Urban Services Planning
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Lecture 59
Fire Stations

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Welcome back in lecture 59, we will talk about fire stations and fire services. So, the different concepts that we will cover are on fire services in India, fire station requirements, emergency fire service design, location allocation of fire services, then we will talk about the allocation models and finally, we will do a case study on Tehran.

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So, fire services in India were initially started in Bombay and Calcutta. And usually, it was first the services were provided by the police department, but eventually it was taken up by the Municipal Corporation and in 1872 The Calcutta fire brigade was formed by the Calcutta municipal corporation. So, after that, during 1950s not after, in the meantime, there was a Standing Fire Advisory Committee was formed SFAC during the year 1956 under the Ministry of Home Affairs, this committee explored the different technical problems, which was there in regards to fighting fire, what sort of equipment's were required and all these things were explored.

And finally, it this committee led to the standing fire advisory council SFAC. And this was in the year 1980. And they are the ones which gave recommendations for constitution of fire acts by different states and all and they also give guidelines on what kind of fire services should be provided, what equipment it should be provided and so on.

Now, based on the recommendations of the Fire Advisory Council, several states came up with their own fire acts as per the recommendations of course, and but current, but many states did not came up as well. So, fire act currently, the Disaster Management Act 2005 and eventually the National Policy and Disaster Management stresses on or provides a model fire act which could be also adopted in different states.

Now, fire services in India as per the 12 schedule, it is mandatory obligation or responsibility of the states, union territories and the ULBs, so it has to be taken up. And so, in most cases, either the Municipal Corporation takes up these services or the state home department is in charge of the fire services for that particular state.

So, several states in several cities ULBs in the cities have taken up this responsibility, but in many cases or in small towns and all the home department is the one responsible for providing these particular services. In addition, airport authorities of India, different large industries, Central Industrial Security Force and some armed forces, some units of armed forces also owns fire services. And usually in case of an event they also aid in the local fire services as well. So, in case of major disasters and all these agencies also come forward to provide their expertise as well as their manpower and equipment.

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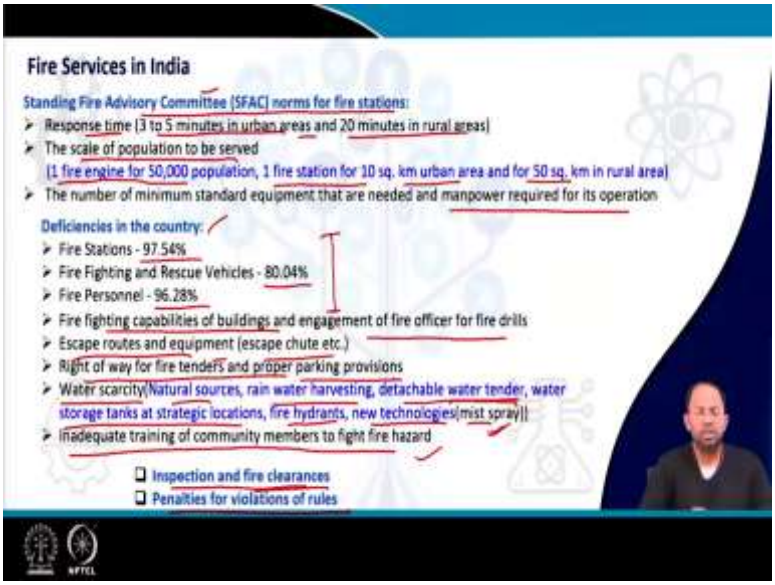

Now, as for the standing fire advisory committee norms for fire stations, the fire stations needs to be set up with a considering a response time of 3 to 5 minutes in urban areas and 20 minutes in rural areas. So, we will discuss about response time primarily what it means is in case event is recorded or reported, the fire (())(4:03) should take around 3 to 5 minutes to reach that particular event.

So, that is the response time. So, how many fire stations you require, how many fire tenders you require? All this depends on the density or the way the land use is there in that particular urban area and the street network for that particular urban area. So, considering the scale of population that has to be served, the norms given is something about one fire engine for every 50,000 people and one fire station for every 10 square kilometre of urban area and for rural areas it could be considered as 50 square kilometres.

So, in 10 square kilometres if 20,000, if one lakh people stay in that case we will have 2 fire engines and 1 fire station. The number of minimum standard equipment that are needed and manpower required for its operation. That means how the fire stations should be organized, what equipment should be there, these are also specified in this particular fire advisory norms that are given by the fire advisory norms.

Now, this particular Advisory Committee also recognize that our country is lacking in fire services to a huge extent for example, around we have the lack, the deficiencies to the extent of 97 percent in regards to fire stations, in regards to firefighting and rescue vehicles, the deficiencies around 80 percent. In regards to fire personnel, the deficiency is around 96 percent.

So, it is a huge deficiency that needs to be addressed. And that is why there has been many cases of fire in recent years. And in many cases, we have found out that the complexity of the events are so difficult for example, when there was a event recently in Kolkata regarding one hospital fire, patients died because they were not able to be evacuated.

Then there are other cases where chemical fires are there, how to fight those kinds of fires, in cases where maybe X-ray or a radioactive machine gets compromised by a fire, how to deal with those kinds of emergencies. So, there are a lot of technical concerns also which has to be addressed. So particularly, firefighting capabilities of buildings, each building new building that are coming up should have its own firefighting capability, as well as like, you know, not only internal sprinkler networks, but also a peripheral fire hydrants and so on.

So, but in many cases, buildings do not have that. In addition to that they should have adequate escape routes and equipment such as escape chutes, which are not there. And buildings should also or complexes should engage a fire officer who will conduct regular fire drills so that the occupants know what to do when event of a fire.

So, all these things are missing in many cases, and this requires proper inspection. And right now, it is mandated that for every building needs to have fire clearances to be given the final completion certificate, and this inspection and fire clearances are usually carried out by the fire services department. And there has to be strict penalties for violation of rules otherwise, people will not follow or people will somehow go around this or (())(7:25) these particular rules.

Now, the other aspects of firefighting is of course, the right of way of fire tenders as you can know that in India, we have very limited right of way and many cases, large fire tenders have difficulty negotiating the traffic and all So, maybe we can look into those plans needs to be formulated and also proper parking provisions in the areas where firefighting will happen.

So, suppose in critical areas, there has to be parking provision, so that fire tenders can be parked there and then they can fight fire. Then the other aspect is water scarcity. Many of our urban areas are very dense, it does not have water bodies nearby. So, we have to make provision for natural sources, rainwater harvesting, if required, detachable water tenders could be also added, we can have added you know, this water storage, we can also have water storage tanks at strategic locations, and also fire hydrants could be laid out and certain new technologies such as mist spray, and all these things, it could be considered for fighting fire

or you know make sure that we can use less water to get to cover more areas such as this technology or to provide make provisions for storage of water at different locations.

Then finally, inadequate training of committee members to fight fire hazards. So, we do not have any proper training of your community members and all, so that in case of fire, how they can help the fighting it and so on. So, these kinds of trainings could be conducted as well. So, these are some of the aspects which needs to be looked at or these are the deficiencies which needs to be taken care of in our country.

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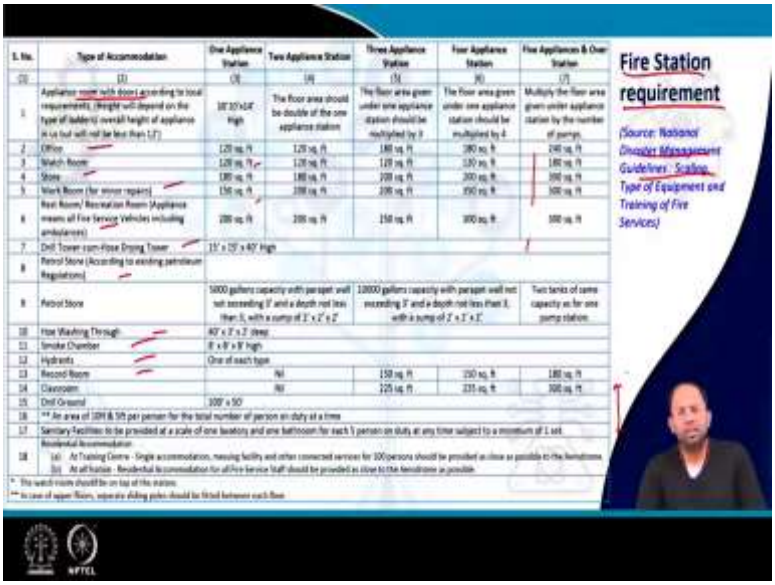

Now, this chart shows the different fire station requirements as listed in the National Disaster Management Guidelines. And it is so you can see that when we are creating a fire station or we are reserving area for fire station in an urban area, so these are the different things that is required appliance room, office, space, watch rooms, store rooms, work rooms, restrooms, drill tower, petrol store, hoe washing, smoke chamber, hydrants, record room and so on.

So, these standards are given as you can see that were there for single unit fire station tender fire station, these are the values which are given over here for multiple units, the floor size is multiplied and actually we have got different set of requirements for larger fire station as well. So, these are standards which could be followed to determine for a particular area for a particular population group, how many fire tenders would be required and for each for that many number of fire tenders and that many number of and we can determine what would be the location of the fire station and what should be the size of the fire station. So, size of the fire station can be determined using this particular chat.

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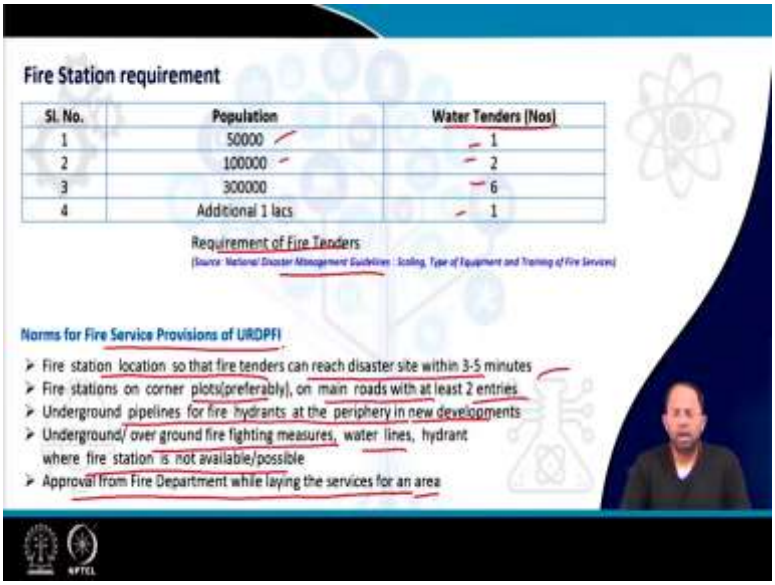

So, how many fire tender requirement is there? So, these are water tenders or vehicles which you know which this water tanks which are actually used for fighting fire. So, usually for 50,000 people, we should have 1, for 1 lakh people we should have 2, but for 3 lakh people we can have 6 and for addition of 1 lakh we should keep on adding 1 fire tender. So, this is more or less the standards given in the National Disaster Management Guidelines.

Now, as per URDPFI, it has given some additional considerations for urban planners when how they should provide this fire stations and so on. So, the station location should be such that the fire tenders can reach disaster site at 3 to 5 minutes same standard as given in that committee guidelines. Fire Station on corner plots preferably, so that movement of the vehicles parking of the vehicles are easier.

And it should be definitely on the main roads with at least two entries, so that the roads is easily accessible from other areas, underground pipelines for fire hydrants at the periphery of new developments, all new developments should have this fire hydrants at the periphery, so that fire tenders can put in their hoses over there and use that water stored water for fighting fires, underground over ground fighting measures such as water lines, hydrants, where fire station is not advisable or not available or not possible.

So, there are many dense areas but at least we should have fire hydrants so that fire tenders can utilize those. Then approval for fire departments while laying the services for an area. So, because there are multiple fire hydrants and all, all services that has to be laid out, it should while laying it, we can also take up to take permission from the fire department as well.

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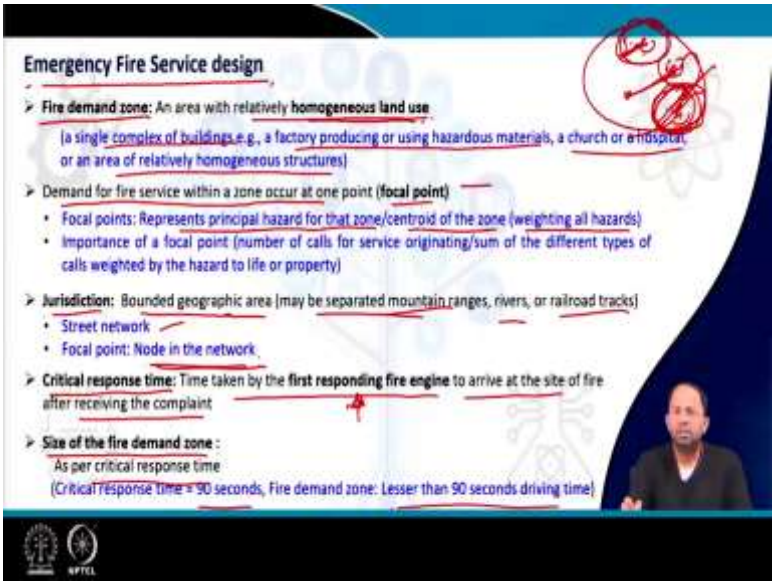

Now, coming to Emergency Fire Service Design, there are different things that we need to first understand, for example, first we have to understand about the five demands zone, now how do I categorize different areas and say this is one zone and then the other zone is different. So, it should be have relatively homogeneous land use.

So, that means the zone should roughly be uniform, it is better to not have industrial area with a residential area why? Because the hazards are different, the risks are different. So, we should have different provisions for fighting fires in a industrial area compared to a residential area. So that is why we should make zones which are relatively homogeneous.

So, a zone can be a single complex of buildings or it could be a factory producing or using hazardous material or it could be a church or a hospital or an area of relatively homogeneous structures, maybe residential area. Now, how do I determine the amount of requirement for that zone or how do I determine the distance from that zone, for that we have to determine demand for fire service within a zone, we determine a single point that is a focal point that means I have got a different a large area, we break it into different zones and there could be a focal point for each zone.

Now, the focal point could be the centroid of the zone or it could be the major you know the risk or structure which is susceptible to fire that could be also the focus of that zone or the focal point of that zone. So, whenever we measure the distance of or the time taken for a fire tender to reach that particular zone, we will measure it from the location of the fire station to this particular focal point.

So, focal point represents principal hazard for that zone or the centroid of the zone, where all centroid of the zone could be considered by weighing all the hazards like for example, this is a zone we have got one industry over here, residential area here, each has got different levels of risk or hazard. And then based on that risk, we can give weightages we can multiply that and determine which is the approximate centroid for that zone.

So, it may not be the geometric centroid, but it could be centroid as per its distance from the different levels of risk and the different parts of that zone. So, it is a weighted point or location inside that particular zone. So basically, it is a representative point in that zone, which is considered as the which will be used for further calculations of distance and other things.

Then jurisdiction is the bounded geographic area may be separated, now this we can say this is the bounded geographic area, it could be based on administrative boundaries, but this can also be separated by a mountain range, there could be a river in between it could be there could be a railroad track. So, all these things needs to be considered when we consider the jurisdiction and we can again divided into that okay, one fire station will serve this part, other fire stations will serve this part.

Now, along with this area, we should also be having detailed information on the street network of that area, and the focal point is basically a node in that street network. So, that is how if we do earlier we have learnt about this network analysis and all while we are learning about solid waste management and solid waste, carrying of solid waste from one part of the city to another. So, here also a node, this particular zone is basically a node in the network when we calculate the network distances for travel time and so on.

The next concept is that of critical response time, that is the time taken by the first responding fire engine to arrive at the site of fire after receiving the complaint. So, this is the first fire engine. So, this is the one which is the fire engine, which is dedicated for this particular zone, how much time it will come take to arrive, but of course, other fire engines can join in from the surrounding zones, but they will reach a little bit later maybe so, that is not a problem.

So, the first responding fire engines response time is taken as a critical response time, then size of the fire demand zone could be determined as per the critical response time. So, if critical response time is 90 seconds, then fire demand zone could be in designing such a way so that it is lesser than 90 minutes of driving time.

So, suppose I have a city I have to design this, you know this radius of this fire demand zone in such a way so that of any fire that breaks out in this particular zone or maybe at the focal point of the main hazardous industry of that zone, in that case, the time taken to reach is only 90 seconds. So, accordingly I have to determine that around one station, what is the extent this vehicle can travel to reach the different points. So, that becomes the fire zone for that particular station.

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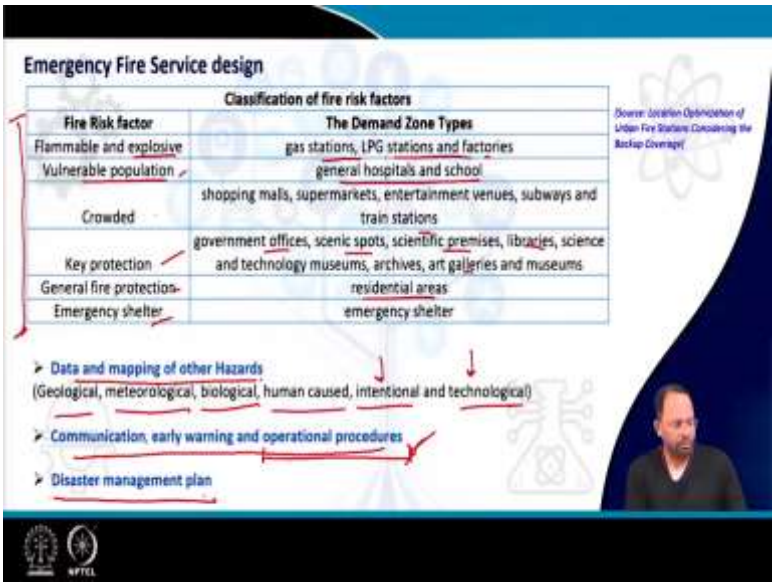

Now, next comes the classification of the different risks, different areas have got different risk for example, flammable and explosive risk factor is there for gas stations, LPG stations and factories, for general hospitals and schools, there is these people are vulnerable. So, that means they have to be evacuated, there needs to be stretches to carry these people. So, that kind of provisions has to be done. Shopping malls, supermarkets, entertainment, venues, subways, train stations are crowded. So, you need to manage the crowds. So, you require other sorts of manpower.

Government offices, scenic spots, scientific premises, libraries, science, technology, museums, archives, galleries, these are key areas which needs to be protected residential area has a general fire protection areas, emergency shelters or emergency protection areas. So, accordingly we can classify these areas as for different kinds of risks and based on that we can determine what sort of services or equipment's we should carry or how important is that risk all these things can be determined from this.

In addition, we can map other hazards as well such as geological hazards, maybe subsidence, there may be other issues are there, metrological hazards, biological hazards, human caused

certain kinds of event intentional like terrorist activity and all these things are intentional hazards, technological hazards based on certain failures of technology and all. So, all these different kinds of hazards could be also there in an area. So, that also needs to be considered.

Along with that, we overall, we managed, we determine the hazard risk and all for that we can determine that, how we can categorize the different zones. Once the zones are segregated, each zone can be given a focal point we can determine the response time to that particular zone. And we can based on that we can determine the number of stations.

But along with that we also need to develop communication, early warning and operational procedures for the fire services. That means if I do not have standard operating procedures during a event, which does not fall into the obvious category, then how do I deal with that. So, to prevent confusion, during emergency periods, this also has to be written or also has to be specified. Then finally, there has to be a disaster management plan that is in case of a disaster. How do I deal with that?

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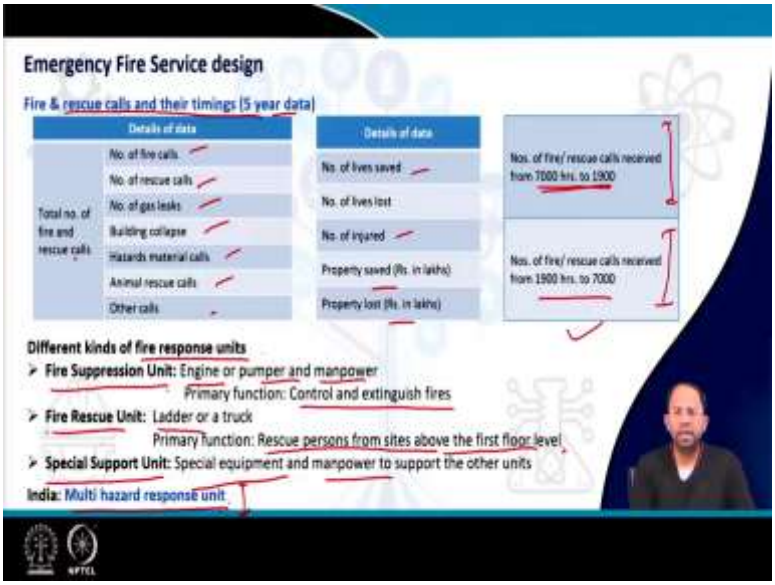

So, to determine what sort of hazards, then the timing of those particular hazards, so we need to create certain databases, so fire and rescue calls and the timings for the last 5 years are usually recorded. For example, total number of Fire and Rescue calls come from a particular area, such as number of fire calls, number of rescue calls, number of gas leaks, building collapse, hazardous material call, animal rescue calls and other calls.

And similarly, we record data on lives lost, life saved, numbers of injured, property saved, property lost in financial terms, based on all these records, we can determine which zones are

more hazardous, what kind of hazard it is, and accordingly we can designate separate zones in an area. Now, number of and then also we record the timings at different calls received from 7 hours in the morning to evening and from evening to again in the night throughout night to 7 hours. So, we can record the calls which are coming on at what time of the day.

This will help us to understand the or predict the requirement for staff equipment at different times of the day at different seasons event. So, that actually helps us to do trend analysis to determine what kind of manpower we should have at different points of time and what sort of preparedness we should have at different points of time.

Then there are different kinds of fire response units usually there is a fire suppression unit this is fire tender or a pumper along with manpower of course, primary function is to control and extinguish fire, then there is a fan rescue unit, which is basically a ladder or a truck with primary function is to rescue person from sites above the first-floor level.

So, people willing to jump out of a window or maybe somebody got stuck somewhere. So, all these things are important. So, this is the Fire Rescue Unit. And then there are special support units, which have special equipment or manpower to support either the fire suppression unit or the Fire Rescue Unit. So, in India, usually we have multi hazard response units that means units can also respond to multiple kinds of hazards. So, we have got different kinds of personnel inside each unit that could be utilized to respond to different problems.

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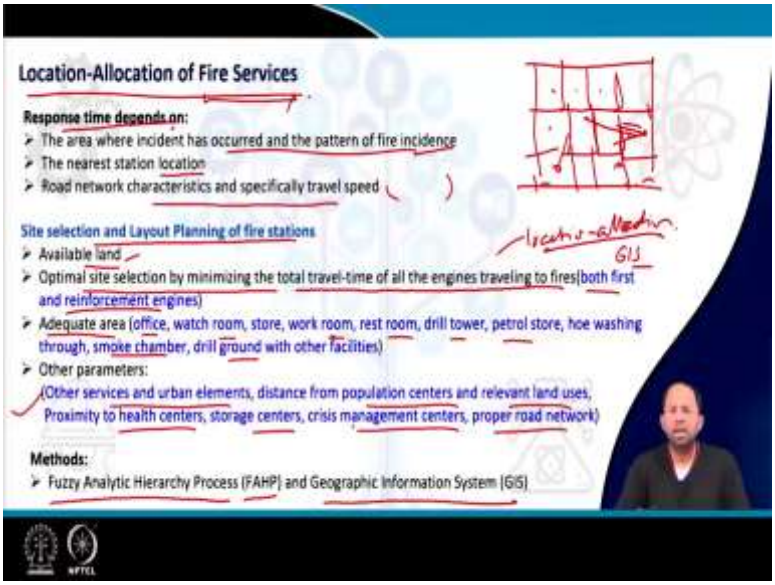

So, the response time, now we have to determine that how do I do location allocation of fire services, how do I distribute the different fire stations in an area. So, the response time is the

primary factor of course, that we have learned. So, it depends on the area where incident has occurred and the pattern of fire incidences. So, that means in an area if a fire breaks out very often, that means at one point of time, that could be multiple fires.

So, based on the incidence patterns, that from recorded data, we can determine that and also the area, how dense it is, what sort of people live there all these things plays a role in determining what sort of response I should provide and in what time I would be able to provide it. Then the nearest station location from that particular area and the road network characteristics and specifically travel speed that is possible in that area during that point of time. So, this overall determines that at what distance we can locate, at what density we can locate this fire service stations or fire stations in an urban area.

Now, site selection and layout planning for fire stations is based on available land of course, these are primarily government land, then optimal site selection by minimizing the total travel time of all Indians traveling to the fire it could be just for we can determine one dedicated fire station for one area or one fire tender for one area or we can have that we can consider that multiple engines will travel to that area from surrounding zones as well. So, we minimize the travel time of all engines together.

So, this is basically a location allocation problem. And in GIS we can solve this very easily using some tools and here we can determine, we can determine the location of the fire station as per the distribution of events and so on or fire events or so on. So, in case of multiple engines, both the first and the reinforcement engines both the times are considered and accordingly we determine which would be the suitable location for the fire engines.

For example, the way we do about, go about is I have the city we divided into different zones. Now, I locate the fire stations based on available spaces or all these things so this becomes one option. And this some locations could be skewed then we can determine the in case we did not, put a distribution of fire events and see what is the minimum time in which this could be addressed and for different fire events.

And based on that we can minimize the overall travel time for that area and determine which would be the best possible scenario for locating with that fire stations in that area. So, the other considerations are not only available land, but how much of it so, if there is adequate area or not. So, there should be space for offices, washrooms, stores, walk rooms, restrooms, drill tower, petrol stores, home washing, smoke chambers, drill ground and other facilities. So, all this should be there.

And other parameters such as distance from other services, distance from population centers, relevant land uses, proximity to health centers, storage centers for equipment, crisis management centers, proper road network all these things also plays a role in the selection of location for a fire station and people use different techniques for determining So, it is basically a two stage procedure, the first stage is to consider all these parameters and create determine how important these parameters are in the decision making process.

So, usually people use analytic for your fuzzy HP processes, it could be analytical hierarchy process or fuzzy analytical hierarchy process and then geographical information system is usually determined to determine the travel time or response time to different fire events and all and based on that these two data that is the weight importance of that location as well as response time, we can take a call on which were which is the best possible scenario for setting up fire station or which possible locations are best set for setting up fire stations in an urban area.

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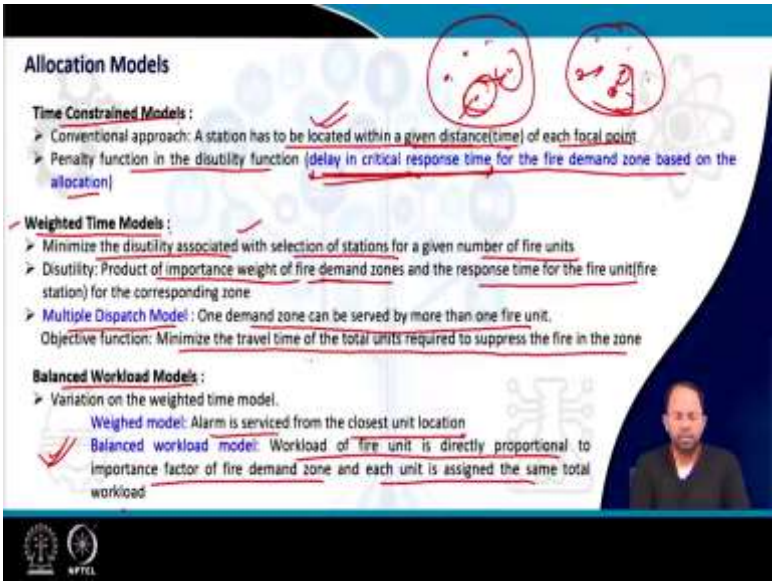

So, the allocation models could be of different types, one could be a time constraint model, where in the conventional approach the idea is a station has to be located within a given distance or time of each focal point. So, we have got different focal points in an urban area, more hazardous areas and so on. So, the fire station has to be located in such a way so that they are within a travel time given distance or time from that particular focal point.

So, this is a constraint level, constraint-based approach. So, there is a constraint of travel time. The penalty function, so, we can use utility functions here as well. So, a penalty function is introduced, where the delay in critical response time for fire demand zone is

based, based on the allocation is determined suppose we have a certain scenario of allocating fire stations in an urban area.

So, if I do this sort of allocation, what is the overall delay that is happening, so we determine the delay in critical response time compared to the standard and then we change the locations and then for another scenario, scenario 2, we create locations in another point and then we again determine the delay, wherever it is list, we will adopt that as the best possible option. But initial locations are selected based on other factors weightages and so on.

Now, waited time model is where we minimize the disutility associated with selection of stations for a given number of fire units. And here the disutility is determined by it is a product of importance weight of the fire demand zone, and the response time for the fire unit. So, it is not only just based on the response time, but also based on the importance of the fire zone. So, if our area is important, so if I am delayed to reach there, then there is more chance of damage. So, that is why importance of that area is multiplied with the response time and overall, we determine the utility of locating these stations and then determine which sort of option is the best option and then we choose that option.

Now, multiple dispatch model is a modification of the basic model where in the basic model we only consider one demand zone can be solved by 1 fire unit whereas in multiple dispatch model we can assume one demand zone could be served by multiple fire units from other areas. So, in this case, the objective function is to minimize the total travel time of the total units required to suppress fire in the zone.

Now, in there is one variant of this weighted time model which is the balanced workload model. So, here is where in case of weighted model, whenever alarm is there that is a fire has event has happened. So, each alarm is serviced by the closest unit location. So, that means the closest fire station will respond to that.

But in case of balanced workload model, the idea is work load of fire unit is directly proportional to the importance factor of the fire demand zone and each unit is assigned the same total workload. So, that means every units workload should be similar. So, that means if one unit can reach a certain area, another unit can reach a certain area, but the location of the unit should be such that overall workload for this particular unit is same because the hazard and all these things are different for this area.

So, overall workload needs to be balanced for all the different units. So, this is a much more complicated way of doing this thing. So, this is the most basic way, this is where a little bit complication comes in, because you have to understand the importance of each zone, and this is further complicated because we are considering multiple fire units will respond to one, we can do that over here as well. But over here, definitely we have to understand that each unit has got different workload, we have to balance not only the response times the importance as well as how much work each unit is doing and that has to be prioritized.

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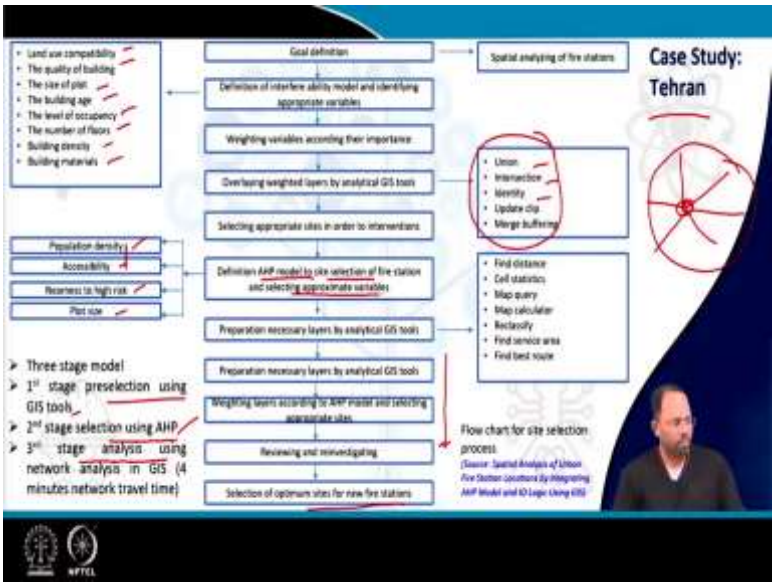

So, this is a case study from Tehran, the selection of location is done in three stages. So, the first stage is pre-selection of certain plots or areas where I can set up the station this could be done using GIS tools. So, over here the considerations are land use compatibility, quality of the building, size of plot, building age, level of occupancy, number of floors, building density building materials, all these things are considered to do some pre-selection of plots where we can set up the fire station.

So, and then based on some GIS tools and all this like union intersection, these are standard GIS tools of like when you overlap different layers, you can take out certain portions of it common shared areas and so on. So, using this kind of standard GIS tools we can determine based on which are the available areas where we can set up fire stations.

So, this is the first step. The second step is where using an AHP we determines the importance of those particular areas. So here, population density, accessibility, nearness to high risk, plot size, all these things are considered for defining the HP model of site selection for fire station and selecting approximate variables.

So, that means we determine which variable is more important compared to the other using pairwise comparison and we give weightage to different aspects. And overall, this helps us to determine the second layer of importance for the different locations you can say. So, here the third word, the third stage is once we have determined the importance, we now need to determine the distance of travel or the response or the response time.

So, third stage of analysis involves network analysis. Using network analysis in GIS we can determine from any point or the location of the station, what is the time to reach all the other points, so that we can determine and we can add this all up to determine a figure for total amount of time taken for response. So, multiplying with the importance of that particular factor and the response time combining all these things, the all these factors, the location of optimum size of fire station are determined in this particular study.

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So, these are some of the references that you can use. To conclude, efficient well planned and well-equipped fire services are essential to respond to fire events. And significant efficiencies in regards to fire services in India needs to be addressed through adequate funding and technological interventions, thank you.