Introduction to Multimodal Urban Transportation System
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Lecture – 56
Urban Transport and Sustainability:
An Introduction to Pedestrian Road Safety and Associated Risk Factors

Welcome back friends. We would now take you into the realm of safety in multimodal urban transportation systems and look at how you can improve the safety of pedestrians in your urban area.

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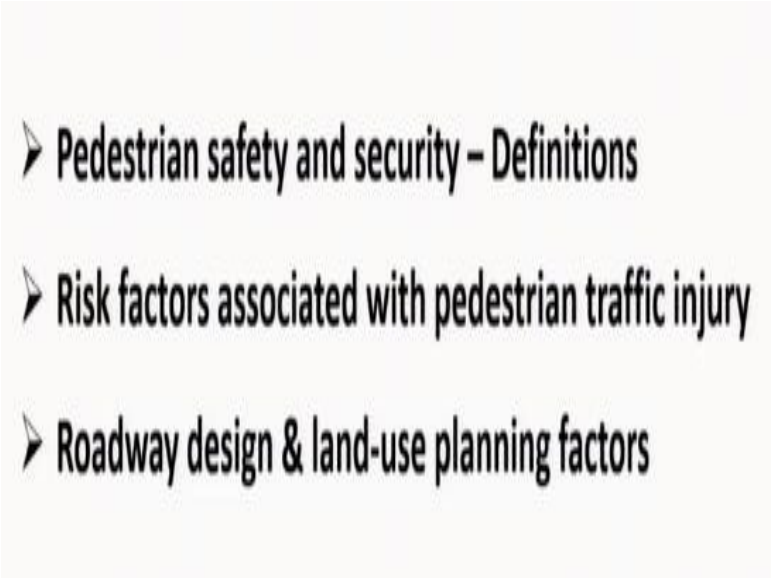

Now, safety in itself is a very large topic, and we can have a NPTEL course purely on safety. So, we are only going to cover 2 or 3 lectures on safety and are going to give you a high-level overview of what do we mean by pedestrian safety and why should you be interested in providing safe designs and safe infrastructure, what are the different risk factors involved and how you can incorporate them in your land use and design of roadways.

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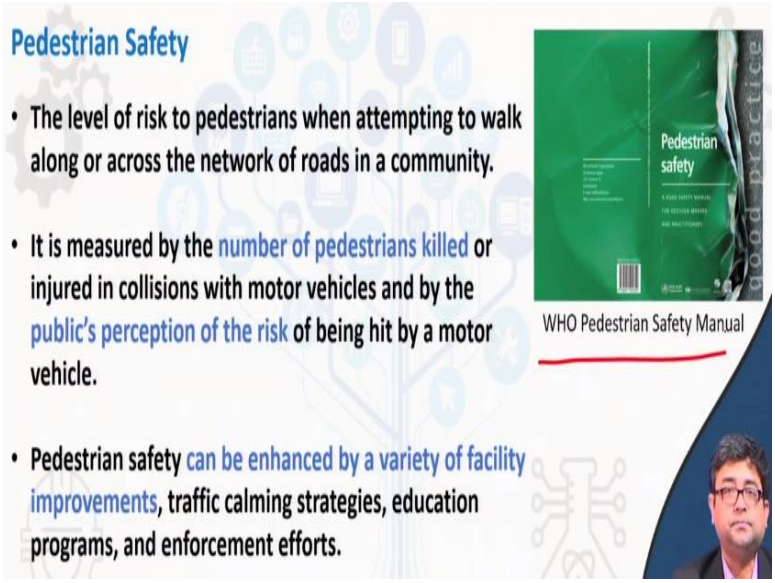

Now, when we talk about pedestrian safety, we are trying to say that the level of risk that pedestrians face when attempting to walk along or cross any network of roads in a community. The level of risk that the pedestrians face. So, what are the different kinds of risks that one may face, it may be because of the volume of vehicles that are on the road, it may be because of the speed of vehicles that is on the road. It may be because of the condition of the vehicles that are on the road and it may be because of multiple other factors such as distraction while walking, such as poor road design. So, there are different factors that may give rise to a risk to the pedestrian while he or she is walking along the road or crossing an intersection. So, this safety is usually measured in the number of pedestrians killed or injured in collisions with motor vehicles and by public's perception of risk of being hit by a motor vehicle.

There are two ways. The actual is the count of the number of accidents or crashes that have happened between pedestrians and vehicles and the second is even the perception of say the unsafe intersections. Even if there are no actual accidents that have happened, but if the pedestrians perceive that this location is dangerous for him or her, he or she may not be willing to walk on that road. So, there are two ways to look at safety.

Pedestrian safety can be enhanced by a variety of facility improvements such as traffic calming strategies, education, and enforcement efforts. So, this is a very, very broad understanding of what pedestrian safety means, and we will be taking most of the materials on pedestrian safety from the WHO, World Health Organization's pedestrian safety manual

that has been developed. So, even the World Health Organization is looking at pedestrian safety as a health risk, because of the severity of the injuries that are involved.

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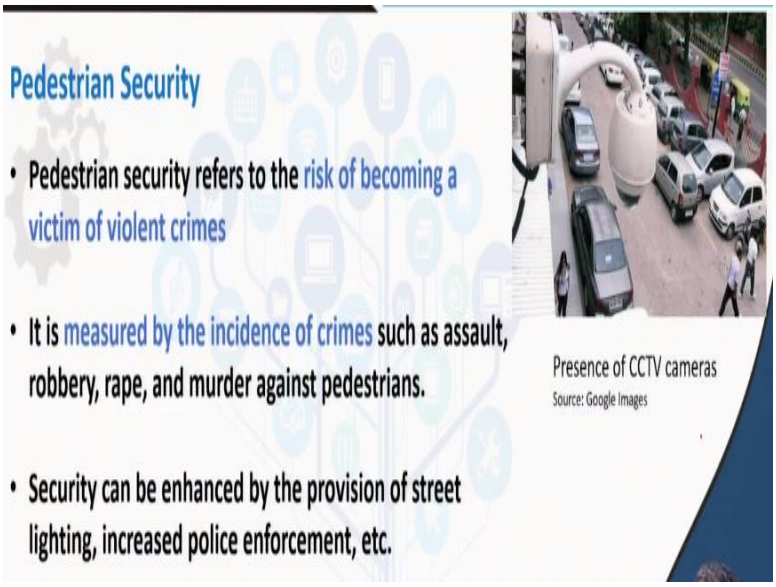

The other aspect that is also included when we talk about pedestrian safety is pedestrian security. So, these two have slight difference in their meaning. When we say pedestrian security what we mean is the risk of becoming a victim of a violent crime while you are walking. Violent crime includes assault, robbery, rape or even murder against pedestrians. So, what happens is when you are walking you may be a) is a risk of being hit by a vehicle, and b) is you may be robbed.

There is risk of being robbed, risk of other kinds of assault while you are walking because while you are walking you are vulnerable to the entire environment around you, while you are driving a motor vehicle, especially a car, you are surrounded by the environment within the car. Even in two-wheeler you can speed away from the situation whereas when you are a pedestrian, you are usually a vulnerable road user and you may be vulnerable to different forms of assault.

So that is the aspect that security deals with and safety deals with the accident part of the risk. So, security can be enhanced with the provision of street lighting, increased police enforcements, all the CCTV cameras that have now installed, all of these gives rise to an improved sense of security among the pedestrians.

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So, why should you be looking at pedestrian safety? Is it a big cause of concern? What are the numbers when you talk about pedestrian accidents? so on and so forth. So, if you look at the numbers by itself, you know that safety along our roads is a major issue. We almost lose 400 lives on Indian roads every day on an average. So, on average every day an equivalent of a Boeing plane crash happens on our roads.

But unfortunately, not a lot of effort or not that degree of effort is being put into reducing these accidents. So, when you look at from among all the traffic accidents that happens, almost 22% of them are encountered by pedestrians. So, almost one fifth of them happen with pedestrians. Globally about 2 lakh 73,000 or 75,000 were killed in road traffic crashes when we looked at old 2010 data.

So, maybe these numbers have gone up or gone down in the last 10 years is something for us to look at. So, these were the people that were killed. So, the other thing with pedestrian accidents is that many accidents go underreported or unreported. Because if it is a minor accident, nobody tends to want to report that or even reports it, they just brush themselves away and go on their merry path.

So, you never know how many actual accidents are happening. Accidents are reported only almost when there is a grievous injury or there is a fatality or so on and so forth. So, when we talk about the people killed is 2 lakhs, the actual number of accidents would be much higher that the pedestrians encounter. So, this is a serious cause of concern for all of us urban

transport professionals. So, this is what the fatalities might be, actually the number of crashes may be much higher than just fatalities.

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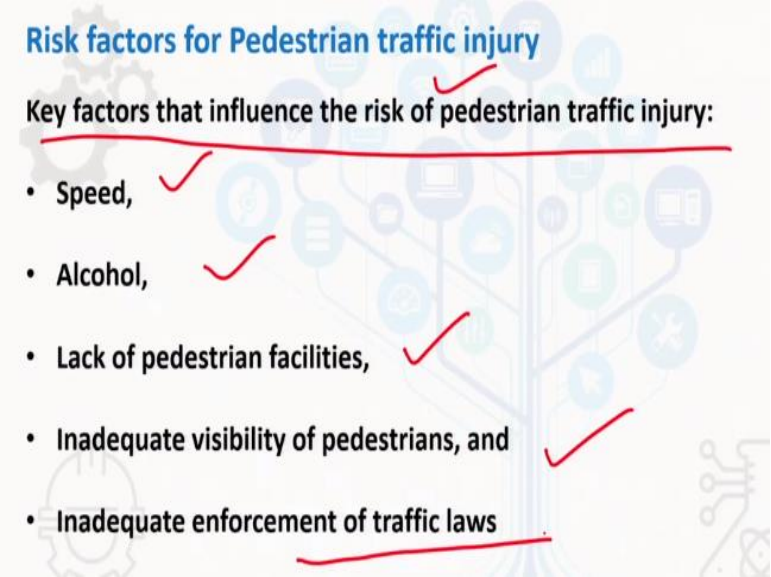

So, when we are looking at what are the key factors that influence the risk of pedestrian traffic injury, worldwide it has been seen that speed is one of the key factors. Speed of vehicles is the foremost factor that increases the risk of pedestrian traffic injury. The next is driving under the influence of alcohol. That is the second key element in increasing the risk of pedestrian traffic injuries.

Then is the lack of actual pedestrian facilities in themselves. Fourth one is the inadequate visibility of the pedestrians. So poor design of the roads and poor lighting and poor gear that people wear is the cause of traffic injuries, and finally inadequate enforcement of traffic laws may also lead to higher risk of pedestrian traffic injuries.

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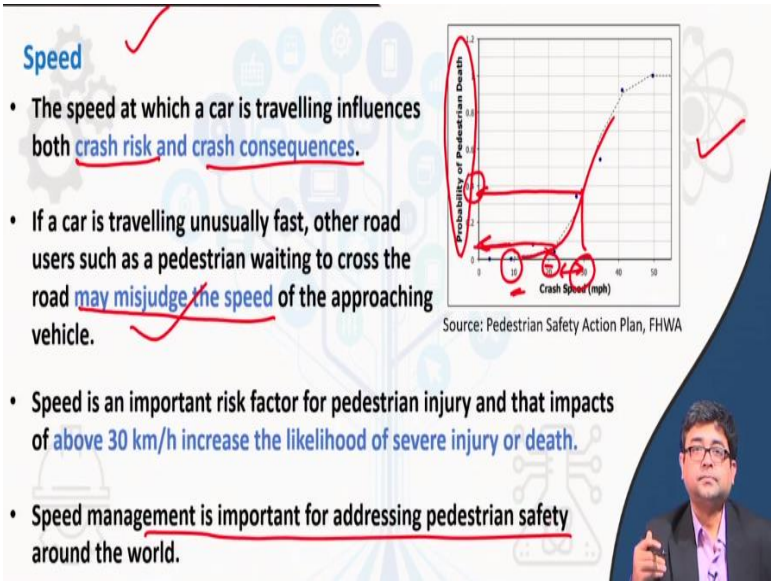

So, when we look at the aspect of speed, what has been noticed is that the speed at which a car is travelling influences both the crash risk and the crash consequences. So, the speed determines not only the risk of a crash, but also what happens if you are involved in that accident. So, what this chart says is that if the crash happens at a lower speed, the probability of the pedestrians succumbing to the injuries is very low.

So, if somebody is traveling at 10 miles per hour and hits a pedestrian, so the probability that he or she would die because of that injury is even less than 10%. But what happens is that it exponentially increases beyond 20 miles per hour. So, if you are hit by a vehicle at 20 miles per hour, your risk of death is still very low. However, just 10 miles per hour increase, your probability of dying goes up almost by 40%. So, there is four times increase in your probability of death while you are a pedestrian if you are hit by a vehicle that is moving at 30 miles per hour as compared to 20 miles per hour. So, this is what the pedestrian and every motorist must be aware of, but 30 miles per hour even does not seem very high. But if you are traveling even at that speed, if you hit a pedestrian their probability of dying is very high, almost 40%.

So, you must be careful when you are driving on the roads, you have to always keep in mind that the road is not only for motorized vehicles, but the road is also for all users. Road is for pedestrian, road is for a bicyclist, road is for different types of non-motorized users as well. So that is the training or that is the behavioral change that all the motorists must bring in themselves. The major cause for these crashes is that the pedestrian misjudges the speed of the vehicle that is coming towards him or her. Because of the lack of judgment of the speed

he or she may want to cross the road right in front of that speeding vehicle. So that will always cause, a cause of accident is always higher because of the misjudgment of the speed. Hence speed management is an important issue of addressal around the world when it comes to pedestrian safety. Speed management includes several design factors, several education and enforcement factors that are involved in managing the speed of motor vehicles.

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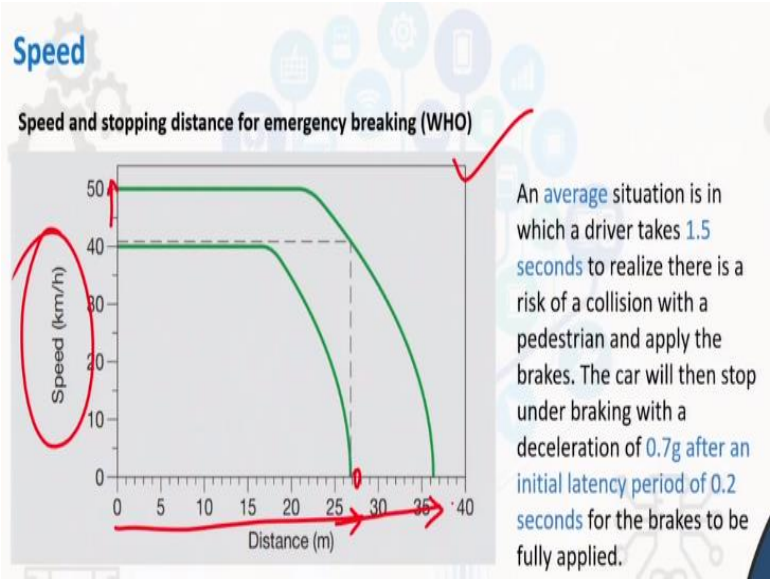

This is another chart which tries to explain the stopping distance, how a motor vehicle can brake depending upon what speed he or she is traveling at. So, if somebody is traveling at 40 kilometers per hour, he or she can brake within 26 or 27 meters from the point where he or she is. Whereas if the speed increases and somebody is traveling at 50 miles or 50 kilometers per hour that stopping distance increases by almost 10 meters. So, the slower you travel, higher the chances that you will be able to brake before a pedestrian if you encounter a pedestrian suddenly and lower are the chances that an accident will happen. So always drive at a speed that is either posted on the road or even sometimes driving at a speed lower than the ones that is posted, especially if the environment has a lot of pedestrians and bicyclists in them.

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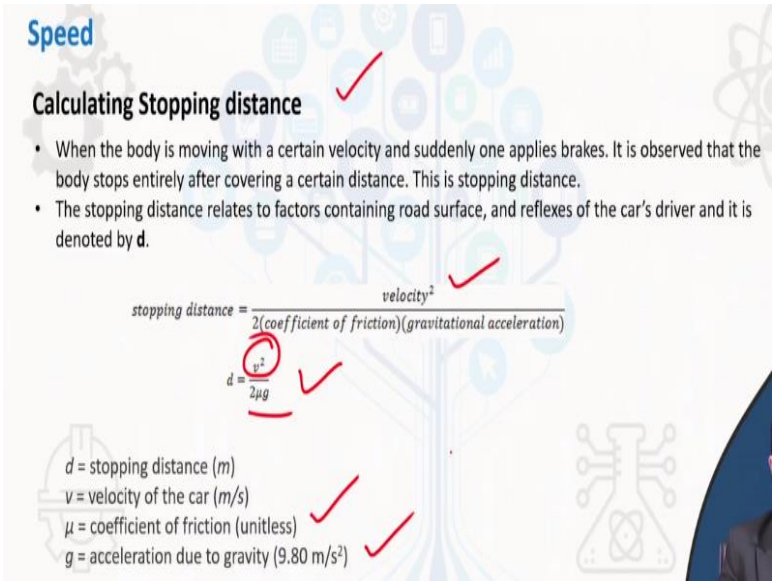

The stopping distance is simply given by a formula that everybody whoever has taken a traffic engineering course in their undergraduate level understands. The stopping distance is related to the speed at which the vehicle is moving, and it is given by the formula velocity square divided by 2 mu g where mu is the coefficient of friction and g is the acceleration due to gravity.

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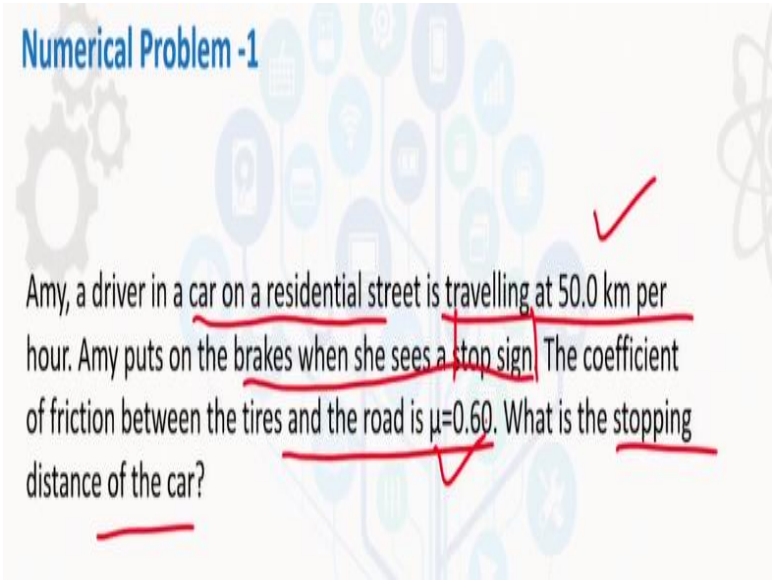

So, if Amy a driver in a car on a residential street is traveling at 50 kilometers per hour and she puts on a brake when she sees a stop sign. The coefficient of friction between the tires and road is 0.6. What is the stopping distance of the car? So, she sees a stop sign, where for example, a pedestrian is waiting to cross. Now she is traveling at an extremely high speed, and with this kind of coefficient of friction, how much distance will it be before she is able to bring her car to a full stop.

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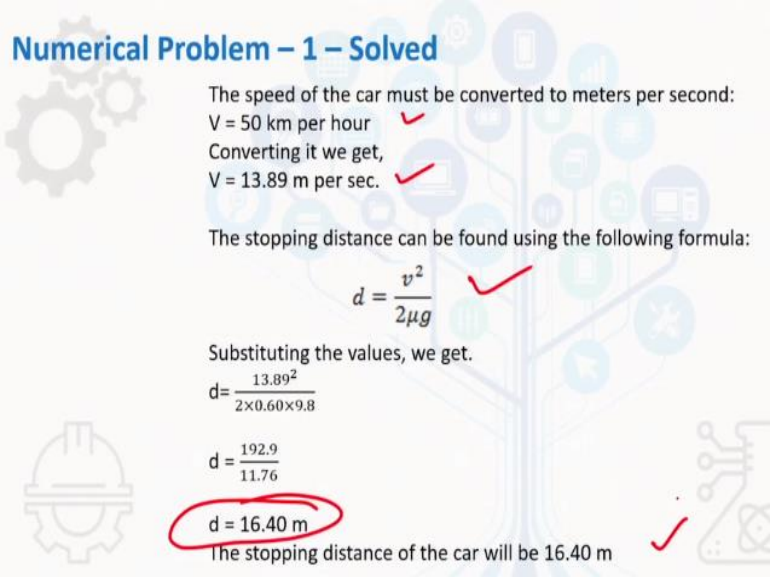

So, if you just convert this into meter per second and put it into this formula, you will see that 16.4 meters is the required distance. So, if Amy is already too close to the stop sign, she may not be able to stop the car in time before the stop sign. So that is what is especially important when you are even designing your crosswalks especially at midblock or at an unsignalized intersection, we must make sure that there is enough stopping sight distance for the motorized vehicles. So, warning signs must be put up much in advance of the intersections so that vehicles can slow down and stop and allow the nonmotorized users, i.ie., pedestrians or bicyclists to cross the road.

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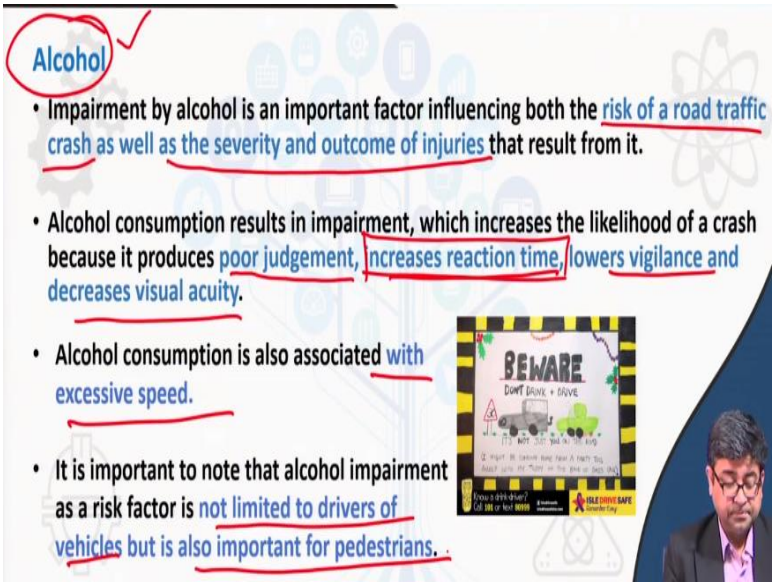

The second most important element in any pedestrian safety related issue is the presence of alcohol in the blood content of the motorcyclist that is involved in the accident. What

happens is impairment by alcohol increases both the risk of the road traffic crash as well as the severity and the outcome of the injuries, just as speed, both the occurrence of the accident is also increased as well as the severity or outcome of the accident also increases. It is also dependent upon whether the person is under the influence of alcohol or not. Alcohol consumption reduces or gives rise to poor judgment, increases the reaction time, and lowers the vigilance and decreases visual acuity. So, this is something that transportation engineers always harp upon saying that it increases the reaction time of the motorists or the driver.

You may be able to react very quickly if you are normally driving, whereas if you are driving under the influence of alcohol, you may not be able to react quickly to the situation where a pedestrian comes in front of you and hence will not be able to apply brakes or maneuver your car around the pedestrian or bicyclist. Alcohol consumption is also associated with excessive speed. The alcohol impairment is a risk not limited to the drivers of the vehicles, but it is also an important for the pedestrians. Even pedestrians should be aware of the environment while they are walking if they have consumed alcohol and should not always be blaming it on the motorcyclists. Pedestrian should also be careful while crossing a road for example if he or she has consumed alcohol. So, alcohol consumption related pedestrian accidents are growing over the years. And this is a cause of concern for many enforcement agencies as well as urban local bodies. Strict vigilance is nowadays in place around certain areas where usually people do consume alcohol and then try to travel and that is completely discouraged.

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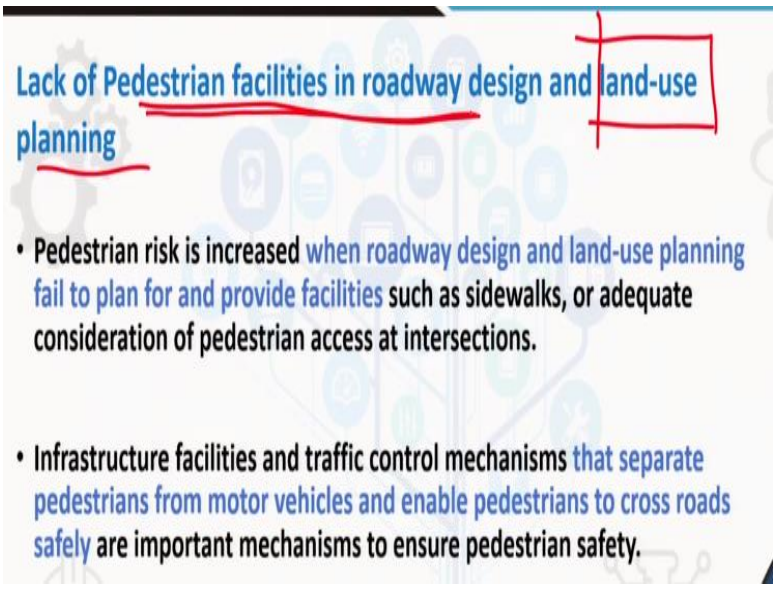

The other part of course is the even lack of pedestrian facilities and poor land use planning as well. You may often encounter for example a school right alongside a high-speed road. A

high-speed national highway or an expressway suddenly sees a school alongside the road and the school has an approach road where a lot of young children are either waiting to get on the bus or trying to cross the road, which creates a completely unsafe situation for all those children or any pedestrian for that matter. So, land use planning when it comes to providing safe pedestrian or nonmotorized infrastructure is especially important and also providing the proper types of pedestrian facilities in the roadway design if there is an intersection that has two or more lanes, then you have to provide a refuge island for example. So, you have already looked at such design principles when we were discussing the NMT modules. So, lack of proper pedestrian facilities is also concerned when it comes to pedestrian safety.

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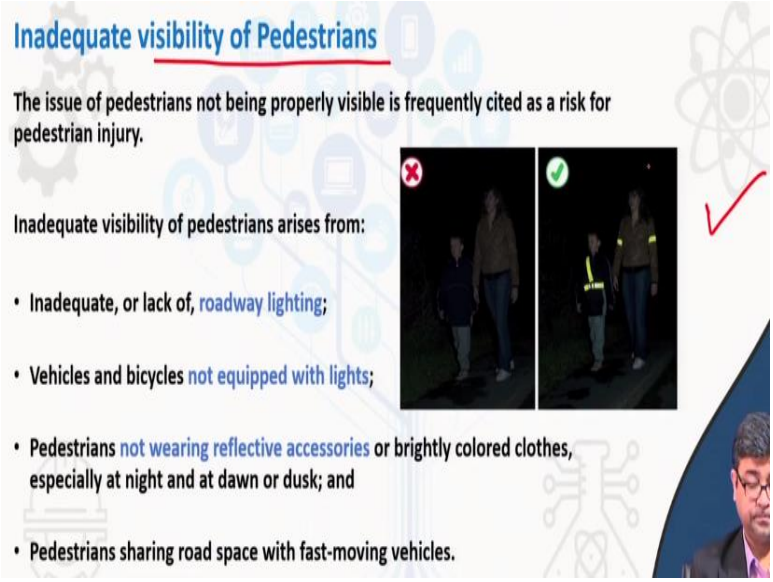

Inadequate visibility of pedestrians is an issue. So, at night you are always recommended to wear something that reflects, that is translucent. Otherwise, you may not be visible to an oncoming motorcyclist, especially if the area is not very well lit. If the area is well lit, it is a different issue. So, there are two issues involved here – the area must be also well lit and also the type of clothes that you wear at night should also be something that is retroreflective in nature and allows greater safety to the pedestrians.

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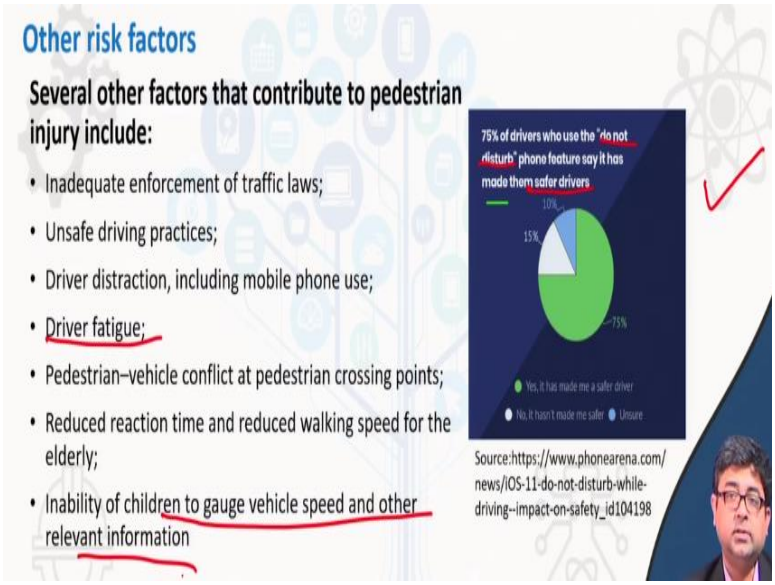

Other new risk factors what we have noticed in our current research is that when motorists drive their vehicles with their mobile phone in a switched off mode or in a do not disturb mode, most of the drivers do feel that it has converted them into safe drivers. So, the use of mobile phones while driving is prohibited in many of the metropolitan areas even in India as well.

So, the next time you are driving a motor vehicle and your phone rings, kindly do not attend to it while you are driving. Either have it at a do not disturb mode or just let it ring and you can pick it up once you park your vehicle. So, these are some things that are education related that drivers must be aware of. Now that you know that the risk of pedestrian injury goes up 40% almost when your speed goes up to 30 miles per hour. You should not be talking on the mobile phone or any other forms of distraction while you are driving should not be entertained to improve the safety conditions of pedestrians.

Driver fatigue is an especially important thing, especially we noticed this among truck drivers who drive for a longer period. So, there is always a relaxation time built into their schedules, so that they do not drive more than 8 hours a day or so. Because due to fatigue again your reaction time increases and you are not able to react in time to avert a dangerous situation, reduced reaction time. Inability of children to gauge vehicular speed and other relevant information. You must be careful when you are dealing with children and elderly people on the streets. It is always safe to accompany them with some adults so that safety is enhanced.

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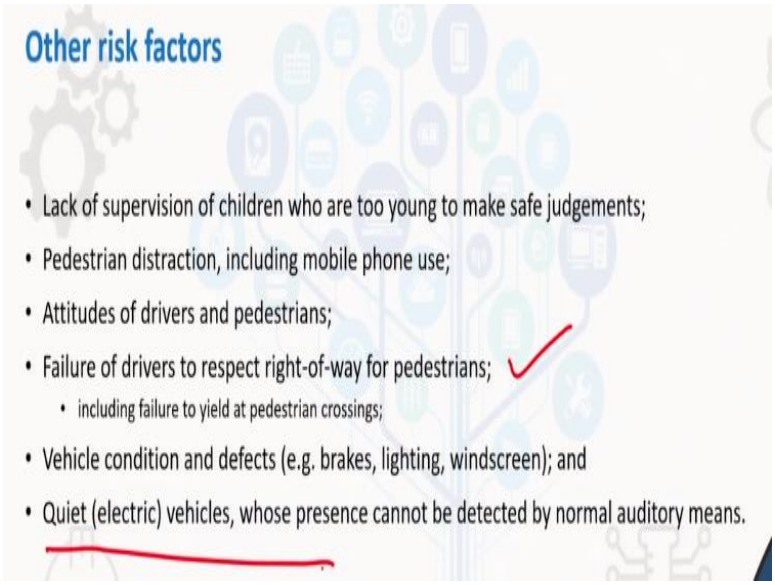

Others include failures of drivers to respect pedestrian right-of-way. Always stop at the stoplight. We have this bad behavior of always taking our vehicles few meters beyond the stop sign or stop line and then stopping and some of us also do not stop if for example there is no cop around in the intersection. So, all such behavior must be strictly avoided, you have to stop before the stop sign, allow the pedestrians to cross or the bicyclist to cross and then only cross the intersection once the signal is green.

So, we also have this tendency of trying to start or start moving ahead of the stop line as you see the countdown clock going counting down towards 0. Do not do that, always have patience while you are driving because safety is of paramount interest. The other newer phenomenon that we are noticing is that some quieter vehicles are causing a little bit of a conflict because people are not able to hear them. Especially in low volume roads where there are not many vehicles and pedestrians may not be able to detect them ahead of time because they are so quiet, but that is something of a newer phenomenon that is happening.

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The other design contributors to pedestrian injury includes traffic mix. So, if there is high mix of trucks or heavy vehicles on the street that does increase the risk to pedestrians. The width of roads and lanes and speed we have already looked at. That is why one of the traffic calming measures is always to narrow the lane width. So, you will see that narrowing the lane width usually reduces the speed of the vehicles that calms the traffic down and it helps promote safety of nonmotorized as well as pedestrian users.

Crossings, pedestrian crossings are almost always not very well designed, the stopping sight distances are not provided. Also, when refuge islands are needed, there are no refuge islands there for pedestrians to safely cross. So those design parameters also cause or contribute to pedestrian injury. High volumes of traffic are also a contributor and just the perception of safety and security of the travel environment causes this issue as well. Perception of safety is always how do you make a person, maybe all the design parameters are good, but the pedestrian still feels that it is unsafe or still they perceive that that intersection is unsafe. So, how do you deal with that kind of situation.

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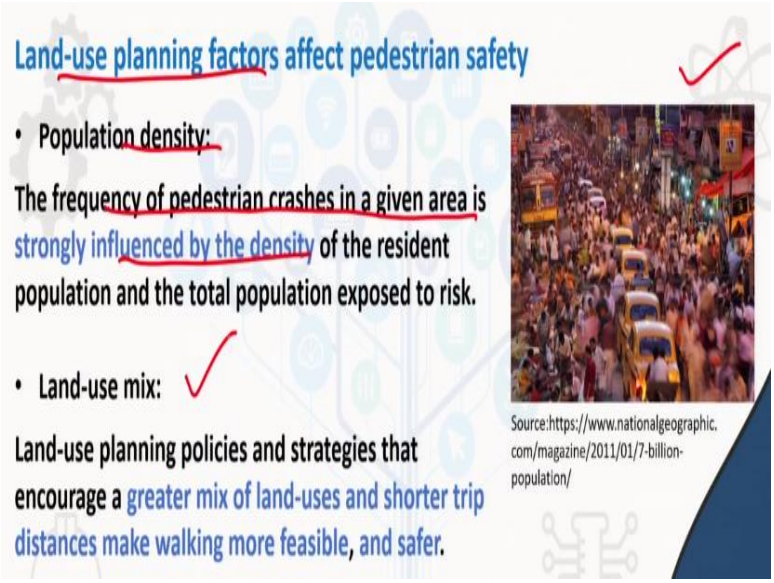

The frequency of pedestrian crashes is strongly influenced by the density of the resident population. If there is a lot of pedestrian activity going on, usually you will see that the streets have lower traffic speed, and the pedestrian related traffic crashes are lower. So, one thing that we always complain about is there is too much congestion in our streets. But the brighter side if you want to look at is that due to this congestion the speeds are so low that the possibility of grievous injury is very less. So that is not an ideal situation, but at least safety wise, it is not hampering pedestrian safety. So, in other words when you are trying to design for a safe road, it is always look at it from the point of view of the vulnerable road user, not only from the point of view of how to make the road safer for the vehicles.

The vehicles are safe, the vehicle motorists are already safe because they are in an enclosed environment in the car or in the two-wheelers, but a vulnerable road user is one that is the most unsafe on the road and you must think about it from the point of view of vulnerable road user when you are trying to design a safe road. A mix of land uses will allow more pedestrian activity again and more pedestrian activity for shorter trips again makes the street automatically calmer and reduces the speed of the motor vehicles.

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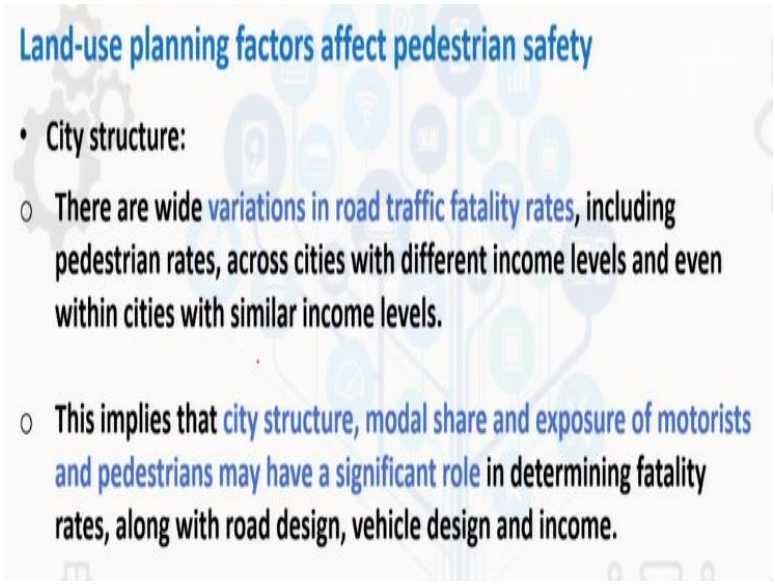

Similarly, the city structure. If your city is very compact and dense, then you would have your land uses close to each other and that could encourage a lot of people to walk, and if the volume of pedestrians walking increases, again the speed of motorized vehicles reduces. So, a compact city usually is very safe city. Whereas if you have a city that has broad and a sprawling city with wider traffic lanes, high volume, high speed lanes usually causes a lot of traffic safety issues or pedestrian safety issues. So, the city structure also determines how safe a pedestrian feels along their streets.

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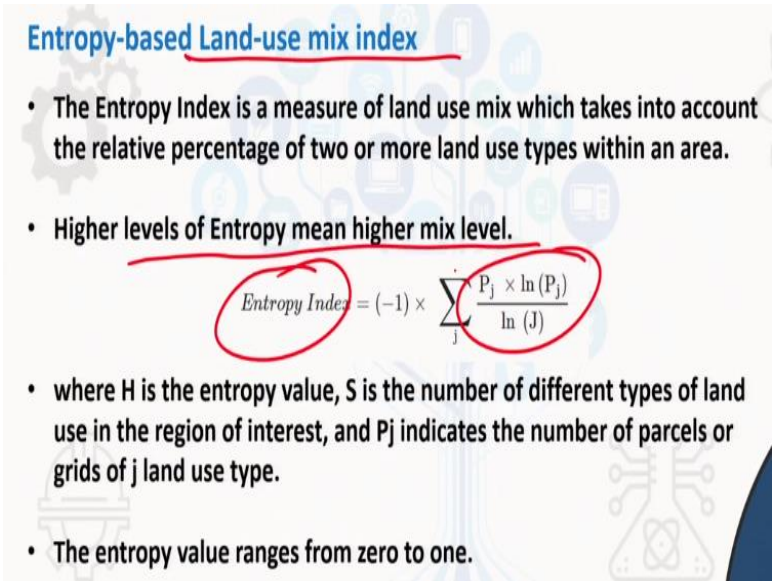

One way to determine the land-use mix in your city is the entropy index. The higher the entropy index means higher land-use mix and higher land-use mix meaning better for safety. So, the entropy index is nothing but the different types of land use, it develops an index to determine what the different types of land use on the different types of parcels.

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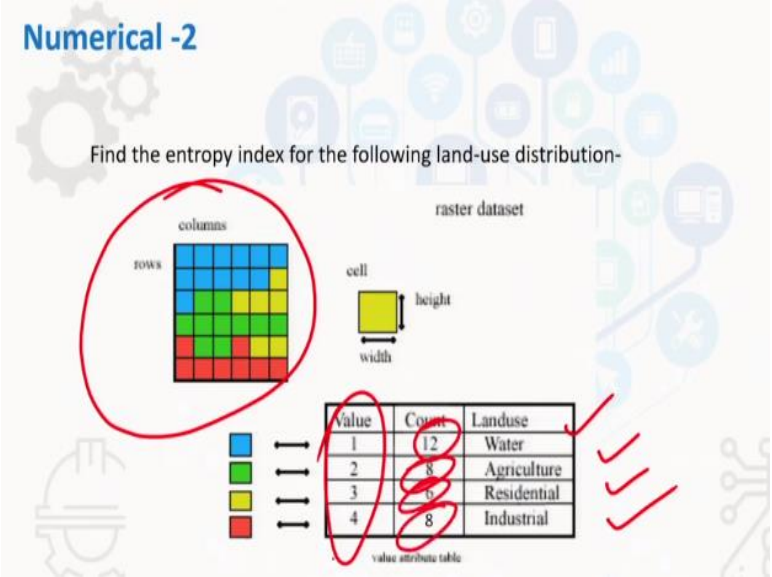

So, for example if you were to be asked to develop an entropy index for this kind of a land use distribution where there are 4 different types of land uses, water, agriculture, residential and industrial and you have different parcels there. You have 12 parcels of water, 8 parcels of agriculture, 6 of residential and 8 of industrial.

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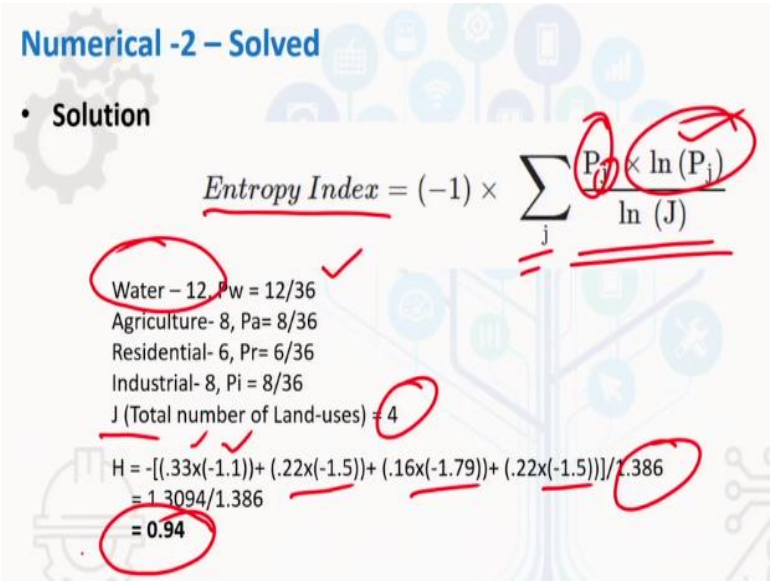

So, for this entire land-use mix, your entropy index would be nothing but a summation of the probability that one cell is a particular type of land use, Pj the probability of that cell being the type of land uses of j times the log of that probability divided by the natural log of all the different types of land uses. So, in this case, J is 4, so you divide everything by natural log of 4 and the probability that one of the cells is water is 12 divided by 36. Because there are 12 different types of or there are 12 water land uses, the total is 12+8+6+8.

So, the total is 36. So, 12 by 36 gives you the probability, 0.33 and the natural log of that probability is one –1.1. If you summate to 4 different types of land uses, divided by the natural log you will get an entropy index of 0.94. So, as the entropy index inches closer to 1 you would tend to say that there is a good mix of different types of land uses and a better mix of land uses usually ensures that there is higher walkability and because land is being close to each other makes people more probable to walking.

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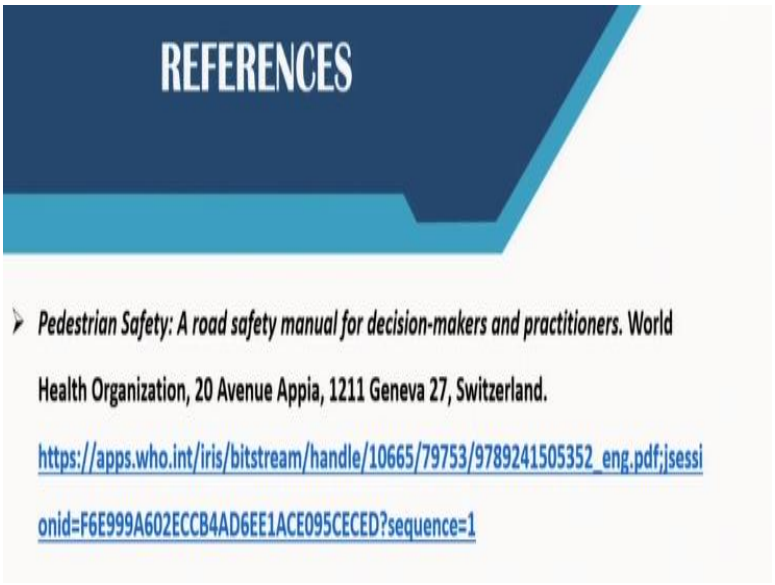

So, that is the end of today's lecture series or today's lecture where we have looked at the pedestrian safety and we have looked at different elements that are involved in the pedestrian safety.

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Key risk factors such as speed, alcohol, lack of facilities and visibility. We have seen how high land-use mix makes walking more feasible and safer and we have also looked at different forms of the city structures and the modal share that influences the risk of pedestrian injury. Thank you very much.