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Highway Safety Methods to be Adopted by Civil Engineers

Prof. Mantri .P.N
Département of Civil Engineering
Vishweshwarayya Abhiyantriki Padvika Mahavidyalay Almala, India

Abstract:
Highway safety is an important aspect of highway construction and engineering. Designing a highway means adopting safety measures so that not only vehicular traffic stays safe, but the pedestrians and bikers also feel safe while moving on the highway. Bott's dots, traffic lights, pedestrian marking, zebra crossings, and traffic circles are some of the important aspects of highway design safety. GPS-based road traffic monitoring systems are one of the modern age inventions that make our road travel safe and efficient. Even bike traffic is also considered while safely designing the highway.

I. INTRODUCTION:

Articles related to highway safety are discussed in this paper.

- Bott's Dots and Safe Driving
- Working of Traffic Light Systems Explained
- Roundabouts, Traffic Circles, and Modern Age Traffic
- GPS based Road Traffic Management System
- The Visual Signals of the Kanban System
- Safety Considerations for Safe Bike Paths
- Rumble Strips and Centerline Ruble Strips Create Safer Roads
- Responding to Rockfall Hazards Around Mountain Roads
- Guide to Road Traffic Safety Barriers

1.1. ELBERT DYSART BOTTS- DOTS AND REFLECTIVE PAINT, TOO

You can see the results of the work of Elbert Dysart Botts on most modern highways throughout the world. They are the raised reflective pavement markers, or Botts' dots, that are used as highway markers for warning drivers.

DR. BOTTS AND BOTTS' DOTS

Dr.Elbert Dysart Botts worked with the California Department of Transportation or Caltrans where he oversaw research concerned with road markings and paint stripes. Caltrans began research on raised pavement markers as far back as 1936, but the research assumed real significance only after the war years. 1953, spurred by the increasing number of accidents that accompanied the economic boom, marked a watershed in the use of raised pavement markers. Prior to this, markings on road pavement were done with painted lines which tended to be obscured by dirt and to become almost invisible in rain. The first of Botts' dots were made of glass and attached to the road with nails. Once the dots got loose under traffic, the nails became a danger as they punctured tires. Further development led to the dots being made of ceramic materials and polyester. The problem of fixing them to pavement led to further research, which then came up with strong epoxy adhesives which replaced the nails and eliminated possible traffic hazards from them. While this epoxy is also credited to Caltrans, it is not known whether Dr. Botts was closely associated with this discovery, though with his being the head of research, credit would accrue to him as well.

THE DEVELOPMENT OF BOTTS' DOTS

Dr. Elbert Botts was a chemical engineer who used to teach at San Jose State College before he was inducted by Caltrans to head their research division Translab. His initial research concentrated on developing paints that would outlast concrete and also remain visible in poor light conditions. He had a background of having worked for a paint company for three years before moving to teaching. He even included glass beads in the paint to improve visibility through headlight reflections, but was unable to meet the standards required. This is when he switched to reflective pavement markers that stuck up above the road surface. Most of the field work using various types of raised pavement markers was conducted on a new freeway in West Sacramento. The main idea of using raised pavement markers came from the fact that paint lines disappeared under water when it was raining, and the raised markers did allow for better visibility. Unfortunately DrBotts died in 1962, two years after retirement at the age of 69, and his work was actually filed away, with even Translab failing to acknowledge it in connection with Dr. Botts. It was only in 1964 that the new head of Caltrans revived the research and developed the present day trend of using square reflectors between groups of the polyester dots.

THE APPLICATION OF BOTT'S DOTS

The system got tacit recognition when the state legislature made the use of Botts' Dots mandatory in 1966. Botts' Dots are now being used in various colors and in conjunction with painted and other reflective markers which make roads safer. Yellow dots indicate a split in the road, whereas red markers indicate lines that cannot be crossed. They are also used across the road as rumble strips warning motorists to slow down. Blue dots are used to indicate areas around fire hydrants. Botts' Dots come in two different basic types. These are either reflective or plain. The plain ones are white or amber colored and are made of ceramic or plastic material in a dome shape. The reflective ones are made of polyester that can take high impact and are square in shape. White dots indicate parallel lanes while center markers are amber. Red dots are an indication that the driver is in the wrong lane and needs to get off immediately. There is a difficulty in using these dots in areas with heavy snowfall as they can be dislodged by snow clearing equipment. These markers are then put on divots in the road. One aspect of the dots that has led to its acceptance was the discovery that they made a thumping noise when tires passed over them, and that, along with the bumping motion

that they created, served notice to drivers that is especially helpful when driving conditions are poor on rainy days.

1.2 HOW TRAFFIC LIGHT SYSTEMS WORK

Gone are the horse and buggy days. Nevertheless, the sad part is that we still do not notice the endless number of traffic signals. Who are the inventors of these signal lights? What makes a traffic light work? These interesting facts make up this article!

INTRODUCTION

Urbanization has brought rapid development in industries due to which the majority of the population is settling down in the cities. This results in a heavy rush in vehicular traffic requiring efficient control to avoid accidents. Traffic lights can be seen arranged one above the other at crucial crossings and junctions in a city. The colors used for traffic lights are green, yellow, and red, out of which red denotes stop, green is used to indicate 'carry on,' and the yellow color is used in between to be ready for either red or green. Lights changes are either preset with a timer or based on current conditions and connected with one another in such a way that traffic can move on the main road controlling their speed. However, these days the interval between traffic lights is computerized and not set. They change, but vary in sync with vehicular traffic.

HISTORY OF TRAFFIC LIGHTS

The question of traffic safety existed even before automobiles were used. This led to the invention of the world's first traffic light in London in 1868. A revolving lantern comprising of red and green signals was set up at a junction in London. These lights were lit with the help of gas and operated by men. A lever at the base of the light was used to turn the colors of the light and allow the traffic to flow. Regrettably, in January 1869, this piece of equipment blew out and hurt the police officer who was controlling it at the time. The contemporary red and green electric traffic light was invented in 1912 by a Utah police officer named Lester Wire. In 1914, the first traffic signal was installed in Cleveland, Ohio. This device had a buzzer apart from the normal red and green colors. The buzzer was used to provide a warning of the color changes. This device was designed by James Hoge and was used by both the police and the fire stations to manage the signals in an emergency. Police officer William Potts invented the first four-way, three-color traffic light in 1920. The first coordinated traffic signal arrangement system was set up in 1917 and had six linked points of intersections operated concurrently by a manual switch. In 1922 in Houston, Texas control of the interconnected lights was done automatically. Inter-linked traffic lights with automatic control were introduced in Wolverhampton, England only in 1927.

TRAFFIC LIGHTS

All of us know that red, green and yellow are used as traffic light signals. Why were these colors selected?

The rules which governed the right of way in maritime to recognize port was red and starboard was green, which signaled that the vessel on the left had to stop to allow the one on the right to cross. Actually, the colors for traffic lights were adopted from the color code used by railway engineers as a traffic signal invented to control the trains on the rail lines. They used red to represent a signal to stop since it represents danger or warning and this color caught the attention of passersby as well. The other two colors used by railway engineers weregreen symbolizing 'caution' and white meaning 'go.' Filters were used in traffic signals and because of this the white color had some problems associated with it. Streetlights, stars, and the glare of sunlight or other lights could be misunderstood as a 'go' signal since they also shone as white from a distance. In order to solve this problem engineers used yellow to denote caution.

WORKING MECHANISM OF TRAFFIC LIGHTS

In olden times, the change in color of traffic lights was preset with fixed timings. This means that when a vehicle draws up exactly as the signal alters from green to red, it has to wait for the next change to green, even if there are no other vehicles in any other directions. Yet the contemporary style consists of signals that are not fixed, but act in response to the presence of vehicles. This system uses a sensor loop embedded in the pavement that detects weak magnetic fields such as the metallic parts of cars. A controller box installed nearby contains a computer that senses the vehicle's presence. If no other cars are found waiting, the controller blinks the green signal. The waiting vehicle then moves on. If a centrally computerized traffic arrangement is installed, then a set of lights can be controlled concurrently allowing smooth passage of traffic.

NEW RESEARCH (ADAPTIVE TRAFFIC LIGHTS)

Traffic lights acting locally will better the control of traffic globally, and this is the new research going on at present. With regard to adaptive traffic lights, a mechanical engineer, GáborOrosz of the University of Michigan says, "It's very interesting- the approach is adaptive and the system can react. That's how it should be- that's how we can get the most out of our current system."

1.3 RISE OF THE ROUNDABOUTS

Roundabouts in America have come a long way since they were first introduced. Today, traffic conditions have changed, traffic density has increased manifold, and these factors have raised questions about the effectiveness of roundabouts. "Give way before entry" is the principle on which a roundabout is designed. The first roundabout was built in 1960s in the United Kingdom Roundabout Sign and it appeared to be an effective solution for the exponentially increasing traffic in the developed nations. The US followed suit and a few roundabouts started to appear in major American cities. The roundabout model is still relatively new to the US, in comparison to traffic circles, which came into existence in the early 1900s. Compared to European countries, Americans are still adjusting to roundabout navigation and this has resulted in less efficient use of roundabouts. Roundabout navigation depends mainly upon two factors: traffic lanes or traffic density and the behavior of the driver. The second factor is not only hard to predict, but it is highly variable, resulting in confusion while reaching or crossing through a roundabout. Secondly, at the time of inception of the roundabout model in the US, only motorist traffic was considered while designing. Gradually, as the number of cyclists and pedestrians increased, it gave rise to another problem- safety concerns for the non-motorists crossing the roundabout (especially bicyclists).

Are Roundabouts and Traffic Circles the Same Thing?

Many people ask this question and the answer is NO. Roundabouts and traffic circles might look the same, but they have huge Traffic Circle differences. A modern roundabout follows the yield at entry principle whereas a traffic signal takes the conventional approach of giving priority to the entering vehicle. Modern roundabouts use smaller diameters whereas traffic circles have provision for both the small and

large diameters. Small diameters are used for traffic calming and the large diameter circles are used to maintain the normal traffic flow. The upper speed limit while crossing through a roundabout is 25 mph, whereas a traffic signal allows speeds above 25 mph. Modern roundabouts minimize weaving movement within the circular section of the road. Traffic circles allow weaving and weaving sections are provided to take care of conflicting traffic movements. As the entry speeds are low, the deflection angle is kept low for the modern roundabouts. Traffic circles have large deflection angles.

MODERN ROUNDABOUTS - THE DRAWBACKS

Roundabouts are popping up like mushrooms in the US. Old traffic circles are disappearing at an alarming rate and people are made to believe that modern roundabouts are the best thing that ever happened to humankind, which will not only channelize traffic, but also avoid intersection crashes and ensure the safety of non-motorists. However, there are certain drawbacks associated with modern roundabouts.

What are the major disadvantages of having roundabouts in your city?

One important factor in the case against roundabouts is that they are, by design, slow. When you have a roundabout every mile or two, you might end up spending more time on the road and less time with your family. As compared to traffic circles, roundabouts increase the travel time by a huge margin. In case of traffic congestion, the gap between vehicles becomes less. This can result in low-speed crashes and fender benders. Queue development can cause long lines at the entry points. Higher maintenance costs make modern roundabouts an expensive solution for traffic control. Like traffic circles, very large roundabouts require huge land mass and long splitter islands further increase the cost. Very large roundabouts eat up a lot of public space. Temporary widening and outside diameter space requirement increase the running cost of construction as well. Roundabouts are not at all friendly for handicapped people, especially for visually impaired pedestrians. Additional pedestrian signals need to be installed to safe-guard them. Cyclists suffer the most because of blind spots on a roundabout. Traffic rules allow inside lane turn-outs. In America this means that a vehicle in the inside lane- closest to the island- can turn right across the outside lane in order to exit. This can be unexpected to a bicyclist approaching behind the turning vehicle, and the bicycle can, at the same time, be in the motorist's blind spot at an unexpected angle (neither behind, beside, or ahead). Alternative pathways have to be designed to avoid roundabout exit accidents and that increases the cost of construction. Roundabouts are not suitable for "platooned" traffic flow. Emergency vehicles like ambulances cannot make it through roundabouts easily. The need of the hour is bringing forward an effective traffic management system that not only takes care of complex traffic conditions, but also costs less to manage. Cost effectiveness and optimum use of land are two key requirements of building an effective traffic navigation system, and unfortunately roundabouts do not fulfill both these conditions. Traffic circles are in use across the world and have been for quite some time. Many people are used to them. Roundabouts require educating people about navigation and crossing methods, which is a stressful exercise. In America, roundabouts and traffic circles must go hand-in-hand. Major cities can easily accommodate roundabouts, but for the smaller cities, traffic circles can serve the purpose without waste of money or land. Even the traffic circles need to be improved because the traffic density and traffic behavior has changed a lot in recent years.

1.4 GPS-BASED ROAD TRAFFIC MONITORING SYSTEM - A STUDY OF THE CELL PHONE-BASED MODEL

For cost effective traffic control, efforts are on to create GPS based road traffic monitoring systems. Researchers, individuals, groups, and telecom companies are studying the prospects of such a system. This article discusses a cell phone based model while also considering its practicality.

ROAD TRAFFIC MONITORING SYSTEM– THE CURRENT SCENARIO

At present, most road traffic monitoring systems use sensors and video cameras to check the speed of vehicles and to take snapshots of vehicles that violate signals. However, the cost of this equipment has restricted the current video camera-based road traffic monitoring systems to certain very important areas and important highway intersections - where there are greater possibilities of traffic congestion and accidents. The government is willing to cut down the costs of the "sensor and video camera based road traffic monitoring system" so that it can implement it widely. To achieve this, it has permitted several research groups and telecom companies to come up with a model- both practical and cost effective- covering large areas (not only certain portions of the city and highway intersections). There are several research projects going on, some using government grants and some on their own – conducted by telecom giants such as Nokia, UTStarcom, and others. The common point in all these researches is that almost all of them are considering GPS-based road traffic monitoring system to bring down the overall costs of maintenance because the costs of the GPS devices are low and are showing a further downward trend. Almonst every person with a vehicle has a GPS device or can afford a GPS device for vehicles, which means that the stage is already set. We just need to put the different components in place so that the desired GPS-based road traffic monitoring system can be put into place. The following section discusses the cost effective model of GPS based road traffic monitoring system proposed by Nokia, a leading telecom company.

GPS-BASED ROAD TRAFFIC MONITORING SYSTEM – AN OVERVIEW

The model for GPS-based road traffic monitoring system presented by Nokia is based on the fact that almost every vehicle driver already has a cell phone. If the model is implemented, the cell phones can be upgraded to ones that contain GPS units if the existing ones do not have one already. The basic concept of this model is to trace "each" vehicle using the signals sent out by the GPS unit in the cell phone. The model claims to monitor real time flow of traffic using the GPS enabled cell phones while securing the privacy of cell phone users.

The model suggested by Nokia for GPS based road traffic monitoring system employs use of:

1) GPS enabled cellular handsets;
2) a central server for each area;
3) the Internet; and,
4) a unit to view the traffic condition. This unit can be the cell phone itself, a GPS unit, or any other device capable of connecting to the Internet and displaying the traffic conditions.

Each area under observation will have a central server of its own, thereby using several servers to cover a larger area. These central servers can be integrated using wireless connections to create a network that covers an entire city. Each car will be equipped with a GPS-enabled mobile phone. The GPS unit will contain some software that will send signals

carrying data on the vehicle's speed and location to the central server for that area. With all vehicles in an area sending signals to the central server, there will be ample data to compute the traffic conditions of that area. Once computed, the results will be uploaded to the Internet in form of images (graphs or charts). This information can be viewed by anyone on his/her cell phones or any other device able to browse the Internet. The best thing about this model is that both drivers and the traffic police can view the traffic conditions in real-time with a delay of only few milliseconds. While speaking on the model's feasibility, a Nokia staffer says, "Enlisting GPS-equipped cell phones into traffic monitoring systems could help provide information on everything from multiple side-street routes in urban areas to hazardous driving conditions or accidents on vast stretches of rural roads. GPS-based systems can pinpoint a car's location with an accuracy of a few meters and calculate traveling speed to within three miles per hour." This is quite true but there are certain obstacles that will have to be considered for implementing this model of GPS based road traffic monitoring system.

Nokia's GPS Based Road Traffic Monitoring System Model – Possible Problems

Roping in Cell Phone Service Providers

The first and foremost problem that may interfere with Nokia's GPS-based road traffic monitoring system is the fact that different people use different service providers for their cell phones. As all the residents of US cannot be persuaded to use the same service provider, all the different service providers in US will have to be roped in so that the model works offering full data on vehicle movements. Even if one service provider backs out, the model will yield partial results. However, Quinn Jacobson, Nokia Research Center's research leader is confident that there will be no problem as these service providers will only benefit from being part of the GPS-based road traffic monitoring system. Also, drivers will not let the service providers back out as there are additional benefits to the GPS-based road traffic system than just traffic updates. According to Jacobson, "Integration of traffic information with functions such as calendar and online timetables means that the mobile device can act as personal travel planner. With the increasing number of vehicles, a proper road traffic monitoring system will help drivers save time and precious fuel by taking alternate routes based on real time traffic information."

BANDWIDTH PROBLEM

Assuming that the cell phones in Nokia's model of GPS-based road traffic monitoring system send out signals every three seconds, the system will require a huge bandwidth considering the number of cell phones active at any given point of time. Alexander Bayen, professor of systems engineering at Berkeley's California Center (the institute is also part of Nokia's GPS traffic monitoring research), says that they are working on a solution to find an optimum subset of the entire data so that the model does not need such a huge bandwidth. However, I could not get any clue anywhere as to what kind of solution they are considering.

USER PRIVACY: A MAJOR PROBLEM

Most of the users of the cell phones will not want their phones to send out signals indicating their whereabouts that can be intercepted by unwanted sources, too. According to Jacobson, if users are not willing, they can turn off the GPS feed in the cell phone. This will not affect the proposed GPS-based road traffic monitoring system as it will disassociate the data with the cell phone and use it anonymously employing SSL (bank type encryption) so that the data is not used by anyone else, thereby protecting the privacy of the cell phone owner. Read our article on GPS Cellphone - Ethics Violations.

Unwilling Users – People not Willing to Participate in the Monitoring System

There will be drivers who will not be willing to contribute. They may not use GPS-based cell phones or may turn their GPS off. There will be a hard time persuading such drivers. However, considering the benefits of this GPS-based road traffic monitoring system, the percentage of such people will be very low. The results of computing at the central server will not be affected, so the servers will still be able to upload real-time traffic information to the Internet. I also went through some other proposed models for GPS based road traffic monitoring systems, out of which, one was more stable than the Nokia model but it was not as cost effective as the model discussed here.

1.5ADDING UP THE ADVANTAGES OF THE KANBAN SYSTEM

The word Kanban may not be part of your daily vocabulary when it comes to scheduling. But after learning about the advantages of the Kanban system and its role in just in time (JIT) manufacturing, Kanban may become a household word for you.

THE VISUAL SIGNALS OF THE KANBAN SYSTEM

ADVANTAGES OF THE KANBAN SYSTEM

The Kanban System is an integral part of implementing the Just in Time (JIT) manufacturing philosophy which was designed to control inventory and reduce waste. The history of the Kanban system can be traced back to the late 1940s when Toyota made a cultural commitment to continuous improvement to drive its manufacturing processes to peak performance. The term Kanban is a Japanese word whose English translation means signboard or visual signal. A well-timed Kanban system works exactly like a traffic signal in managing the flow of traffic and meeting the real time needs of customers by sending clears signals on when to start, slow down, and stop production. Each Kanban signal also carries valuable information about the volume and sequencing of the production. Toyota originally used cards attached to different supply containers to communicate what materials in the production line were needed, but today many variations exists, including signboards and electronic systems. The result is an efficient system where products are only replenished when they are consumed further downstream in the process.

IMPROVEMENT IN PRODUCTION

The main advantage of the Kanban system lies in its innate ability to drive down costs and waste by improving the flow of production. Many of the scheduling advantages of the Kanban system spring from naturally from the core elements of lean and just in time manufacturing strategies. These strengths become more pronounced when the flow of production is reduced to small batches to accommodate product variations. With a Kanban system in place, managers and supervisors see the benefits of the Kanban system in:

Better managed inventory levels. Too much inventory can result in cash flow problems by adding overhead expenses for storage, insurance, and security. On the flip side, too little inventory can damage the reputation of the business for being unreliable, resulting in lost sales and dissatisfied customers.

The Kanban system combined with good inventory practices smooths out inventory levels and eliminates carrying costs.

Smoother manufacturing flow. Because the Kanban system focuses on current conditions, production levels are calculated to take into account downtime, scrap, and changeover time of equipment to ensure that the production schedule is met.

Overproduction elimination. As a demand pull system, Kanban is less likely to result in overproduction because of the need to create buffer inventory to address unexpected delays resulting from quality problems with suppliers or minor disruptions in the transportation network.

Reduced risk of Inventory obsolescence. Many products have a shelf life or product lifecycle that can expire unless the product reaches the consumer in a timely manner. In these changing economic times, brand loyalty has faded and can no longer save a company that does not deliver its goods on time.

RESPONSIVENESS TO DEMAND

Manufacturing is more than just about the mechanics of production and a series of calculations to determine changeover, lead time, and downtime for equipment to derive an ideal production schedule. Production is foremost driven by customer demand which can run in a various patterns from predictable to sporadic, from increasing to declining, and from seasonal to no seasonal. One of the biggest advantages of the Kanban System is that it improves the responsiveness to changes in demand. In this way, the Kanban system is similar to a smart traffic light with its ability to sense when the traffic, or in this case the demand, is building up. When the pent up demand reaches a predetermined level, the system sends the appropriate signal -- the traffic light changes to green or, in the factory, production is sped up.

EMPOWERMENT

Another advantage of the Kanban system is that it places control in the hands of the operators who are in the best position to oversee production. People on the front lines have the most knowledge about the daily operations and have a pulse on the real-time flow of the work. Also, shifting accountability for monitoring the daily runs frees up the time of supervisors to focus on long term planning needs. Empowerment is an effective managerial tool because it reinforces education and training; increases mutual respect among employees, generates enthusiasm and dedication to a common goal; lowers absenteeism, and increases productivity. Another by-product of empowerment is conquering resistance to change because employees participate directly in the decision making process.

QUALITY CONTROL AND SELF-DISCIPLINE

A final advantage of the Kanban system is found in the fabric of its purpose to promote an environment devoted to quality improvement. Because the Kanban system uses small lot sizes at various points in the production, quality control issues can be more easily pinpointed at the source. Also, the Kanban system eliminates excess inventory which tends to mask quality problems by remaining undetected for longer periods of time. Thus, the need for buffer inventory to resolve quality problems is reduced, and this system becomes self-perpetulating as inventory reduction leads to further quality improvment results.

A FINAL TALLY OF THE ADVANTAGES OF THE KANBAN SYSTEM

In adding up the advantages of the Kanban system, managers should recognize that the system's strengths lie in creating a more orderly and highly visual accountability system. The visual signals not only aid in improving production flow and responsiveness to customer demand but also in shifting workers' focus on quality improvment and team work through empowerment and self-monitoring activities.

1.6 DESIGN CONSIDERATIONS FOR SAFE BIKE PATHS

Bike paths are as important as highways and proper design guidelines must be followed while designing them. Bicycle safety tips are an important aspect of design and what types of roads are suitable for bikers will be discussed in this article. Read on to know about best bike path designs.

BICYCLE PATH

Designing a bike path is not as simple as it may sound. In most of the American states, bike-car collisions have already created a lot of problems. Bikes cannot move on the highway along with other speeding vehicles because bikes move very slowly in comparison to cars and other vehicles. One single design is not the solution because they differ depending on the type of traffic and traffic density of the region. Different design methods need to be implemented to develop a balanced commuting channel for the bikers. According to the US Department of Transportation, walking and bicycling facilities must be a part of the road project and cannot be ignored unless under exceptional circumstances. With gas becoming more expensive, high inflation rates, and increased pollution levels, governments and private organizations are promoting cycling activities and to promote it, it becomes even more important to design safe pathways for bikers and offer the best possible road facilities to them.

THE DESIGN GUIDELINES

Safety and accessibility are two important factors associated with bike path design. Those driving a car or a motorcycle often pay no attention to bikers because bikes are considered to be easy vehicles, they move slow, weigh less, and can manage in less space. However, a biker would not be hurt less in an accident, so safety becomes the primary concern while designing a bike path. Accessibility means taking care of intersections, busy traffic areas, and the merging of bike lanes with the main highway. How bikers access the exclusive bike lanes and how do they switch to the main highway without disturbing the flow of traffic is another important aspect. A single design cannot be proposed for a state or a big region because traffic conditions are not same throughout the region, so a mixed design approach is adopted to design safe pathways for bikers. The US Department of Transportation and Federal highway Administration has also stated that adopting a mixed approach will always lead to a better and more economical network.

Major designs that are implemented in American States, recommended by the authorities are mentioned below.

1. Exclusive Bike Lane
2. Mixed or Shared Use Paths
3. Parking Permitted or Praking Prohibited Bike Lanes
4. Off Road Cycle Lanes
5. Canberra Bicycle Lane

Exclusive Bike Lanes are designed and developed on the side of the main road. These roads run parallel to the highway and intersect very rarely, mainly at the traffic signals. Usually these lanes are designed in cities where the roads run for a considerable distance without turning. It helps the bikers to stay safe and travel equal distance as the motorists do. However such lanes are expensive to build and maintain.

Mixed or shared path use is one such model which is combination of different lanes. These lanes usually are designed in cities where Shared Pathway number of bikers commuting on a daily basis along with the traffic density is high. Bikers travel on the main roads along with the motorists and the lanes keep on merging and diverging from the main road depending upon the traffic conditions. Segregated bike lanes are designed on the main highway and are painted with white stripes. Moreover, these lanes are exclusively meant for the bikers and motorists cannot run their vehicle on these roads while passing or for any other reason. However, the mixed pathways require very high level of safety measures because if the bike lanes are not equipped with painted boundaries, indicating boards and warning boards, the accidents are bound to happen. Considering the ever increasing population and number of new vehicles rolling in every year, mixed modal pathways are the need of the hour because they not only save time and money, but also help bikers to move along with the mainstream traffic.

PROTECTED BIKELANE

Parking permitted or parking prohibited bike lanes, as the names signify, allow or prohibit the motorists to park their vehicles alongside the bike lanes. When the parking is prohibited, it strictly means that no car should be parked or even enter into the bike lanes. When motorists try to park the vehicles in the prohibited lanes, bikers often face problems. Just imagine you take a turn on an exclusive bike lane and all of a sudden you find a car parked in the middle of the lane. Even in the parking permitted lanes, accidental probability is high because very often motorists open up the doors of their cars on the bike lanes creating trouble for the bikers. Off road bike lanes are not the lanes where the general bikers would like to go but still off road bike lanes are constructed to help bikers commute through off-road destinations. Bikers generally would not complain about a shortcut that saves considerable time.

INTERSECTIONS & TRAFFIC SIGNALS - GREATEST HURDLES

Irrespective of the design and type of bike pathway, the greatest hurdles are the merging of bikers and motorists on a traffic signal or an intersection. Most accidents happen in these places because regulating the bikes and motors at such junctions becomes difficult. The Department of Transportation states that while approaching an intersection the bike stripes must be dashed so that bikers get an idea that motorists can turn right and enter the bike lane while turning. At large intersections, mixed or shared pathways become problematic because of vehicles coming from all the directions and entering into the bike lanes becomes inevitable. Even at the traffic signals, if the queue is too long or the signal is too busy, motorists often tend to enter into the bike lanes. This can be avoided by segregating the bikes from motor vehicles as the traffic signal is approached. Another hurdle remains drainage problem over the bike lanes. In hilly regions, exclusive bike lanes are constructed at a height above than the main road. If the water drainage system is not put in place, it will surely create problem for the main traffic movement and affect the strength of road too. Bike accidents happen just like other accidents and bikers need to follow bicycle safety tips to ensure their own safety. Bikers must not try to rush with the motorists because a bike is a bike and a car is a car. Drive safely, try not to rush and when moving in the traffic, ensure that a helmet is on your head because if it is not on your head, it will definitely create problems.

1.7 RUMBLE STRIPS AND CENTERLINE RUMBLE STRIPS

Rumble strips whether used on edges or centerline of roads are considered a road safety feature as the vibration and rumbling that they produce help to alert drivers who are inattentive.

RUMBLE STRIPS AS SAFETY DEVICES

CENTER LINE RUMBLE STRIPS

Rumble strips and centerline rumble strips are being used to reduce accidents and warn inattentive drivers. Rumble strips can even be laid across a travel lane so that they can warn drivers that they are approaching areas ahead where they need to exercise caution. Such strips are also accompanied by signage warning of the impending danger. Rumble strips were first used in 1952 and have followed a number of designs. Initially the asphalt pavement was itself milled or formed in such a way as to create the indentations required for the rumble strips. This has now been totally replaced by ceramic or plastic raised systems made famous by Botts' Dots. Such strips produce rumbling that creates specific frequencies in the audible range and traffic engineers have used this to create singing shoulders or musical roads.

PROBLEMS WITH RUMBLE STRIPS

Rumble strips have however not been without their share of controversy, and people staying near freeways have complained against the noise produced by such rumbling strips. As a result many authorities do not install rumble strips in suburban areas where low speed restrictions are in place. Rumble strips are also sometimes viewed as a hazard for cyclists, whose narrow wheel base may find the rumble strips difficult to ride over. Climate is another factor that does contribute to the success or failure of a rumble strip. In northern areas prone to severe winters, such strips can get filled with ice or even traction sand and become ineffective. This can also happen in desert or sandy areas where winds can fill up the space in the rumble strips. Steering wheel vibration is another aspect that worries traffic engineers, and this has something to do with the gaps between rumble strips and is being studied for the best pattern to be followed.

THE IMPORTANCE OF CENTERLINE RUMBLE STRIPS

Centerline rumble strips are mainly used on two lanes, two way roadways and are meant to create warnings for drivers to avoid potential accidents with opposing traffic. Accidents happen due to side swiping or head on collisions. It has been established that the installation of centerline rumble strips has led to reduction in such accidents, especially on rural roads, most of which fall into the two lanes, two way roads category. Such roads do not have any dividing medians and thus no impending mechanisms to traffic running in opposite directions. Different designs of the centerline rumble strips have led to the use of double 4 inch strips laid parallel to the road and 6 inch lateral strips that are said to increase visibility as well as prevent damage to the center line strips. Other designs use strips that may be laid continuously or in lengths of 12 inch to 30 inch with the width varying from 4 to 8 inches. Depth of grooves is normally kept at half an inch, which is considered enough to produce the rumble. Centerline rumble strips require very little maintenance and do not contribute to degradation of the pavement as had been the apprehension.

MAKING CENTERLINE RUMBLE STRIPS

Centerline rumble strips can be milled on the center of the roadway with machines that have been specially designed for this job. Quite often painted lines are also used in addition to the rumble strips for better visual identification. These lines can be on both sides of the milled rumble indentation. In such cases the width of the rumble strip is reduced. Spacing between strips can be 12 to 24 inches, though the maximum decibels which serve as warning are in those strips that have a 12 inch distance. Length of strips in the direction of traffic is best at 6 inches and the width across traffic 12 inches. A depth of about a quarter of an inch in the milled surface is considered adequate to produce the sound caused by air being forced out of the depression. Carpeting or relaying of the surface of a road would require that these rumble strips have to be redone. It has to be however ensured that the thickness of the new layer is sufficient to take the new milling that is required to create the rumble strips

1.8 RESPONDING TO ROCK FALL RISK ON PUBLIC ROADWAYS

Construction of highways and railways is challenging around mountains and steep slopes. Each require special study by geologists and geotechnical engineers. Through geotechnical analysis, slopes are identified that are critical and require special protection. The "Rockfall Hazard Rating System" for the Federal Highway Administration was introduced by the Oregon State Highway Division. It is used to define the overall stability of slopes along mountainsides against major sliding or toppling failures in order to protect the highway below from known hazards through various methods. However, analysis of hundreds of miles of mountain highway can be more difficult than rocket science. In this article we take a look at the important things done under this rating system in regard to determining slopes that are hazardous and require immediate remedial work. You can also use the table in the image given below for the exact ratings of all the factors of this rating system.

SLOPE HEIGHT

Slope height is an important measure of risk because rocks present on the higher slopes have higher potential energy. Measuring slope height requires determining only the vertical height of the slope (in place of the slope distance) or measuring the highest point from where rockfall can be reasonably expected. There might be some cases where rocks are coming from a slope present above the roadway cut. In this situation, add the cut height to the original height of the slope.

DITCH EFFECTIVENESS

"Ditch" is the area in between the slope and the roadway. The ditch effectiveness is defined as ability of the ditch to prevent falling rock from reaching the road. There are certain factors that need to be considered for measuring ditch effectiveness.

SLOPE HEIGHT AND ITS ANGLE

- Slope irregularities
- Quantity of the rockfall
- Anticipated size of the block
- Parameter and shape of the ditch

Measuring slope irregularities is important because it can increase or decrease the speed of falling rocks and there would be more tendency of rocks reaching the road.

PERCENT OF DECISION SIGHT DISTANCE ROCK FALL FENCE PROTECTING ROAD

Sight distance is the length at which an obstacle of a specific height is visible to the driver. The percent decision sight distance is the measurement in feet that is used to determine from what distance a normal driver can make an instantaneous decision if any obstacle comes in front of him. It is important because curves of the roadways along the mountains can limit the ability of a driver to notice rocks present on the road.

GEOLOGIC CHARACTER

As the name says, it defines the geologic character of the slopes. These are classified in two cases. The first case includes the structural conditions such as adhesive or continuous joints present in the slopes, rock friction angle, hydrostatic head if water is present, and other discontinuities. Furthermore, the second case includes slopes having differential erosions or overstepped slopes. Measurement of rock friction is also important determining the potential of the rocks to move over one another.

QUANTITY OF ROCKFALL PER EVENT

This rating determines what type of rockfall may most commonly occur. For example, if rocks fall individually, considering the sizes of the rocks is required. If a number of small and large sized rock fall, use the mass of the fallen rocks in the last event to determine the rating. Usually these measurements can be easily determined from the maintenance history. However, if there is no event history, estimate it through observing the conditions of the slope. This factor is also beneficial for future remedial measures.

CLIMATE AND THE PRESENCE OF WATER

Studying the climate and the presence of water in the slope is essential. This is because water and freeze cycles contribute an important role in rock movement. If the area gets less than twenty inches rain per year, it is called a low precipitation area; if the value is more than fifty inches, it is then called a high precipitation area. The impact of freezing or thaw cycles can be determined by the freezing conditions of the area.

OTHER IMPORTANT PARAMETERS

The rockfall hazard rating also includes the width of the roadway. This measurement is appropriately called "Roadway Width" and defines the maneuvering room for a driver to avoid rockfall. If the width is variable, consider the minimum width of the roadway for this rating. The "Average Vehicle Risk" rating represents the average time of which a vehicle will be present in the hazard zone. It is based on factors like daily traffic and the posted speed limit in an area. Next is "Difference in Erosion Ratings." This measurement defines common physical and chemical erosion processes happening in the slope. The effect of human action is also a factor to consider into it. The difference in erosion rates explains how quickly erosion is taking place at the particular slope. All the above points are important and essential to determine for the Federal Highway Administration's rating system for rockfall hazards. However, there is one more point to consider, and that is the rockfall history of slopes. This is because historical data directly represents which slopes are very hazardous and require remedial work. Again, the maintenance officer is the best person for getting the history of such events.

1.9 ROAD TRAFFIC SAFETY BARRIERS

Life is precious, and should not be wasted by road accidents. Use of the road safety features and proper driving may prevent

road accidents. The roads have been designed keeping in view the human factors in road safety. Safety posters and slogans can influence humans towards safe driving.

IMPORTANCE OF ROAD SAFETY

Risks will always exist that are related to road safety, and their total elimination may not be possible. However, all risks, including road Importance road safety driving risks, can be mitigated by the implementation of appropriate remedial measures. The state and the general public have a responsibility to control and manage road risks. The human factors in road safety should be the prime parameter while designing roads. Safety posters and slogans, and observing a horrific accident picture do have a positive effect on the human mind. Drivers may benefit from the shortest driving instructions that are available at several training institutions. Road safety must constantly be kept in mind. Each individual is responsible for the road safety. The circumstances on the roads are unpredictable, due to which it is only proper planning, implementation, and conscientiousness that can assist to reduce the road accidents. Road traffic victims, injury, and suffering represent a severe universal state that adversely affects the lives of individuals. This is an important matter considering the financial effects on the state and the community. The state has the responsibility to arrange measures for the prevention of accidents, while the public is expected to strictly abide by the road safety regulations.

SAFE ROAD DESIGN

The safe road design is an important feature that can significantly contribute to prevent road accidents. The better roads have on the curves to increase the vehicle stability. This is particularly important for the vehicles that have a higher centre of gravity. The roads should be cambered in accordance with the design analysis, with round surfaces. Such roads will decrease the ice and standing water, mainly to avoid the frost damage, and also increase the traction when the weather is poor. The roads should have suitable arrangements to facilitate drainage, particularly on the bends. The current road barriers, intended for safety, are designed to ensure maximum absorption of the impact, with minimum risk to the vehicle occupants. The side rails are firmly fixed with the ground, and the poles for lights are planned to fracture at the bottom, instead of stopping a car violently. The road fixtures like fire hydrants and the road signs are designed to fall on impact. The trees along the roads are removed to improve visibility. The guard rail ends are fitted with impact attenuators that slowly take in the vehicle kinetic energy. The vehicle slows smoothly before striking the guard rail end. Several other techniques are employed for the dissipation of the kinetic energy. Barrels filled with sand transfer the vehicle momentum to the sand.

ROAD MARKINGS

The numerous hazards on the road are generally indicated multiple times, much before their appearance, to enable timely measures by the drivers. Mainly, the marking materials used for pavements and roads are reflective, including prisms or glass spheres that efficiently reflect light from the headlights of the vehicle. Thus, the driver can easily be warned about the dangers ahead. Lanes are distinguished by the use of Botts' dots and Cat's eyes. Botts' dots are normally round raised markers for pavements that are not reflective. These markers are used for the marking of lanes on highways and main roads. Feedback is provided to the drivers while moving across the travel lanes. They are similar to rumble strips, and are generally white, but can be also yellow. The cat's eye is a safety gadget that is utilized in road markings. It consists of reflective glass that is fixed in a rubber casing. It marks the road centre for the convenience of the driver. Cat's eyes are primarily useful in haze. Furthermore, tone bands are engraved into the road edges that awaken the drowsing drivers when they move off the road edge. Tone bands may also be commonly called rumble strips. Alternatively, raised rib markings may be used that consist of a line marking, with regular diagonal ribs. They improve the edge description during wet conditions, or during darkness.

II. CONCLUSION

- Risks will always exist that are related to road safety, and their total elimination may not be possible. However, all risks, including road Importance road safety driving risks, can be mitigated by the implementation of appropriate remedial measures
- The presence of lighting not only reduces the risk of traffic accidents, but also their severity. Surveys have shown that the public are in favour of street lighting as a way of improving road safety and that, if anything, it needs to be improved in some areas
- The human factors in road safety should be the prime parameter while designing roads. Safety posters and slogans, and observing a horrific accident picture do have a positive effect on the human mind.
- Centerline rumble strips are mainly used on two lanes, two way roadways and are meant to create warnings for drivers to avoid potential accidents with opposing traffic. Accidents happen due to side swiping or head on collisions.
- Safety standards like Bott's Dots, Working of Traffic Light Systems, Roundabouts, Traffic Circles, PS based Road Traffic Management System, The Visual Signals of the Kanban System, Safety Considerations for Safe Bike Paths, Rumble Strips and Centerline Ruble Strips Create Safer Roads

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