will be a difficult situation as far as the movement of the wheels is concerned over that. Then heavy thermal stresses on long rails. This is as already discussed, it is going to take as a fact in terms of not only the movement of the rail but also in terms of the gap requirements especially expansion gaps which are to be provided. Looking at all these aspects the length of the rails has been restricted to as what we have seen is 12.8 or 11.89 meter in the cases of broad gauge or meter gauge or narrow gauge track conditions.

Now, coming to the 90 UTS sections. As we have seen that we have two types of the sections which we have been using one is 72 kg per meter rail section another is 90 UTS rail section.

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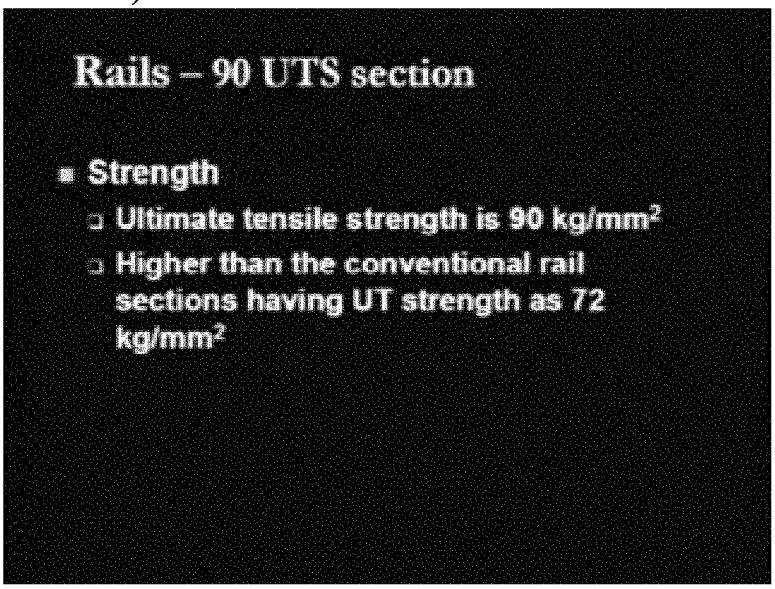

That is 90 kg per mm square ultimate tensile strength section and now this is heavier or this is a section which is having a better strength condition. Here the tensile strength is of the amount of 90 kg per mm square as compared to the conventional rail section which are having the value as 72 kg per mm square and that is how it is having a better strength value. So it can be used at those places where the heavy loads are coming or where the heavy stresses are getting induced.

Another thing is related to the stresses. In this case 90 UTS rail section provides allowable shear stresses of the nature of 22.5 kg per mm square.

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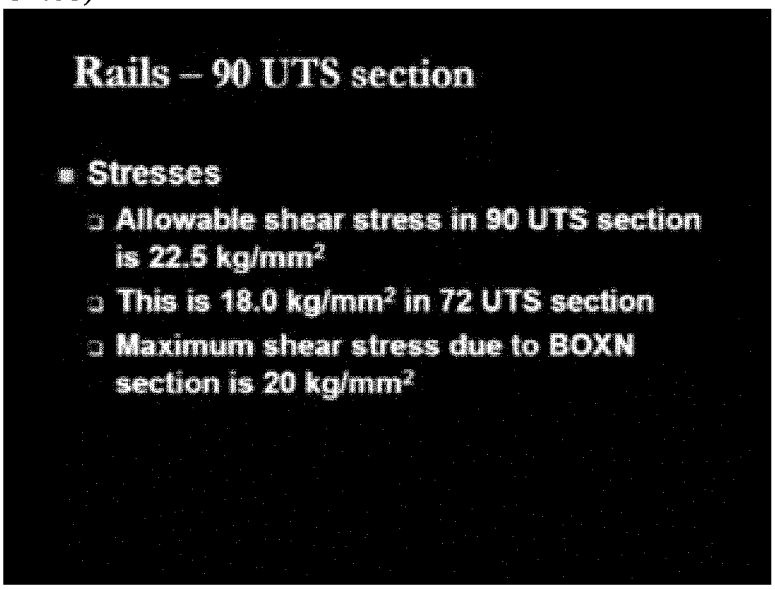

Now in the case of 72 UTS rail section the value of allowable shear stresses is 18 kg per mm square but in the today's condition when we are we are having a sort of box and wagons being used for the movement of the freight or we are having the heavy loads of the passenger traffic which are moving in certain directions. In those conditions the maximum shear stress are reaching to a value of 20 kg per mm square. Therefore, the 72 kg or 70 per mm square or 72 UTS rail section will not be able to take up these type of stresses and it is better to shift to 90 UTS rail section in this cases. Another characteristic of 90 UTS rail section is related to its hardness. We are having that hardness due to higher hardness value the resistances of the wear are also lesser.

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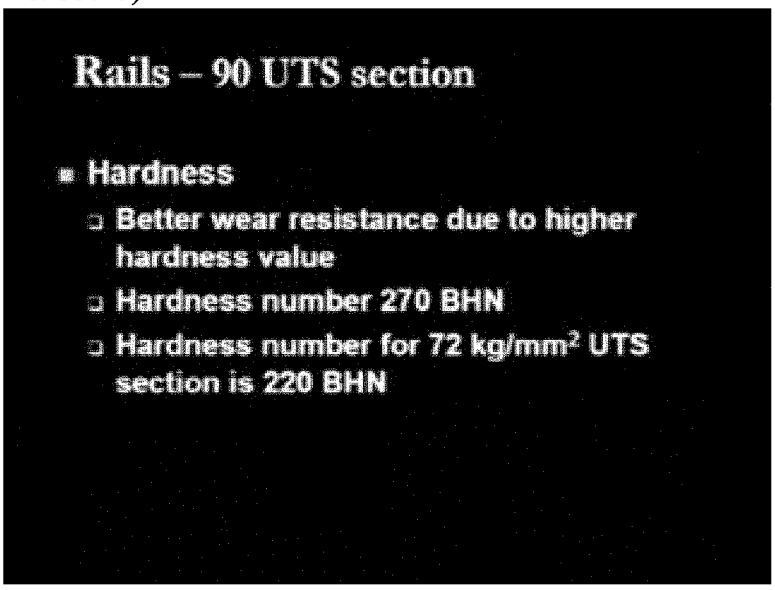

The 90 UTS rail section is having hardness number of 270 BHN; this is Brinel Hardness Number, as you must have studied in the previous years. This is the way of defining the hardness based on the indentation in the metal. So on the basis of that it is giving a value of 270 as a hardness number whereas in the case of 72 kg per mm square UTS rail section this value is 220 BHN, so it is quite higher as compared to that one.

Then the next step, next value which is of advantageous condition to 90 UTS rail section is of its service life. The 90 UTS rail section is having 50 percent higher service life as compared to conventional 72 kg per mm square UTS rail section.

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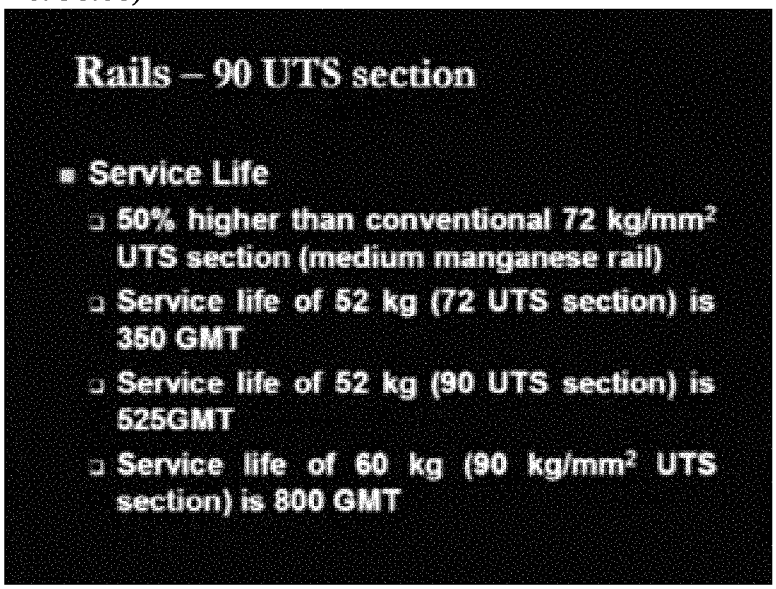

So this is another aspect which has a long term effect in terms of its maintenance or the periodicity of the maintenance or the replacement requirements of the rail sections. If we look it with respect to amount of loading conditions then what we found is that the service life of 52 kg of 72 UTS section is 350 gross million tones of the load in a year. Whereas in the case of 90 UTS section with the same of 52 kg per meter rail section it is 525 GMT and if we also change the sectional load of that rail section from 52 kg to 60 kg per meter and still we are maintaining with the 90 UTS rail section what we found is that the service life increases to 800 GMT. It means in the previous case it is increasing as something like one of the half times or in the case of later one it is increasing more than two times.

So this is how the service life has been increased in the section and therefore the maintenance requirements of those will get reduced. It has economical aspect in this sense. So that is why the 90 UTS section now are of more in use in all those track conditions where they are heavy loads moving or there are differential loads moving in different directions. Then they also adaptable for high speed tracks or heavy loads corridors. They have a lesser wear on curves and gradients with this lesser wear is related directly to the hardness number as we have seen it has a higher hardness number as compared to the conventional systems and obviously service life as we have seen

previously is as high as 50 years. Maintenance life is comparable to the life of other components like concrete sleepers, elastic fastenings etcetera.

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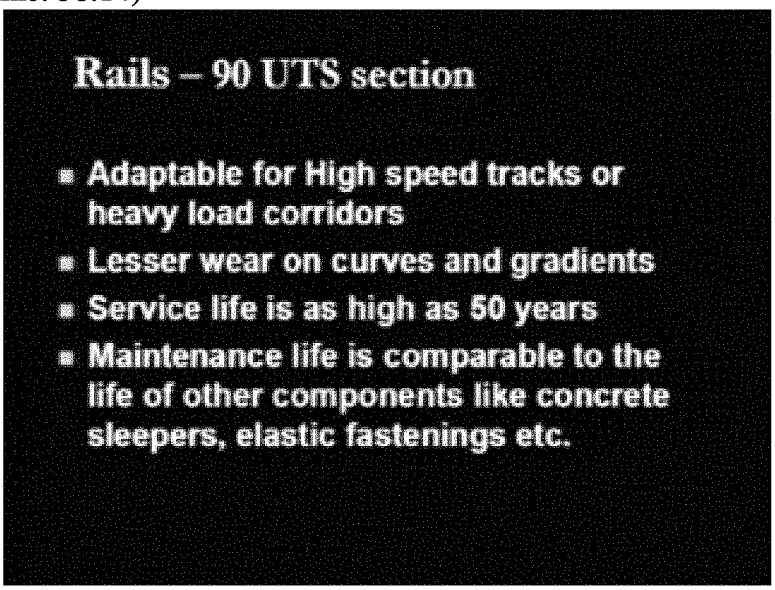

This is one more aspect here. Now the overall system of track is not of one single component being provided it is a combination of components. Now when we have a combination of components then the service requirements or the maintenance requirement of all those components will be there and if the periodicity or the maintenance requirement of those all those components are different then it means at one time we have to take out one component and by doing that the rest of the component also to be loosened out. Then once it is being done then again the time will come for the second component, then for the third component. It means again and again we will be doing the same exercise, whereas if all the component which are being at one place they are having similar life span then at one point of a time all of them material can be taken out and can be replaced simultaneously together. So that is what is the more important optimized and efficient way of doing the maintenance and this is possible in the case of 90 UTS section because it has its life which is comparable to other components to which it is being fixed, that is, the concrete sleepers or the elastic fastenings. Now this is one of the biggest advantage in this case.

Now we come to some of the test we conduct on rail section. The test for grade 710 rails are falling weight test by which we try to find out the fatigue condition of that rail section.

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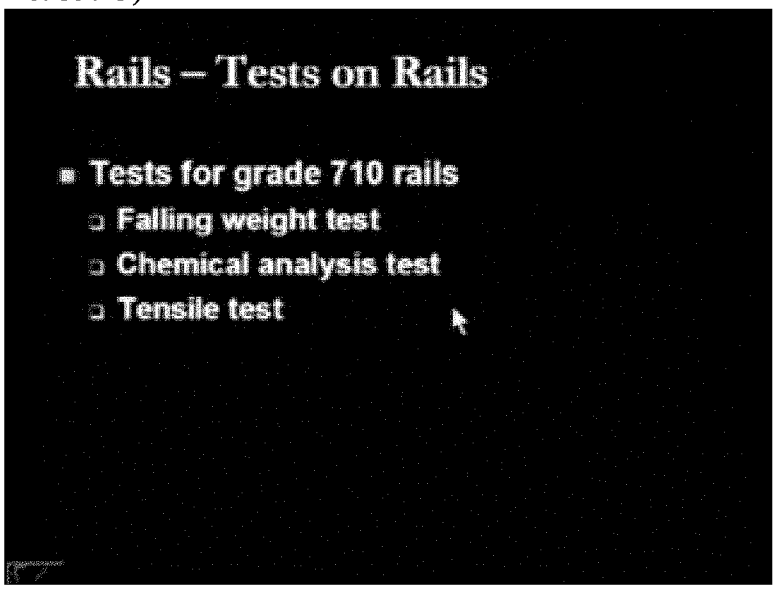

The chemical analysis test is to identify the proportion of the chemicals which have been used; the type of chemicals which have been used in the manufacturing of that rail section and the tensile test so as to identify the tensile strength of the rail section so that we can find out what are the stresses which can be taken up by that rail section. In the case of 880 rail grade there are some more test other than the falling weight test, chemical analysis test and tensile test.

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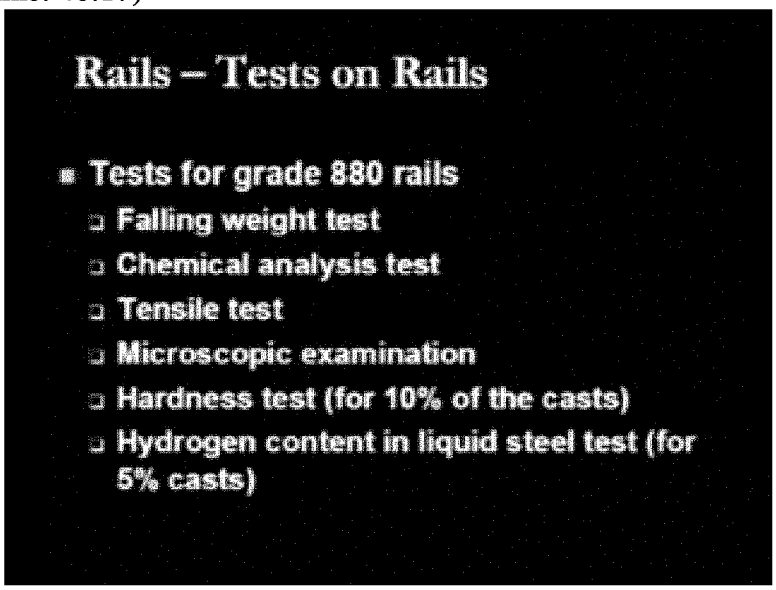

They are microscopic examination where in the microscopic examination helps you to identify the total causes by which that rail section has been created or manufactured and if there is any flow in that one then that can be found out. The hardness test is to be done in the case of the ten percent of the casted materials of the rail sections and similarly

there is another test which is termed as the hydrogen content in liquid steel test and this also to be conducted for limited cases as five percent of the cast. So these are related to 880 rail grade section.
Now, we come to some sort of the deformations or the defects which may be caused in the rails.

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There are different types of deformations or defects; one is corrugation, corrugation is the condition in which at the top surface of the rail section certain irregularities get created. What we found is that at certain locations the material has come out in the form of small, very very smaller minute chipping and that is how that irregularity has been created or there is a wavy pattern that has been created at the top surface of the rail section and this is what is the corrugation which is being created.

Now as soon as anywhere the link stops moves over these corrugated rail section what is being observed is that it creates a large amount of noise and because of this reason that they are creating large amount of noise they are also known as roaring rails ,that is, the rails which make noise. Another is type of deformation which is being observed is hogged rails. These hogged rails have being discussed previously too is a peculiar condition which happens at the joint of the rail sections. At the joint of the rail section what happens is that because of the loosening effect of say the fish plates and the bolts or because of the loosening effect of the ballast cushion which is being provided around the sleepers below the rail sections, or below the sleepers, or because of the any one levels which have been provided or which have been created, got created in the rail section. Whatever means are moving at the top of that one they will strike at one of the rails whichever is having a higher level. So because of this striking the large impact will be created and this large impact will start moving the rail section in the downward direction. So there is a downward movement of the rail section at the end of the rail section and this is what is known as hogged rail.

Another case is of a kink in rail. Kink in a rail is a case where wherever the joints are there the two rail sections goes out of order with each other and that is what is a kink in rail. It is a sort of a condition where the two lines are being jointed together which are at a different grades and that is the point of connectivity of these two lines termed as the kink and this is the type of the thing which happens in the case of rails also if they are not provided together and they have been jointed using a fish plates and the bolts. So you can say that it is sort of a relative movement of one rail with respect to another rail in the lateral direction and creating a kink at that level.

Then buckling of the rail buckling of the rail is related to the effect of the loads which are coming at the top and due to which the rail goes out of its shape and there is a sort of widening of the gauge or there is a sort of a reducing of the gauge because of that buckling of the rail. Damaged rails are the rails which are showing any type of failure pattern it may be the cracking pattern, it may be the loss of the material or it may be any other thing which causes which can categorize the rail into the failure conditions. So that what are the sort of damaged rails. We cannot use those rails, we cannot remedify those rails.

Then they are different type of rail failures. The rail failures may be caused because of various aspects. We will be looking at all those failures in when we take up in detail the rail failures as well as the wear on the rails. What type of wear on the rails can be there, may be on the top of the head, or the side of the rail head, or at the bottom, or what are the reasons due to which those happens and how we can remedify those wears on the rail failures will be of the next aspect which we take up in some other lecture. Now looking at all these sort of deformations, or the type of the defects, or the type of the damage conditions which can be there, we can see some of the things here and this one the corrugation has been shown. This is the sleeper and this is the rail section which is being provided here and these are the corrugations which are being shown.

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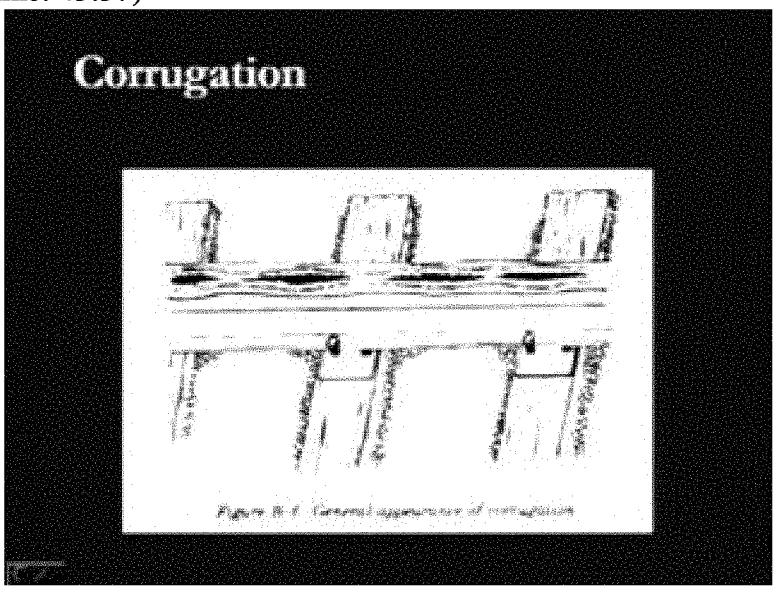

What we see is that this wavy pattern which is being caused here and this is defining this thing as well as there is a sort of a spouting condition which is created at the top of this rail section head which will cause the air being filled in this one and as soon as this wheel moves on this one because of this movement of the wheel with respect to this air filled in there will be noise get created at this one. So, that is why they are also termed as the roaring wheels

Then this is rail end batter or the battering of the rail or hogging of the condition as we have discussed. It happens at the end where the two rails have been jointed together. So what we found is that this is straight profile up to this point and then it is going down like this.

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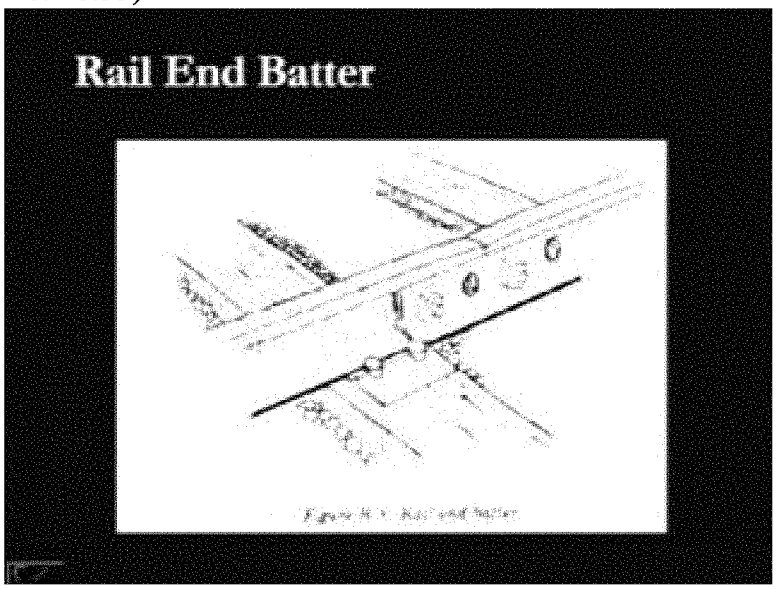

So this is what is the battering effect on this side and this is what is the battering effect of this side. So, once this type of a battering effect has been done now what we have to do is, we have to loosen out these fish plates and then this have to be dehogged means it has to be pulled back to the normal conditions so that they become the same level. So that is the way it is to be done. If it is not possible then it is to be cut out and another section is to be fitted in. Then these are some damaged conditions. Here we can see that the whole of the piece has come out in this case or in this case, that is, from this side it is breaking down this is at the end it is breaking down and this is the starting of breaking of this section from this side or starting of the breaking of the section with respect to the point of connectivity of this web section with this footed condition and this is the curve of the fillet which will be there at this point.

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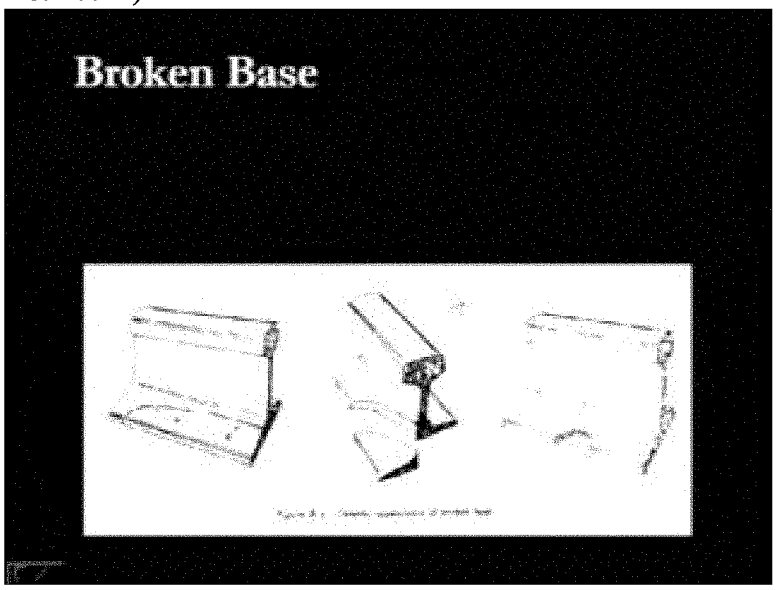

So this type of failures can also be there and that is, what is a broken base failure. Another type of a broken base failure is which where the track is coming through out the section starting from the head, moving through the web and coming towards the foot.

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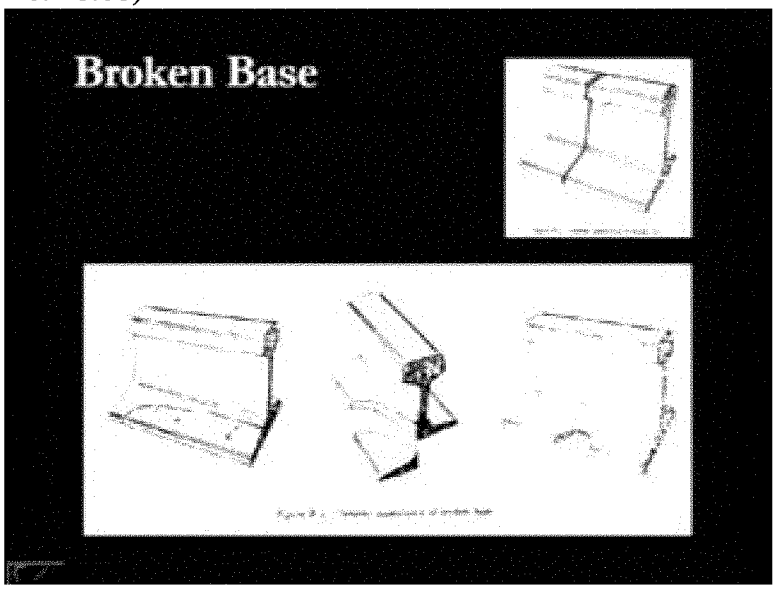

So that is how the total rail section has got divided into parts and we cannot use this rail section. Further, it has to be taken out then there are chances that the material gets chipped off and when this material is getting chipped off in the form of small layers then that is termed as flaking.

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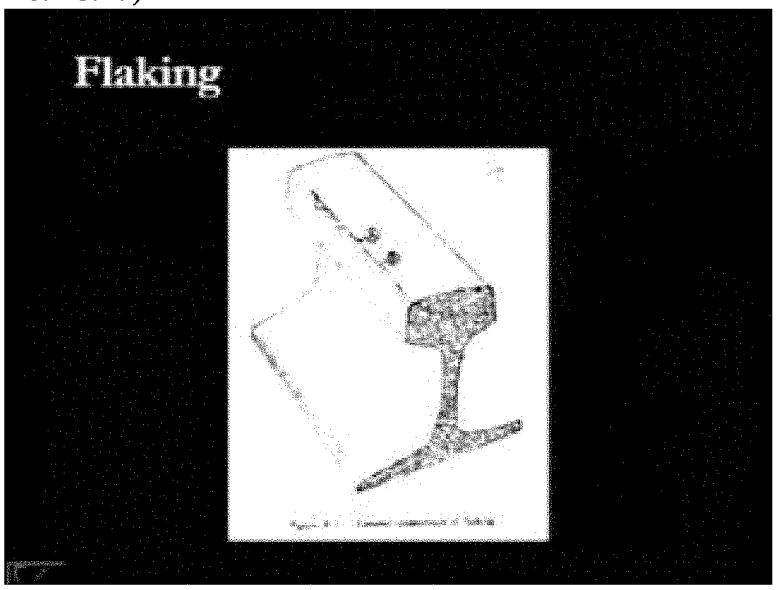

So here this flaking is taking place at this location. Here the location at this location with what found is that there is a smooth profile as such but at this location slowly and slowly there is a irregularity and this material in the lay out form is getting chipped. So this is another type of damage which is getting created to flake rail section and also necessitates to remove the rail section.

Then here we are talking about the piped rail. The piped rail means it is a sort of pipe condition which gets created as we see in this sectional diagram. This material has gone away from each other.

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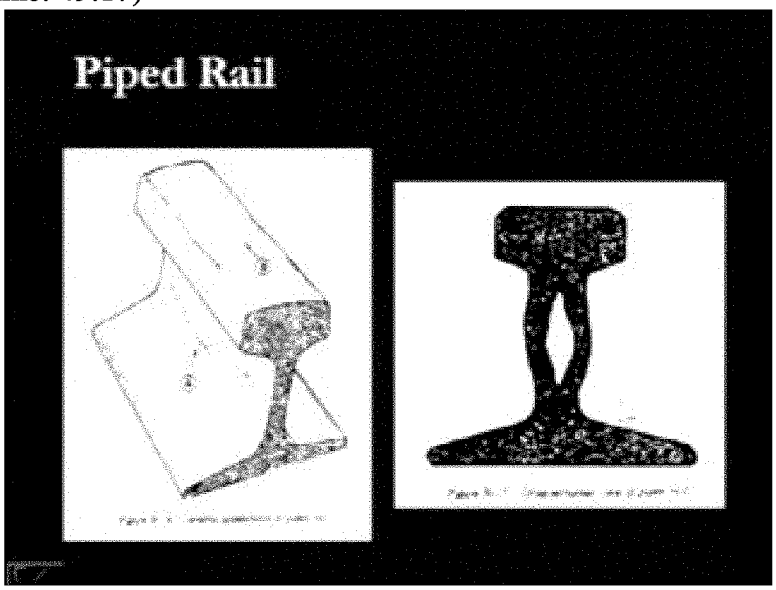

Here what we found is that in the web there is the hole being created in the longitudinal direction. So in this longitudinal direction this is how it has come out on this side as a bulging as well as this is also bulging on this side like this. So this gap gets created and this is what is the pipe being created between the rail where same sort of condition may happen in this location too.

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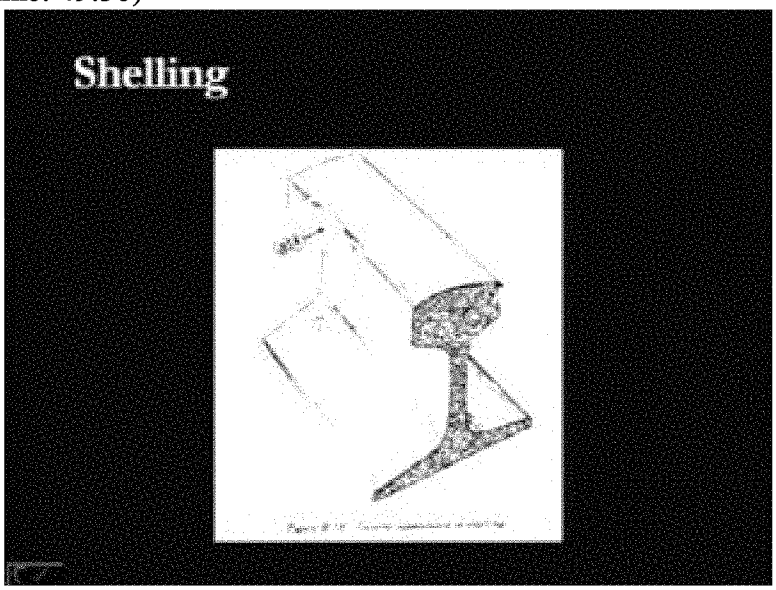

Finally, another case is the shelling. Shelling is a further bigger case of flaking where in the case of flaking very small particles in the layer form was coming out of whatever is the section on which that was happening but in this case what we found is a large amount of material is coming out and when this large amount of material is coming out this is how it will create a sort of a depression at this top surface and therefore if this top surface falls towards the side from where the flanges will be acting then obviously it is going to create a big problem. The one way of dealing with these types of conditions is that we just change the face of the rail section. So if in the initial condition this is the inner side of the rail section and what we can do is that we can make this as outer side of the rail section and we can just turn this rail like this and the outer side of the rail section will become the inner side of the rail section. In that case then we can use the same rail still for some more time period increasing the life of that rail section.

So in these all cases what we have seen is that there are different types of defects which can take place in any of the rail section. So in that sense we have checked in this particular lecture the various requirements and functions of any of the rail sections. We have also seen that what are the different types of the rail sections which are available to us and then on the basis of comparative studies of all those rail section and the historical background of those we have come up to use the flat footed rail sections which are more advantageous as compared to the other sections. Though there are still some more problems related to the loosening effects or to the laying and relaying of those systems and then we have also tried to see the length, the aspects related to the respecting of those length, the selection of any of the rail section on the basis of certain factors and then we

have seen the various type of damages which are caused in any of the rail section. So we are we will be closing this particular lecture at this point of time and we will be taking up another component of the track that is the sleeper in the coming up lecture. So thank you and bye bye.