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Highway Safety Methods to Be Adopted By Civil Engineers

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Abstract:
Highway safety is an important component of highway design and engineering. Safety measures such as Bott's dots, traffic lights, pedestrian marking, zebra crossings, traffic circles, and GPS-based traffic monitoring systems help keep road users and pedestrians safe. Bike traffic is also taken into account when designing highways for safety.

I. INTRODUCTION:

Articlesrelatedtohighwaysafetyarediscussedinthispaper.

- Bott'sDotsandSafeDriving
- WorkingofTrafficLightSystemsExplained
- Roundabouts,TrafficCircles,andModernAgeTraffic
- GPSbasedRoadTrafficManagementSystem
- TheVisualSignalsoftheKanbanSystem
- SafetyConsiderationsforSafe BikePaths
- RumbleStripsandCenterlineRubleStripsCreateSaferRoads
- RespondingtoRockfallHazardsAroundMountainRoads
- GuidetoRoadTrafficSafetyBarriers

1.1. ELBERT DYSART BOTTS- DOTS ANDREFLECTIVEPAINT, TOO

You can see the results of the work of Elbert Dysart Botts onmost modern highways throughout the world. They are theraised reflective pavement markers, or Botts' dots, that areused ashighway markersforwarningdrivers.

DR.BOTTSANDBOTTS'DOTS

Dr.Elbert Dysart Botts worked with the California DepartmentofTransportationorCaltranswhereheoversawresearchconcernedwithroadmarkingsandpaintstripes.Caltransbegan research on raised pavementmarkers as far back as1936, but the research assumed real significance only after thewaryears.1953,spurredbytheincreasingnumberofaccidentsthataccompaniedtheeconomicboom,markedawatershed in the use of raised pavement markers. Prior to this,markingsonroadpavementweredonewithpaintedlineswhich tended to be obscured by dirt and to become almostinvisible in rain. The first of Botts' dots were made of glassand attached to the road with nails. Once the dots got looseundertraffic,thenailsbecameadangerasthey puncturedtires.Furtherdevelopmentledtothedotsbeingmadeofceramicmaterials andpolyester. The problem of fixing themto pavement led to further research, which then came up withstrongepoxyadhesiveswhichreplacedthenailsandeliminatedpossibletraffichazardsfromthem.Whilethisepoxy is also credited to Caltrans, it is not known whether Dr.Botts was closely associated with this discovery, though withhis being the head of research, credit would accrue to him aswell.

THEDEVELOPMENTOFBOTTS'DOTS

Dr. Elbert Botts was a chemical engineer who used to teach atSan Jose State College before he was inducted by Caltrans toheadtheirresearchdivisionTranslab.Hisinitialresearchconcentrated on developing paints that would outlast concreteand also remain visible in poor light conditions. He hadabackground of having worked for a paint company for threeyears before moving to teaching. He even included glass beadsin the paint to improve visibility through headlight reflections,but was unable to meet the standards required. This is when heswitched

to reflective pavement markers that stuck up abovethe road surface. Most of the field work using various types ofraised pavement markers was conducted on a new freeway inWest Sacramento. The main idea of using raised pavementmarkers came from the fact that paint lines disappeared underwater when itwas raining, and the raised markers did allowfor better visibility. Unfortunately DrBotts died in 1962, twoyearsafterretirementattheageof69,andhisworkwasactually filed away, with even Translab failing to acknowledgeit in connection with Dr. Botts. It was only in 1964 that thenew head of Caltrans revived the research and developed thepresent day trend of using square reflectors between groups ofthepolyester dots.

THEAPPLICATIONOFBOTT'SDOTS

The systemgot tacit recognitionwhenthestate legislaturemade the use of Botts' Dots mandatory in 1966. Botts' Dots arenow beingusedinvariouscolorsandinconjunctionwithpainted and other reflective markers which make roads safer.Yellow dots indicate a split in the road, whereas red markersindicate lines that cannot be crossed. They are also used acrossthe road as rumblestripswarning motorists to slow down.Bluedotsareusedtoindicateareasaroundfirehydrants.Botts' Dots come in two different basic types. These are eitherreflective or plain. The plain ones are white or amber coloredand are made of ceramic or plastic material in a dome shape.The reflective ones are made of polyester that can take highimpact and are square in shape. White dots indicate parallellaneswhilecentermarkersareamber.Reddotsareanindication that the driver is in the wrong lane and needs to getoff immediately. There is a difficulty in using these dots inareas with heavy snowfall as they can be dislodged by snowclearing equipment. These markers are then put on divotsinthe road. One aspect of the dots that has led to its acceptancewas the discovery that they made a thumping noise when tirespassedoverthem,andthat,alongwiththebumpingmotion

that they created, served notice to drivers that is especiallyhelpfulwhendrivingconditionsare pooronrainydays.

1.2 HOWTRAFFICLIGHTSYSTEMSWORK

Gone are the horse and buggy days. Nevertheless, the sad partis that we still do not notice the endless number of trafficsignals. Who are the inventors of these signal lights? Whatmakes a trafficlightwork?These interesting facts makeupthisarticle!

INTRODUCTION

Urbanization has brought rapid development in industries dueto which the majority of the population is settling down in thecities. This results in a heavy rush in vehicular traffic requiringefficient control to avoid accidents. Traffic lights can be seenarranged one above the other at crucial crossings and junctionsin a city. The colors used for traffic lights are green, yellow,andred,outofwhichreddenotesstop,greenisusedtoindicate 'carry on,' and the yellow color is used in between tobe ready for either red or green.Lights changes are eitherpresetwithatimerorbasedoncurrentconditionsandconnectedwith one anotherin such away thattraffic canmove on the main road controlling their speed. However, thesedays the interval between traffic lights is computerized and notset.Theychange, butvaryinsyncwith vehicular traffic.

HISTORYOFTRAFFICLIGHTS

The question of traffic safety existed even before automobileswere used. This led to the invention of the world's first trafficlight in London in 1868. A revolving lantern comprising of redand green signals was set up at a junction in London. Theselights were lit with the help of gas and operated by men. Alever at the base of the light was used to turn the colors of thelight andallow the traffic toflow. Regrettably, in January1869, this piece of equipment blew out and hurt the policeofficer who was controlling it at the time. The contemporaryred and green electric traffic light was invented in 1912 by aUtahpoliceofficernamedLesterWire.In1914,thefirsttraffic signal was installed in Cleveland, Ohio. This device hada buzzerapart from thenormal redandgreen colors.Thebuzzer was used to provide a warning of the color changes.This devicewas designed by James Hoge andwas usedbyboth the police and the fire stations to manage the signals in anemergency.PoliceofficerWilliamPottsinventedthefirstfour-way,three-colortrafficlightin1920.Thefirstcoordinated traffic signal arrangement system was set up in1917andhadsixlinkedpointsofintersectionsoperatedconcurrently by a manual switch. In 1922 in Houston, Texascontrol of the interconnected lights was done automatically.Inter-linkedtrafficlightswithautomaticcontrolwereintroduced inWolverhampton, England onlyin1927.

TRAFFICLIGHTS

All of us know that red, green and yellow are used as trafficlightsignals. Why were thesecolorsselected?

The rules which governed the right of way in maritime torecognizeportwasredandstarboardwasgreen,whichsignaled that the vessel on the left had to stop to allow the

oneon the right to cross. Actually, the colors for traffic lights wereadopted from the color code used by railway engineers as atraffic signal invented to control the trains on the rail lines.They used red to represent a signal to stop since it representsdangerorwarningandthiscolorcaughttheattentionofpassersbyaswell.Theothertwocolorsusedbyrailwayengineers weregreen symbolizing 'caution' and white meaning'go.'Filterswere usedintraffic signalsandbecause ofthisthe

white color had some problems associated with it. Streetlights,stars,andtheglareofsunlightorotherlightscouldbemisunderstood as a 'go' signal since they also shone as whitefrom a distance. In order to solve this problem engineers usedyellowtodenote caution.

WORKINGMECHANISMOFTRAFFICLIGHTS

In olden times, the change in color of traffic lights was presetwith fixed timings. This means that when a vehicle draws upexactly as the signal alters from green to red, it has to wait forthe next change to green, even if there are no other vehicles inany other directions. Yet the contemporary style consists ofsignals that are not fixed, but act in response to the presence ofvehicles.Thissystemusesasensorloopembeddedinthepavementthatdetectsweakmagneticfieldssuchasthemetallic partsofcars.Acontrollerboxinstallednearbycontains a computer that senses the vehicle's presence. If noother cars are found waiting, the controller blinks the greensignal.Thewaitingvehiclethenmoveson.Ifacentrallycomputerizedtraffic arrangement is installed, then a setoflights can be controlled concurrently allowing smooth passageoftraffic.

NEWRESEARCH(ADAPTIVETRAFFICLIGHTS)

Traffic lights acting locally will better the control of trafficglobally, and this is the new research going on at present. Withregardtoadaptivetrafficlights,amechanicalengineer,GáborOrosz of the University of Michigan says,"It's veryinteresting- the approach is adaptive and the system can react.That's how it should be- that's how we can get the most out ofourcurrentsystem."

1.3 RISEOFTHEROUNDABOUTS

Roundabouts in America have come a long way since theywere first introduced. Today, traffic conditions have changed,traffic density has increased manifold, and these factors haveraised questions about the effectiveness of roundabouts. "Giveway before entry" is the principle on which a roundabout isdesigned.Thefirstroundaboutwasbuiltin1960sintheUnited Kingdom Roundabout Sign and it appeared to be aneffective solution for the exponentially increasing traffic in thedevelopednations.TheUSfollowedsuitandafewroundabouts started to appear in major American cities. Theroundaboutmodelisstillrelativelynewtothe US,incomparison to traffic circles, which came into existence in theearly 1900s. Compared to European countries, Americans arestill adjusting to roundabout navigation and this has resulted inlessefficientuseofroundabouts.Roundaboutnavigationdependsmainlyupontwofactors:trafficlanesortrafficdensity and the behavior of the driver. The second factor is notonlyhardtopredict,butitishighlyvariable,resultinginconfusion while reaching or crossing through a roundabout.Secondly, at the time of inception of the roundabout model inthe 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-motoristscrossingtheroundabout(especiallybicyclists).

Are Roundabouts and Traffic Circles the Same Thing?ManypeopleaskthisquestionandtheanswerisNO.Roundaboutsandtrafficcirclesmightlookthesame,buttheyhavehugeTrafficCircledifferences.Amodernroundaboutfollowstheyieldatentryprinciplewhereasatrafficsignaltakestheconventionalapproachofgivingpriorityto theenteringvehicle.Modernroundaboutsusesmallerdiameterswhereastrafficcircleshaveprovisionforboththesmalland large diameters. Small diameters are used for traffic calmingand the large diameter circles are used to maintain the normaltraffic flow. The upper speed limit while crossing through aroundabout is 25 mph, whereas a traffic signal allows speedsabove25mph.Modernroundaboutsminimizeweavingmovementwithinthecircularsectionoftheroad.Trafficcircles allow weaving and weaving sections are provided totake care of conflicting traffic movements. As the entry speedsarelow,thedeflectionangleiskeptlowforthemodernroundabouts.Trafficcircles havelargedeflectionangles.

MODERNROUNDABOUTS-THEDRAWBACKS

Roundabouts are popping up like mushrooms in the US. Oldtraffic circles are disappearing at an alarming rate

and peopleare made to believe that modern roundabouts are the best thingthateverhappenedtohumankind,whichwillnotonlychannelizetraffic,butalsoavoidintersectioncrashesandensure the safety of non-motorists. However, there are certaindrawbacksassociatedwith modernroundabouts.

What are the major disadvantages of having roundaboutsinyour city?

One important factor in the case against roundabouts is thatthey are, by design, slow. When you have a roundabout everymile or two, you might end up spending more time on the roadand less time with your family. As compared to traffic circles,roundabouts increase the travel time by a huge margin. In caseof traffic congestion, the gap between vehicles becomes less.Thiscanresultinlow-speedcrashesandfenderbenders.Queue development can cause long lines at the entry points.Highermaintenancecostsmakemodernroundaboutsanexpensive solution for traffic control. Like traffic circles, verylarge roundabouts require huge land mass and long splitterislands further increase the cost. Very large roundabouts eat upalotofpublicspace.Temporarywideningandoutsidediameterspacerequirementincreasetherunningcostofconstruction as well. Roundabouts are not at all friendly forhandicappedpeople,especiallyforvisuallyimpairedpedestrians. Additional pedestrian signals need to be installedto safe-guard them. Cyclists suffer the most because of blindspots 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 inordertoexit.Thiscanbeunexpectedtoabicyclistapproaching behind the turning vehicle, and the bicycle can, atthe same time, be in the motorist's blind spot at an unexpectedangle (neither behind, beside, or ahead). Alternative pathwayshavetobedesignedtoavoidroundaboutexitaccidentsandthat increases the cost of construction. Roundabouts are notsuitable for "platooned" traffic flow. Emergency vehicles likeambulances cannot make it through roundabouts easily. Theneedofthehourisbringingforwardaneffectivetrafficmanagement system that not only takes care of complex trafficconditions, but also costs less to manage. Cost effectivenessand optimum use of land are two key requirements of buildinganeffectivetrafficnavigationsystem,andunfortunatelyroundabouts do not fulfill both these conditions. Traffic circlesare in use across the world and have been for quite some time.Many people are used to them. Roundabouts require educatingpeopleaboutnavigationandcrossingmethods,whichisastressful exercise. In America, roundabouts and traffic circlesmust go hand-in-hand. Major cities can easily accommodateroundabouts, but for the smaller cities, traffic circles can servethe purpose without waste of money or land. Even the trafficcircles need to be improved because the traffic density andtrafficbehaviorhaschangedalotinrecentyears.

1.4 GPS-BASEDROADTRAFFICMONITORINGSYSTEM - A STUDY OF THE CELL PHONE-BASEDMODEL

Forcosteffectivetrafficcontrol,effortsareontocreateGPSbasedroadtrafficmonitoringsystems.Researchers,individuals, groups, and telecom companies are studying theprospects of such a system. This article discusses a cell phonebased modelwhilealso consideringitspracticality.

ROADTRAFFICMONITORINGSYSTEM–THECURRENTSCENARIO

At present, most road traffic monitoring systems use sensorsand video cameras to check the speed of vehicles and to takesnapshots of vehicles that violate signals. However, the cost ofthis equipment has restricted the current video camera-basedroad traffic monitoring systems to certain very important areasand important highway intersections - where there are greaterpossibilitiesoftrafficcongestionandaccidents.Thegovernment is willing to cut down the costs of the "sensor andvideo camera based road traffic monitoring system" so that itcan implementitwidely.To achieve this, ithas permittedseveral research groups and telecom companies to come upwith a model- both practical and cost effective- covering largeareas(notonlycertainportionsofthecityandhighwayintersections). There are several research projects going on,someusinggovernmentgrantsandsomeontheirown–conducted by telecom giants such as Nokia, UTStarcom, andothers. The common point in all these researches is that almostall of them are considering GPS-based road traffic monitoringsystem to bring down the overall costs of maintenance becausethe costs of the GPS devices are low and are showing a furtherdownward trend. Almonst every person with a vehicle has aGPS device or can afford a GPS device for vehicles, whichmeans that the stage is already set. We just need to put thedifferent components in place so that the desired GPS-basedroadtrafficmonitoringsystemcanbeputintoplace.Thefollowing section discusses the cost effective model of GPSbased road traffic monitoring system proposed by Nokia, aleadingtelecomcompany.

GPS-BASEDROADTRAFFICMONITORINGSYSTEM –ANOVERVIEW

ThemodelforGPS-basedroadtrafficmonitoringsystempresentedby Nokia is basedon thefact that almost

everyvehicledriveralreadyhasacellphone.Ifthemodelisimplemented, the cell phones can be upgraded to ones thatcontain GPS units if the existing ones do not have one already.The basic concept of this model is to trace "each"vehicleusing the signals sent out by the GPS unit in the cell phone.The model claims to monitor real time flow of traffic using theGPS enabled cell phones while securing the privacy of cellphoneusers.

The model suggested by Nokia for GPS based road trafficmonitoring systememploysuse of:

1) GPSenabledcellularhandsets;
2) acentralserverforeacharea;
3) theInternet;and,
4) a unit to view the traffic condition. This unit can be the cellphoneitself,aGPSunit,oranyotherdevicecapableofconnecting to the Internet and displaying the traffic conditions.Each area under observation will have a central server of itsown,therebyusingseveralserverstocoveralargerarea.Thesecentralserverscanbeintegratedusingwirelessconnectionstocreatea network thatcoversan entirecity.Each car will be equipped with a GPS-enabled mobile phone.TheGPSunit willcontainsome softwarethatwillsendsignals carrying data on the vehicle's speed and location to the centralserverforthatarea.Withallvehiclesinanareasendingsignalstothecentralserver,therewillbeampledatatocompute thetraffic conditions of thatarea. Once computed,the results will be uploaded to the Internet in form of images(graphs or charts). This information can be viewed by anyoneon his/her cell phones or any other device able to browse theInternet. The best thing about this model is that both driversand the traffic police can view the traffic conditions in real-time with a delay of only few milliseconds. While speaking onthe model's feasibility, a Nokia staffer says, "Enlisting GPS-equipped cell phones into trafficmonitoring systems couldhelp provide information on everything from multiple side-street routes in urban areas to hazardous driving conditions oraccidents on vast stretches of rural roads. GPS-based systemscan pinpoint a car’s location with an accuracy of a few metersand calculate traveling speed to within three miles per hour."This is quite true but there are certain obstacles that will haveto be considered for implementing this model of GPS basedroad trafficmonitoringsystem.

Nokia'sGPSBasedRoadTrafficMonitoringSystemModel –Possible Problems

RopinginCellPhoneServiceProviders

The first and foremost problem that may interfere with Nokia'sGPS-basedroadtrafficmonitoringsystemisthefactthatdifferent people use different service providers for their cellphones. As all the residents of US cannot be persuaded to usethe same service provider, all the different service providers inUS will have to be roped in so that the model works offeringfull data on vehicle movements. Even if one service providerbacks out, the model will yield partial results. However, QuinnJacobson,NokiaResearchCenter'sresearchleaderisconfidentthattherewillbenoproblemastheseserviceproviders will only benefit from being part of the GPS-basedroad traffic monitoring system. Also, drivers will not let theservice providers back out asthere are additional benefitstothe GPS-based road traffic system than just traffic updates.AccordingtoJacobson,"Integrationoftrafficinformationwith functions such as calendar and online timetables meansthat the mobile device can act as personal travel planner. Withtheincreasingnumberofvehicles,aproperroadtrafficmonitoring system will helpdrivers save time and preciousfuelbytakingalternateroutesbasedonrealtimetrafficinformation."

BANDWIDTHPROBLEM

Assuming that the cell phones in Nokia's model of GPS-basedroad traffic monitoring system send out signals every threeseconds, the system will require a huge bandwidth consideringthe number of cell phones active at any given point of time.AlexanderBayen,professorofsystemsengineeringatBerkeley’sCaliforniaCenter(theinstituteisalsopartofNokia's GPS traffic monitoring research), says that they areworking on a solution to find an optimum subset of the entiredata so that the model does not need such a huge bandwidth.However, I could not get any clue anywhere as to what kind ofsolutiontheyare considering.

USERPRIVACY:AMAJORPROBLEM

Most of the users of the cell phones will not want their phonesto send out signals indicating their whereabouts that can beintercepted by unwanted sources, too. According to Jacobson,if users are not willing, they can turn off the GPS feed in thecell phone. This will not affect the proposed GPS-based roadtrafficmonitoringsystemasitwilldisassociatethedatawith the cell phone and use it anonymously employing SSL (banktype encryption) so that the data is not used by anyone else,thereby protecting the privacy of the cell phone owner. Readourarticle onGPSCellphone-EthicsViolations.

Unwilling Users – People not Willing to Participate in theMonitoring System
There will be drivers who will not be willing to contribute.They may not use GPS-based cell phones or may turn theirGPS off. There will be a hard time persuading such drivers.However,consideringthebenefitsofthisGPS-basedroadtraffic monitoring system, the percentage of such people willbe very low. The results of computing at the central server willnot be affected, so the servers will still be able to upload real-time traffic information to the Internet. I also went throughsomeotherproposedmodelsforGPSbasedroadtrafficmonitoring systems, out of which, one was more stable thanthe Nokia model but it was not as cost effective as the modeldiscussed here.

1.5 ADDING UPTHEADVANTAGESOFTHEKANBANSYSTEM
The word Kanban may not be part of your daily vocabularywhenitcomestoscheduling.Butafterlearningabouttheadvantages of the Kanban system and its role in just in time(JIT) manufacturing, Kanban may become a household wordforyou.

THEVISUALSIGNALSOFTHEKANBANSYSTEMADVANTAGESOF THEKANBANSYSTEM
The Kanban System is an integral part of implementing theJustinTime(JIT)manufacturingphilosophywhichwasdesigned to control inventory and reduce waste. The history oftheKanbansystemcanbetracedbacktothelate1940swhenToyotamadeaculturalcommitmenttocontinuousimprovementtodriveitsmanufacturingprocessestopeakperformance.ThetermKanbanisaJapanesewordwhoseEnglish translation means signboard or visual signal. A well-timed Kanban system works exactly like a traffic signal inmanaging theflow of trafficandmeeting the real timeneedsof customers by sending clears signals on when to start, slowdown, and stop production. Each Kanban signal also carriesvaluable information about the volume and sequencing of theproduction. Toyota originally used cards attached to differentsupplycontainerstocommunicatewhatmaterialsintheproduction line were needed, but today many variations exists,including signboards and electronic systems. The result is anefficient systemwhere products are only replenishedwhentheyareconsumed furtherdownstreaminthe process.

IMPROVEMENTINPRODUCTION
The main advantage of the Kanban system lies in its innateability to drive down costs and waste by improving the flow ofproduction. Many of the scheduling advantages of the Kanbansystem spring from naturally from the core elements of leanandjustintimemanufacturingstrategies.Thesestrengthsbecomemorepronouncedwhentheflowofproductionisreduced to small batches to accommodate product variations.With a Kanban system in place, managers and supervisors seethebenefitsofthe Kanbansystemin:

Better managed inventory levels. Too much inventory canresult in cash flow problems by adding overhead expenses forstorage, insurance, and security. On the flip side, too littleinventory can damage the reputation of the business for beingunreliable,resultinginlostsalesanddissatisfiedcustomers.

The Kanban system combined with good inventory practicessmoothsoutinventorylevelsandeliminatescarryingcosts.
Smoother manufacturing flow. Because the Kanban systemfocuses on current conditions, production levels are calculatedto take into account downtime, scrap, and changeover time ofequipmentto ensurethattheproductionscheduleis met.
Overproductionelimination.Asademandpullsystem,Kanban is less likely to result in overproduction because of theneed to create buffer inventory to address unexpected delaysresultingfromqualityproblemswithsuppliersorminordisruptionsinthetransportationnetwork.
ReducedriskofInventoryobsolescence.Manyproductshave a shelf life or product lifecycle that can expire unless theproduct reaches the consumer in a timely manner. In thesechanging economic times, brand loyalty has faded and can nolongersaveacompanythatdoesnotdeliver itsgoodsontime.

RESPONSIVENESSTO DEMAND
Manufacturingismorethanjustaboutthemechanicsofproductionandaseriesofcalculationstodeterminechangeover, lead time, and downtime for equipment to derivean ideal production schedule. Production is foremost driven bycustomer demand which can run in a various patterns frompredictable to sporadic, from increasing to declining, and fromseasonal to no seasonal. One of the biggest advantages of theKanbanSystemisthatitimprovestheresponsivenesstochanges in demand. In this way, the Kanban system is similarto a smart traffic light with its ability to sense when the traffic,or in this case the demand, is building up. When the pent updemand reaches a predetermined level, the system sends theappropriate signal -- the traffic

light changes to green or, in thefactory,productionisspedup.

EMPOWERMENT

AnotheradvantageoftheKanbansystemisthatitplacescontrolinthehandsoftheoperatorswhoareinthebestposition to oversee production. People on the front lines havethe most knowledge about the daily operations and have apulseonthereal-timeflowofthework.Also,shiftingaccountability for monitoring the daily runs frees up the timeofsupervisorstofocusonlongtermplanningneeds.Empowermentisaneffectivemanagerialtoolbecauseitreinforce seducationandtraining;increasesmutualrespectamong employees, generates enthusiasm and dedication to acommon goal; lowers absenteeism, and increases productivity.Another by-product of empowerment is conquering resistancetochangebecauseemployeesparticipatedirectlyinthedecision makingprocess.

QUALITYCONTROLANDSELF-DISCIPLINE

A final advantage of the Kanban system is found in the fabricof its purpose to promote an environment devoted to qualityimprovement. Because the Kanban system uses small lot sizesat various points in the production, quality control issues canbe more easily pinpointed at the source. Also, the Kanbansystemeliminatesexcessinventorywhichtendstomaskqualityproblemsbyremainingundetectedforlongerperi odsof time. Thus, the need for buffer inventory to resolve qualityproblemsisreduced,andthissystembecomesself-perpetulating as inventory reduction leads to further qualityimprovmentresults.

AFINALTALLYOFTHEADVANTAGESOFTHEKANBANSYSTEM

In adding up the advantages of the Kanban system, managersshouldrecognizethatthesystem'sstrengthslieincreatinga moreorderlyandhighlyvisualaccountabilitysystem.Thevisual signals not only aid in improving production flow andresponsivenesstocustomerdemandbutalsoinshiftingworkers' focus on quality improvment and team work throughempowermentand self-monitoringactivities.

1.6 DESIGNCONSIDERATIONSFORSAFEBIKEPATHS

Bike paths are as important as highways and proper designguidelines must be followed while designing them. Bicyclesafety tips are an important aspect of design and what types ofroads are suitable for bikers will be discussed in this article.Read onto knowaboutbestbike pathdesigns.

BICYCLEPATH

Designing a bike path is not as simple as it may sound.Inmost of the American states, bike-car collisions have alreadycreated a lot of problems. Bikes cannot move on the highwayalong with other speeding vehicles because bikes move veryslowly in comparison to cars and other vehicles. One singledesign is not the solution because they differ depending on thetypeoftrafficandtrafficdensityoftheregion.Differentdesign methods need to be implemented to develop a balancedcommutingchannelforthebikers.AccordingtotheUSDepartment of Transportation, walking and bicycling facilitiesmust be a part of the road project and cannot be ignored unlessunderexceptionalcircumstances.Withgasbecomingmoreexpensive, high inflation rates, and increased pollution levels,governments and private organizations are promoting cyclingactivities and to promote it, it becomes even more important todesign safepathways forbikers andofferthebest possibleroad facilitiestothem.

THEDESIGNGUIDELINES

Safety and accessibility are two important factors associatedwith bike path design. Those driving a car or a motorcycleoftenpaynoattentiontobikersbecausebikesareconsideredtobeeasy vehicles,theymoveslow,weighless,andcanmanage in less space. However, a biker would not be hurt lessin an accident, so safety becomes the primary concern whiledesigningabikepath.Accessibilitymeanstakingcareofintersections, busy traffic areas, and the merging of bike laneswith the main highway. How bikers access the exclusive bikelanes and how do they switch to the main highway withoutdisturbing the flow of traffic is another important aspect. Asingle design cannot be proposed for a state or a big regionbecause traffic conditions are not same throughout the region,soamixeddesignapproachisadoptedtodesignsafepathways forbikers. TheUS Department of TransportationandFederalhighwayAdministrationhasalsostatedthatadopting a mixed approach will always lead to a better andmoreeconomicalnetwork.

MajordesignsthatareimplementedinAmericanStates,recommendedbytheauthoritiesarementioned below.

1. ExclusiveBikeLane
2. MixedorSharedUsePaths
3. ParkingPermittedorPrakingProhibitedBikeLanes
4. OffRoadCycle Lanes

5. CanberraBicycleLane

Exclusive Bike Lanes are designed and developed on the sideof the main road. These roads run parallel to the highway andintersectveryrarely,mainlyatthetrafficsignals.Usuallythese lanes are designed in cities where the roads run for aconsiderable distance without turning. It helps the bikers tostaysafeandtravelequaldistanceasthemotoristsdo.Howeversuchlanesareexpensivetobuildandmaintain.

Mixedorsharedpathuseisonesuchmodelwhichiscombinationofdifferentlanes.Theselanesusuallyaredesigned in cities where Shared Pathway number of bikerscommuting on a daily basis along with the traffic density ishigh. Bikers travel on the main roads along with the motoristsand the lanes keep on merging and diverging from the mainroad depending upon the traffic conditions. Segregated bikelanes are designed on the main highway and are painted withwhite stripes. Moreover, these lanes are exclusively meant forthebikersandmotoristscannotruntheirvehicleontheseroads while passing or for any other reason. However, themixed pathways require very high level of safety measuresbecauseifthebikelanesarenotequippedwithpaintedboundaries,indicatingboardsandwarningboards,theaccidentsareboundtohappen.Consideringtheeverincreasing population and number of new vehicles rolling inevery year, mixed modal pathways are the need of the hourbecause they not only save time and money, but also helpbikerstomovealongwiththemainstreamtraffic.

PROTECTEDBIKELANE

Parkingpermittedorparkingprohibitedbikelanes,asthenames signify, allow or prohibit the motorists to park theirvehiclesalongsidethebikelanes.Whentheparkingisprohibited, it strictly means that no car should be parked oreven enter into the bike lanes. When motorists try to park thevehicles in the prohibited lanes, bikers often face problems.Just imagine you take a turn on an exclusive bike lane and allof a sudden you find a car parked in the middle of the lane.Even in the parking permitted lanes, accidental probability ishigh because very often motorists open up the doors of theircars on the bike lanes creating trouble for the bikers. Off roadbike lanes are not the laneswhere the general bikerswouldlike to go but still off road bike lanes are constructed to helpbikerscommutethroughoff-roaddestinations.Bikersgenerallywouldnotcomplainaboutashortcutthatsavesconsiderabletime.

INTERSECTIONS & TRAFFIC SIGNALS - GREATESTHURDLES

Irrespectiveofthedesignandtypeofbikepathway,thegreatest hurdles are the merging of bikers and motorists on atrafficsignaloranintersection.Mostaccidentshappeninthese places because regulating the bikes and motors at suchjunctions becomes difficult. The Department of Transportationstates that while approaching an intersection the bike stripesmust be dashed so that bikers get an idea that motorists canturnrightandenterthebikelanewhileturning.Atlargeintersections, mixed or shared pathways become problematicbecauseofvehiclescomingfromallthedirectionsandentering into the bike lanes becomes inevitable. Even at thetraffic signals, if the queue is too long or the signal is too busy,motorists often tend to enter into the bike lanes. This can beavoided by segregating the bikes from motor vehicles as thetraffic signal is approached. Another hurdle remains drainageproblem over the bike lanes. In hilly regions, exclusive bikelanes are constructed at a height above than the main road. Ifthe water drainage system is not put in place, it will surelycreate problem for the main traffic movement and affect thestrength of roadtoo.Bike accidents happen just like otheraccidentsandbikersneedtofollowbicyclesafetytipstoensure their own safety. Bikers must not try to rush with themotorists because a bike is a bike and a car is a car. Drivesafely, try not to rush and when moving in the traffic, ensurethat a helmet is on your head because if it is not on your head,itwilldefinitelycreateproblems.

1.7 RUMBLESTRIPSANDCENTERLINERUMBLESTRIPS

Rumble strips whether used on edges or centerline of roads areconsidered a road safety feature as the vibration and rumblingthattheyproducehelpto alertdrivers who areinattentive.

RUMBLESTRIPSASSAFETYDEVICESCENTERLINERUMBLESTRIPS

Rumble strips and centerline rumble strips are being used toreduce accidents and warn inattentive drivers. Rumble stripscan even be laid across a travel lane so that they can warndrivers that they are approaching areas ahead where they needtoexercisecaution.Suchstripsarealsoaccompaniedbysignage warning of the impending danger. Rumble strips werefirst used in 1952 and have followed a number of designs.Initially the asphalt pavement was itself milled or formed insuchawayastocreatetheindentationsrequiredfortherumblestrips. This hasnow been totally replaced by ceramicor plastic raised systems made famous by Botts' Dots. Suchstrips produce rumbling that creates specific frequencies in theaudible range and traffic engineers have used this to createsinging shouldersormusicalroads.

PROBLEMSWITHRUMBLESTRIPS

Rumble strips have however not been without their share ofcontroversy,andpeoplestayingnearfreewayshavecomplainedagainstthenoiseproducedbysuchrumblingstrips. As a result many authorities do not install rumble stripsin suburban areas where low speed restrictions are in place.Rumblestripsarealsosometimesviewedasahazardforcyclists, whose narrow wheel base may find the rumble stripsdifficulttorideover.Climateisanotherfactorthatdoescontributetothesuccessorfailureofarumblestrip.Innorthern areaspronetoseverewinters,suchstripscangetfilled with ice or even traction sand and become ineffective.This can also happen in desert or sandy areas where winds canfill up the space in the rumble strips. Steering wheel vibrationis another aspect that worries traffic engineers, and this hassomething to do with the gaps between rumble strips and isbeingstudiedforthe bestpatternto be followed.

THEIMPORTANCEOFCENTERLINERUMBLESTRIPS

Centerline rumblestrips aremainly used on twolanes, twoway roadways and are meant to create warnings for drivers toavoidpotentialaccidentswithopposingtraffic.Accidentshappen due to side swiping or head on collisions. It has beenestablished that the installation of centerline rumble strips hasled 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 noimpendingmechanismstotrafficrunninginoppositedirections. Different designs of the centerline rumble stripshave led to the use of double 4 inch strips laid parallel to theroad and 6 inch lateral strips that are said to increase visibilityaswellaspreventdamagetothecenterlinestrips.Otherdesignsusestripsthatmaybelaidcontinuouslyorinlength sof 12 inch to 30 inch with thewidth varying from 4 to 8inches. Depth of grooves is normally kept at half an inch,which is considered enough to produce the rumble. Centerlinerumblestripsrequireverylittlemaintenanceanddonotcontribute to degradation of the pavement as had been theapprehension.

MAKINGCENTERLINERUMBLESTRIPS

Centerline rumble strips can be milled on the center of theroadway with machines that have been specially designed forthis job. Quite often painted lines are also used in addition tothe rumble strips for better visual identification. These linescan be on both sides of the milled rumble indentation. In suchcasesthewidthoftherumblestripisreduced.Spacingbetween strips can be 12 to 24 inches, though the maximumdecibels which serve as warning are in those strips that have a12 inch distance. Length of strips in the direction of traffic isbest at 6 inches and the width across traffic 12 inches. A depthofaboutaquarterofaninchinthemilledsurfaceisconsidered adequate to produce the sound caused by air beingforcedoutofthedepression.Carpetingorrelayingofthesurface of aroadwould require that these rumble strips haveto be redone. It has to be however ensured that the thickness ofthenew layerissufficienttotakethenewmillingthatisrequired tocreate therumble strips

1.8 RESPONDINGTOROCKFALLRISKONPUBLICROADWAYS

Construction of highways and railways is challenging aroundmountainsandsteepslopes.Eachrequirespecialstudybygeologists and geotechnical engineers. Through geotechnicalanalysis,slopesareidentifiedthatarecriticalandrequirespecial protection. The "Rockfall Hazard Rating System" forthe Federal Highway Administration was introduced by theOregonStateHighwayDivision.Itisusedtodefinetheoverall stability of slopes along mountainsides against majorsliding or toppling failures in order to protect the highwaybelowfromknownhazardsthroughvariousmethods.However, analysis of hundreds of miles of mountain highwaycan be more difficult than rocket science.In this article wetakealookattheimportantthingsdoneunderthisratingsystem in regard to determining slopes that are hazardous andrequire immediate remedialwork. You can also use the tablein the image given below for the exact ratings of all the factorsofthisratingsystem.

SLOPEHEIGHT

Slope height is an important measure of risk because rockspresentonthehigherslopeshavehigherpotentialenergy.Measuring slope height requires determining only the verticalheightoftheslope(inplaceoftheslopedistance)ormeasuringthehighestpointfromwhererockfallcanbereasona bly expected. There might be some cases where rocksare coming from a slope present above the roadway cut. In thissituation,addthecut heighttotheoriginalheightoftheslope.

DITCHEFFECTIVENESS

"Ditch" is the area in between the slope and the roadway. Theditch effectiveness is defined as ability of the ditch to preventfalling rock from reaching the road. There are certain factorsthatneedtobeconsideredformeasuringditcheffectiveness.

SLOPEHEIGHTANDITS ANGLE

- Slopeirregularities
- Quantityoftherockfall
- Anticipatedsizeoftheblock
- Parameterandshapeofthe ditch

Measuringslopeirregularitiesisimportantbecauseitcanincrease or decrease the speed of falling rocks and there wouldbemore tendencyofrocksreachingthe road.

PERCENTOFDECISIONSIGHTDISTANCEROCKFALLFENCE PROTECTINGROAD

Sight distance is the length at which an obstacle of a specificheightisvisibletothedriver.Thepercentdecisionsightdistance is the measurement in feet that is used to determinefrom what distance a normal driver can make an instantaneousdecision if any obstacle comes in front of him. It is importantbecause curves of the roadways along the mountains can limittheabilityofadriverto noticerockspresentontheroad.

GEOLOGICCHARACTER

As thename says, it defines thegeologic characteroftheslopes.Theseareclassifiedintwocases.Thefirstcaseincludesthestructuralconditionssuchasadhesiveor continuous joints present in the slopes, rock friction angle,hydrostatic head if water is present, and other discontinuities.Furthermore,thesecondcaseincludesslopeshavingdifferential erosions or overstepped slopes. Measurement ofrock friction is also important determining the potential of therockstomove over one another.

QUANTITYOFROCKFALLPEREVENT

Thisratingdetermineswhattypeofrockfallmaymostcommonlyoccur.Forexample,ifrocksfallindividually,considerin g the sizes of the rocks is required. If a number ofsmall and large sized rock fall, use the mass of the fallen rocksinthelasteventtodeterminetherating.Usuallythesemeasurements can be easily determined from the maintenancehistory.However,ifthereisnoeventhistory,estimateitthrough observing the conditions of the slope. This factor isalsobeneficialfor futureremedialmeasures.

CLIMATEANDTHEPRESENCEOFWATER

Studying the climate and the presence of water in the slope isessential. This is because water and freeze cycles contribute animportant role in rock movement. If the area gets less thantwenty inches rain peryear,it is calleda low precipitationarea; if the value is more than fifty inches, it is then called ahigh precipitation area. The impact of freezing or thaw cyclescanbedeterminedbythe freezingconditionsofthearea.

OTHERIMPORTANTPARAMETERS

Therockfallhazardratingalsoincludesthewidthoftheroadway. This measurement is appropriately called "RoadwayWidth"anddefinesthemaneuveringroomforadrivertoavoid rockfall. If the width is variable, consider the minimumwidth of the roadway for this rating. The "Average VehicleRisk"rating represents the average time of which a vehiclewill be present in the hazard zone. It is based on factors likedaily traffic and the posted speed limit in an area.Next is"Difference in Erosion Ratings."This measurement definescommonphysicalandchemicalerosionprocesseshappeningin the slope. The effect of human action is also a factor toconsider into it. The difference in erosion rates explains howquickly erosion is taking place at the particular slope. All theabove points are important and essential to determine for theFederal Highway Administration's rating system for rockfallhazards. However, there is onemore point to consider, andthat is the rockfall history of slopes. This is because historicaldata directly represents which slopes are very hazardous andrequire remedial work. Again, the maintenance officer is thebestpersonforgettingthehistoryof suchevents.

1.9 ROADTRAFFICSAFETYBARRIERS

Life is precious, and should not be wasted by road accidents.Useofthe roadsafetyfeaturesand properdrivingmayprevent road accidents. The roads have been designed keeping in viewthe human factors in road safety. Safety posters and sloganscaninfluence humanstowardssafedriving.

IMPORTANCEOFROADSAFETY

Risks will always exist that are related to road safety, and theirtotaleliminationmaynotbepossible.However,allrisks,including road Importance road safety driving risks, can bemitigatedbytheimplementationofappropriateremedialmeasures.Thestateandthegeneralpublichavearesponsibility to control and manage road risks. The humanfactors in road safety should be the prime parameter whiledesigning roads. Safety posters and slogans, and observing ahorrificaccidentpicturedohaveapositiveeffectonthehuman mind. Drivers may benefit from the shortest drivinginstructions that are available at several training institutions.Road safety must constantly be kept in mind. Each individualis responsible for the road safety. The circumstances on theroadsareunpredictable,duetowhichitisonlyproperplanning,implementation,andconscientiousnessthatcanassist to reduce the road accidents. Road traffic victims, injury,and suffering represent a severe universal state that adverselyaffects the lives of individuals. This is an important matterconsideringthefinancialeffectsonthestateandthecommunity.Thestatehastheresponsibilitytoarrangemeasures for the prevention of accidents, while the public isexpected tostrictlyabide bythe roadsafetyregulations.

SAFEROADDESIGN

Thesaferoaddesignisanimportantfeaturethatcansignificantly contribute to prevent road accidents. The betterroads have on the curves to increase the vehicle stability. Thisis particularly important for the vehicles that have a highercentre of gravity. The roads should be cambered in accordancewith the design analysis, with round surfaces. Such roads willdecrease the ice and standing water, mainly to avoid the frostdamage, and also increase the traction when the weather ispoor. The roads should have suitable arrangements to facilitatedrainage, particularly on the bends. The current road barriers,intendedforsafety,aredesignedtoensuremaximumabsorption of the impact, with minimum risk to the vehicleoccupants. The side rails are firmly fixed with the ground, andthepolesforlightsareplannedtofractureatthebottom,instead of stopping a car violently. The road fixtures like firehydrants and the road signs are designed to fall on impact. Thetrees along the roads are removed to improve visibility. Theguard rail ends are fitted with impact attenuators that slowlytake in the vehicle kinetic energy. The vehicle slows smoothlybefore striking the guard rail end. Several other techniques areemployedfor the dissipationof the kinetic energy. Barrelsfilledwithsandtransferthe vehiclemomentumtothesand.

ROADMARKINGS

Thenumeroushazardsontheroadaregenerallyindicatedmultiple times, much before their appearance, to enable timelymeasures by the drivers. Mainly, the marking materials usedfor pavements and roads are reflective, including prisms orglass spheres that efficiently reflect lightfrom theheadlightsof the vehicle. Thus, the driver can easily be warned about thedangers ahead. Lanes are distinguished by the use of Botts'dotsandCat'seyes.Botts'dotsarenormallyroundraisedmarkers for pavements that are not reflective. These markersare used for the marking of lanes on highways and main roads.Feedback is provided to the drivers while moving across thetravellanes.Theyaresimilartorumblestrips,andaregenerallywhite,butcanbealsoyellow.Thecat'seyeisasafety gadget that is utilized in road markings. It consists ofreflective glass that is fixed in a rubber casing. It marks theroad centre for the convenience of the driver. Cat's eyes areprimarily useful in haze. Furthermore, tone bands are engravedinto the road edges that awaken the drowsing drivers whentheymoveofftheroadedge.Tonebandsmayalsobecommonlycalledrumblestrips.Alternatively,raisedribmarkings may be used that consist of a line marking, withregulardiagonalribs.Theyimprovetheedgedescriptionduring wet conditions,or duringdarkness.

II. CONCLUSION

- Risks will always exist that are related to road safety, andtheir total elimination may not be possible. However, allrisks, including road Importance road safety driving risks,can be mitigated by the implementation of appropriateremedialmeasures
- Thepresenceoflightingnotonlyreducestheriskoftrafficaccidents,butalsotheirseverity.Surveyshaveshown that the public are in favour of street lighting as away of improving road safety and that, if anything, itneedstobe improved insome areas
- The human factors in road safety should be the primeparameterwhiledesigningroads.Safetypostersandslogans, and observing a horrific accident picture do haveapositive effectonthehumanmind.
- Centerline rumble strips are mainly used on two lanes,two way roadways and are meant to create warnings fordrivers to avoid potential accidents with opposing traffic.Accidentshappenduetosideswipingorheadoncollisions.

- SafetystandardslikeBott'sDots,WorkingofTrafficLight Systems, Roundabouts, Traffic Circles, PS basedRoad Traffic Management System, The Visual Signals ofthe Kanban System, Safety Considerations for Safe BikePaths, Rumble Strips and Centerline Ruble Strips CreateSafer Roads

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