Applying Context Sensitive Design to the Innovative Development of Major Highway Projects

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Applying Context Sensitive Design to the Innovative
Development of Major Highway Projects

This paper explains how Context Sensitive Design (CSD) is being applied in the development of major Canadian projects requiring the construction and upgrading of arterial corridors. It continues the thesis of the author's paper to the 2002 TAC conference, which dealt with the emerging topic of CSD.

In the design field, CSD is about influencing driver behaviour. In the broader project field, context sensitive solutions are assisting Canadian highway authorities attaining their goals for improving safety, reliability and capacity, while balancing the needs and concerns of the environment and stakeholders. CSD can also enhance constructability and operation.

This paper explores contemporary road design procedures that address the community context and follow the 1999 TAC Guidelines. These Guidelines allow for flexibility and the use of ranges of geometric parameters (domains) when supported by professional engineering judgement. They permit creativity and initiative as long as all decisions are documented with design heuristics and valid research. In this way, the context of communities, in terms of values and preferences, may be accommodated into road designs.

The paper explains how project guidelines are being prepared for new road projects using the TAC Guidelines as their principal reference and explicitly addressing traffic safety. This is done by specifying geometric consistency and crash prediction modelling. These requirements place engineers at the forefront of the design task, mindful of their duties to society and to the likelihood of legal challenge.

CSD project guidelines focus on designing for consistent operating speeds. This introduces speed management and the use of speed reduction techniques. These can involve a variety of measures supported by human factor research. They entail conceiving a road message for drivers, by means of cross-section and horizontal alignment, that indicates the intended speed behaviour. Drivers adapt to constant speeds when design elements are consistently applied for selected design speeds.

Central to the paper is the topic of road aesthetics and the desirability of incorporating a community theme to corridor planning. This encourages consistency in roadside treatments as well as intersection and driveway layouts. Themes also deal with guide signing, intelligent traffic systems and lighting.

This paper will add to the understanding of CSD and to its application in other Canadian provinces.

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Applying Context Sensitive Design to the Innovative Development of Major Highway Projects

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1. Purpose of this Paper

This paper sets out a context sensitive design (CSD) approach for use on major road projects involving new construction or the upgrading of arterial corridors. It is usual for a unique, significant project to require a specific set of guidelines especially where operating speeds are to be limited. Such guidelines must incorporate safe engineering geometric design (surface design) requirements. This geometry should be consistent with a visual theme and an aesthetics plan developed specifically for the Context Sensitive Design of the project.

2. Context Sensitive Design

In the geometric design field, CSD is about influencing driver behaviour. In the broader project field, context sensitive solutions are assisting Canadian highway authorities attain their goals of improving safety, reliability and capacity, while balancing the needs and concerns of the environment and stakeholders. CSD can also enhance constructability and operation.

Project specific guidelines lead the designer to complete a design report at the conclusion of the design task. This report documents the decisions made during the design process and are detailed on the construction drawings. The design report should substantiate matters dealing with safety as well as illustrate the proposed visual theme for the facilities and the suggested aesthetics of the physical features.

Project specific guidelines should use the contemporary road design procedures of the 1999 TAC Guidelines. These Guidelines allow for flexibility and the use of a range of geometric parameters (domains) when supported by professional engineering judgement. They permit creativity and initiative as long as all decisions are documented and backed up with design heuristics and valid research. In this way, the context of communities, in terms of their values and preferences, can be accommodated into road designs.

One of the central objectives of the 1999 TAC Guidelines was to highlight the need for designers to address explicit rather than nominal traffic safety. This is done by stipulating both geometric and operating consistency and by utilizing crash prediction modelling. These requirements place engineers at the forefront of the design task, mindful of their duties to society and to the possibility of a legal challenge.

Operating consistency requires the use of speed management and speed reduction techniques. These can involve a variety of measures which are supported by human factor research. They entail designing a clear road message for drivers. This is done by means of a cross-section and horizontal alignment that indicates the desired speed behaviour. Drivers adapt to constant speeds when design elements are consistently applied for selected design speeds.

Project specific guidelines should focus on the topic of road aesthetics and the desirability of incorporating a community theme to corridor planning. This encourages consistency in the treatment of roadside elements as well as of structural features. Themes also deal with guide signing, intelligent traffic systems and lighting.

Finally, whenever there is a departure from a long-established practice, there is resistance and scepticism. Applying the processes of the 1999 TAC Guidelines, instead of using "cookbook" standards, have produced their share of detractors both from professionals and politicians. This paper concludes by summarizing these matters by pointing to ways of dispelling public concerns and ensuring advancement of road design practice.

3. Contextual Project Objectives, Theme and Aesthetics

Few managers of new or upgraded road projects pause, at the outset, to visualise their completed facility. Road engineers are still largely motivated by functional considerations and by regulatory agency requirements. Yet there is something of the aesthetic in all of us and starting with the end in mind will greatly enhance the acceptability of our future road works

3.1 Typical Road Project Objectives

The design of a new or upgraded road project may have varied objectives. Typical amongst them may be:

- to develop a facility that is affordable both to society and to the project's business case;
- to influence safe driving behaviour at moderate speeds;
- to provide capacity for higher traffic volumes;
- to address all road users (drivers, bus users, cyclists and pedestrians); and
- to incorporate community and aesthetic values.

Most Canadian road proponents are required to hold community workshops in order to be in touch with the public and elected representatives about their design plans. This consultation establishes whether plans are in keeping with community expectations together with incorporating suggestions for civic character and urban form.

3.2 Corridor of Area-Wide Themes

It is usual for buildings, especially public buildings, to incorporate a theme that defines its form. Famous buildings in all Canadian cities have tried to capture their surrounding features such as waterfront, mountain or prairie. Rapid transit lines usually incorporate a common theme in their urban and station appearance. Roads have tended to appear to be more matter-of-factual except where they have been adapted as ceremonial parkways.

A look around many Canadian cities shows renewed interest in streetscaping. These take the form of boulevard strip plantings of trees and shrubs. Most of these undertakings are costly and tend to take place in a piecemeal manner and not as a preconceived corridor plan. Road corridors usually pass through many different jurisdictions which have developed their own requirements to the exclusion of common themes. Yet streetscaping that is not undertaken consistently can be unsafe and ineffective.

Development of a common corridor or network theme provides identity and character to a road. The theme should embrace both the functionality and objectives of the project and foresee a unique appearance in the completed facility, one that is both acceptable and affordable. The theme provides the basis for the aesthetic features that are to be incorporated into the design.

3.3 Aesthetic Considerations

Aesthetic features are sometimes applied to structures but more often to prominent bridges. Landscaping usually supplements road aesthetics. Yet there are many ways that geometric designers can incorporate aesthetics into their plans.

Designs of bridges, roadway and roadside features should be compatible with the aesthetic theme of the overall corridor and community context. They should respond to the historic, ambient and community values, while respecting cost, environment, functionality and constructability. Aesthetics also involves legibility which is the ability of users and those living adjacent to a road corridor to understand its purpose and its components with ease.

Visualizing is the process of establishing an image of a proposed facility, prior to its detailed design and subsequent construction. The image of the road may relate to some idea or existing road that fulfills the vision. The image will incorporate road elements such as medians, boulevards, bicycle and pedestrian facilities in their aesthetic form. Once the vision is sketched, photographed or verbalized the geometric requirements can then be designed.

Possible Visions of a Contextually Designed Road

Common aesthetic features are most noticeable at transitions from one structural form to another or from one urban form to another. Heraldic icons that provide an image of area, its features or history are often used at bridge portals. Portal features are used at entrances to towns or cultural centres. Simpler forms of transition may involve distinct forms of plantings or landscaping. Transition features convey the sense of interest and location. They also have a regulating effect on traffic operations and on vehicle speeds.

The continuation of common aesthetics are provided by the form of a number of geometric features including;

- boulevard character and plantings,
- intersection character and roundabouts,
- guide signing,
- sound attenuators,
- light fixtures,
- handrails and guardrails,
- pedestrian and cycling layouts.

4. Designing for all Road users

Designing for all road users is a common requirement that carries a tone of special interest. Roads have tended to be designed for automobiles, the most common road vehicle. Truckers demand more attention to their needs as do transit operators and emergency services. Recently cyclists have been exacting more road space. Likewise, pedestrian associations have been formed to lobby for more pleasing access for commuter and recreational walkers. People with ambulatory, auditory and visual disabilities have long required better accommodation for their needs. CSD provides the opportunity to incorporate the requirements of all road users in a meaningful and practical manner

4.1 Design Vehicle Accommodation

The design vehicle for most new roads is the WB-20 (tractor- or semi-trailer). This vehicle is 2.6 m wide, approximately 20 m and a height of 4.3 m. Accommodating WB-20 vehicles rather than the standard WB-19 vehicle, is still a questionable requirement on most Canadian road networks, especially for interchange ramps and intersection turning roadways.

4.2 Transit Accommodation

Transit vehicles use the travelled lanes of most roads along with other general purpose traffic. Their conflict occurs at stopping points and there is an ongoing debate as to whether busses should pull off or hold up traffic by stopping on the travelled lanes. Traffic forecasts indicate ongoing congestion on most urban arterials with only moderate levels of bus usage. The accommodation of bus bays adjacent to limited speed facilities with thematically designed bus shelters are the safest for both road and transit.

4.3 Pedestrian and Cyclist Accommodation

Most Canadian communities require that pedestrians and cyclists be accommodated as legitimate road users similar to motorized vehicles. The presence of such users on roads defines their community character facilities rather than high-speed freeways.

The attractiveness of pedestrian facilities is a function of their walkability. This implies safe and attractive pathways, free from noise, dirt and fumes. Pedestrians may choose to walk along busy roads in temperate conditions if the sidewalks are planted with trees or foliage. All pedestrian facilities must be designed to incorporate the ambulatory and visibility needs of disabled users.

Appropriate provision for cyclists on the new or refurbished roads should compel cyclists to be part of the traffic and to operate in the same manner as other road vehicles. Commuter or regular cyclists take the most direct route to their destinations. They are serious road users who do not expect to be hindered by unnecessarily steep or rough pathways or by deviations through cycle routes of a recreational nature.

Bicycle lanes have their best application on inter-community arterial roads, adjacent to and configured with the right-hand travelled lane. This is the least expensive form of cycling infrastructure. When necessary on arterials, bicycle lanes can double as emergency stopping lanes for motorized traffic.

4.4 Operations and Maintenance Vehicle Accommodation

Road operators are charged with the long-term operation and maintenance of road projects. The geometric design of road facilities needs to reflect the requirements of operators to enable them to:

- store of emergency and maintenance vehicles and equipment;
- use intelligent transportation systems to monitor the traffic flow and incidents and to respond to emergencies; and
- provide turnarounds and diversions for use in the event of an emergency.

5. Incorporating Human Factors into Geometric Design

The influence of human factors on driver behaviour is documented and incorporated in the various Guidelines presented in the Transportation Association of Canada's Geometric Design Guide for Canadian Roads and the 2001 British Columbia Ministry of Transportation Supplement.

Human factors have become an important consideration in geometric design. The ability of the driver to process road information in a timely fashion is key to designing a safe road. The following is a brief discussion of these human factors and how they influence driver behaviour.

Human factors allow information to be provided to road users on their ability to:

- comprehend rapidly changing road environment;
- process the information from the road environment;
- carry out required manoeuvres (curve negotiation, lane changes, emergency and non-emergency stops).

A designer's knowledge of human factors can assist in providing for:

- roads with a consistently lower operating speed;
- design and location of signing that will allow comfortable wayfinding for unfamiliar drivers; and
- geometric design that encourages safe operation in keeping with driver expectations.

In assessing road user behaviour, the human factors specialist in traffic safety considers the impacts of age, inexperience, impairment, unfamiliarity with the road, fatigue and other stressors causing erratic and unpredictable performance.

It is estimated that 90% of the information used by drivers is visual. The visual field of the human eye is very large. However, only a small area of direct vision allows accurate comprehension. At 80 km/hour, the driver moves 2 metres during the shortest glance. During more complex visual tasks, like reading a sign which might take up to 2 seconds, a driver can move up to 45 metres or more during a single fixation. Each glance takes time which means that two seconds or more can elapse between glances at a given area. Fast moving vehicles, bicyclists and running pedestrians can appear "out of nowhere".

When we drive at speeds our information processing capabilities are severely challenged. The higher the speed, the simpler the road design must be for us to cope. For this reason freeways have the simplest design – no pedestrians, bicyclists, at-grade intersections or oncoming traffic.

Designing roads in a consistent manner is critical because drivers are limited in the speed with which they can process information, and consequently rely on looking for information in familiar places and making familiar responses. When designs correspond to driver expectations reflexes are faster and more accurate.

6. Context Sensitive Design Alignment Considerations

6.1 Influencing Driver Behaviour with Horizontal Alignment

Design elements associated with the horizontal and vertical alignment of the road have the most important influence on driver speed and perception. These elements primarily involve the curve radius, the length of tangents and vertical gradients. They also involve the length of spirals, available sight distance, decision sight distance and vertical curvature.

Alignment parameters require consistent application in order to influence safety with consistent driver speeds and positive guidance. Drivers tend to speed up when entering tangent sections. This is more likely to occur on rural rather than urban sections where speed is curtailed by at-grade intersections.

Driver operational speed is limited by the sight line to the circular curve ahead. Speeds on long tangents can be suppressed by speed management measures such as using delineators like milled centrelines and inside lane edge rumble strips. Narrower lane widths tend to reduce speed, landscaping that is close to the lane stimulates peripheral vision and gives the driver a strong cue as to operating speed. In speed transition zones, operation can be managed by design elements that support the speed change. In specific cases, where speed needs to be reduced due to a sharp curve or a hazard, transverse lane markings can be used.

Further reference to speed characteristics and design heuristics are provided in TAC, AASHTO and Lamm (References 1, 2 and 3).

The following text provides project guidelines for undertaking road alignment designs to influence operating speeds.

6.2 Alignment Parameters

Exhibit 6.2 provides an example of the alignment parameters applicable to operating speeds of the ranges indicated. Ranges of design dimensions are shown for each element. These ranges (design domains) can be used to influence the operating speed conditions and driver behaviour. Selection of design dimensions need to be documented using critical engineering judgment. The dimensions conform to the Transportation Association of Canada's Geometric Design Guide for Canadian Roads.

Exhibit 6.2 Ranges of Design Dimensions for Anticipated Operating Speeds

Anticipated 85th Percentile Operating Speed (km/h)*	70 – 80	50 - 60
Horizontal Curvature		
Minimum Curve Radii (m)	250 – 340	120 – 190
Curve Spirals (m)	50 – 80	40 – 60
Maximum Superelevation	6% - 8%	4% - 6%
Tangent Cross-Slope	2% - 3%	
Weaving Distance (m)	500 - 700	
Minimum Stopping Sight Distance (m)	120 – 150	77 – 90
Decision Sight Distance (m)	185 – 275	120 – 150
Lane Widening	Verify requirements for WB-20 design vehicle	
Vertical Curvature		
Maximum Grade	5%	6%
Sag K Factor	25 – 40	15 – 25
Crest K Factor	25 – 40	10 – 25
Vertical Clearance	5.0 – 5.3 M	

* Note Definitions of speed.

- **Operating speed** is the speed selected by <u>drivers</u>.

- **Design speed** is a speed for which <u>vehicles</u> have been tested for safe operation and for which design parameters have been calculated. Drivers do not necessarily recognize or operate at the design speed and the term should be avoided.

- **Posted speed** is a <u>statutory</u> requirement. Posted speed should be at or below the design speed.

6.3 Design Consistency

Designers should be encouraged to undertake a design consistency analysis on the alignment layout of the Crossing and Connectors using both safety auditing and recognized design consistency models.

The approach should examine consecutive sections of road to ensure that the driver's response to changes in alignment result in consistent operating speeds.

A design consistency analysis, as described in Lamm (Reference 3) should verify the driver operating speed profile for the design layout and the vehicular response to the speed. It should also consider the consistent appearance of the road and the consistent use of cross-sections, intersections and interchanges. Conformity is also required in the implementation of road signs and markings.

For good design, the 85th percentile operating speeds (V_{85i}) on two succeeding road elements (curves and tangents) should vary less than 10 km/h.

$$V_{85i} – V_{85i+1} < 10 \text{ km/h}$$

For a good design, the 85th percentile operating speed should not exceed the design speed (V_d) by more than 10 km/h.

$$V_{85i} – V_d <10 \text{ km/h}$$

6.4 Anticipated 85th Percentile Operating Speed

Contemporary design practice requires designing for the anticipated operating speed of drivers on each particular segment of the road. This operating speed should be the 85th percentile speed below which 85% of drivers are expected to operate. In keeping with the context of designing limited-speed facilities. The speeds shown in **Exhibit 6.2** have been established by both TAC and AASHTO as safe operating speeds for the design.

In practice, drivers operate at speeds they consider comfortable for the conditions and it should be the objective of the designer to create a design to meet the 85th percentile conditions.

6.5 Minimum Curve Radii

Drivers interpret their speeds on curves by their sense of vision, maximum superelevation and side friction. Vision is quantified by minimum sight distance. Superelevation in urban areas is 4% to 6%. Side friction under normal, wet (not icy) driving condition has a value of 0.14 to 0.18.

Minimum curves control the operating speed on the roadway. In order to influence the driver's choice of the anticipated operating speeds, designers need to use the range of limiting curves shown in **Exhibit 6.2**. Designers should blend these curves with preceding and succeeding lengths of tangent sections and with sections of bridges, under-and over-passes or tunnels that impact peripheral driver vision.

Designers can never rely on posted advisory speed signs to manage the speed on a road facility. Longer curve radii are not necessarily safer if they induce higher speeds and should only be used to improve stopping or decision sight distances.

6.6 Spiral Lengths

Spirals are curves of constantly changing radii. Spirals are used to smooth the speed transition of drivers and are particularly applicable to interchange ramp design. Spirals also provide transition for developing superelevation run-off and improvement of visual aesthetics.

All circular curves should be designed with spirals to smooth the transition and appearance of the curve and to allow adequate development of superelevation.

The range of spiral lengths can be applied to all circular curves. Longer lengths should be applied to shorter radius curves. Spiral parameters conform with those shown in the Transportation Association of Canada's Geometric Design Guide for Canadian Roads.

6.7 Superelevation

Most Canadian roads are designed using 6% maximum superelevation which is suitable for wet weather conditions and only occasional icing. Under certain conditions, superelevation rates of 8% and 4% can be used to influence geometry and speeds and designers should be encouraged to apply wider ranges of values that suit the context of the design.

6.8 Stopping and Decision Sight Distances

Stopping sight distances should be provided on all new and upgraded facilities with particular attention to horizontal and vertical curves and on sight triangles at all intersections. The measurement of stopping sight distance has received extensive research in the last ten years and designers should be encouraged to justify their use of values based on this research.

Decision sight distance remains a little-used criterium that should be applied for visibility at the approaches to all intersections and interchanges where guide signs are provided for decision purposes. Decision sight distances in the design domain vary according to the need for stopping manoeuvres or lane-change manoeuvres.

6.9 Guide Sign Placement Relative to Decision Points

The requirement to complete a manoeuvre, and the type of manoeuvre required can add significantly to the total time required for a driver to read and respond to a guide sign, and consequently to the distance at which a sign should be legible. If a destination is on a guide sign adjacent to a turn point, the driver must be able to read the sign, look for a gap in traffic to change lanes, change lanes and reduce speed before reaching the turn point.

For lane changes, manoeuvre time is the sum of the time required to search for a gap in traffic and the time to actually perform the lane change. Gap search time increases as traffic volume increases, since it is more difficult to find suitable gaps in traffic. Typical lane change manoeuvre times are shown below.

Traffic Volume	Gap Search Time [sec]	Lane Change Time [sec]	Total Manoeuvre Time [secs]
Low	3.5	4.5	8.0
High	5.3	4.5	9.8

During a lane change in low-density traffic, a distance equivalent to 8 seconds at the operating speed will be covered. With a 90 km/h operating speed, 200 m will be covered in 8 seconds.

If a speed reduction from 90 km/h to 40 km/h has to be made in order to turn off the road, the driver will require 5.7 seconds, during which a distance of 103 m will be covered.

6.10 Lane Widening

Widening of curves may be required to upgraded roads, interchange ramps, and intersection turning roadways in order to accommodate the off-tracking requirements of large WB-20 trucks. The width of these roadways needs to be verified using the procedures and templates contained in TAC.

6.11 Vertical Alignment

Vertical grades and curvatures do not have the same influence on speeds as horizontal curves. Grades do effect truck operation. The rate of change of vertical curvature together with driver eye height (1.05 m) and the tail light (0.38 m) affect stopping and decision sight distances. These heuristics are discussed in TAC and Lamm (Reference 1 and 3).

Maximum grades for operating consistency should be 6% on lengths less than 1.5 km to enable steady operation of loaded trucks with standard mass to power ratios. Additional truck climbing lanes are usually expensive to build in urban areas and with the increased power of trucks may also be unnecessary.

Sag and crest vertical curves are based on headlight and taillight controls. Longer crest values may be required on crest curves immediately before guide signs requiring decision manoeuvres.

6.12 Other Points of Alignment Consistency

Lane balance and a consistent number of lanes to accommodate merging, diverging and weaving manoeuvres between interchanges and major intersections are critical considerations in urban driving conditions. These sections need to be analyzed using the “Highway Capacity Manual – 1997” to verify that sufficient length and width are being provided for weaving. Micro-simulation tools such as Freesim and Corsim can also be used to evaluate vehicle manoeuvring.

7. Context Sensitive Design Cross-Section Considerations

7.1 The Road Message

The cross-section of a road is the primary conveyor of the operating message for drivers. Designers should be encouraged to explore alternative cross-sectional layouts in the interests of designing to influence driver behaviour. The factors that influence the message are:

- the surrounding land form and natural environment;
- the adjacent land uses;
- the level of traffic congestion;
- intersection and driveway impediments;
- the presence of vulnerable road users;
- the posted speed;
- the width of lanes; and
- the degree of confinement and manoeuvring restriction.

This section discusses four elements of urban cross-sections in relation to their implementation.

7.2 Traffic Lanes

The subject of traffic lane widths has been topical in recent years and the conventional width of 3.7 m has been vigorously challenged. Many municipalities have applied "road dieting" to road widths and so, to reduce travel speeds and accommodate bicycles. Many of these measures are more applicable to the residential areas where roads have been overbuilt or traffic conditions have not increased to the extent estimated. European road agencies consistently use narrower lane widths than North America and their crash rates are also lower.

Traffic lane widths are a function of the vehicles that will use them. The limiting design vehicle in BC, Canada and the USA, is the highway truck that is 2.6 m wide and 4.00 m high. Highway buses are 2.3 m wide and passenger vehicles, 1.8 m wide. Bicycles occupy a 1.0 m width and pedestrians 0.6 m width.

The lateral moving space is the space needed by a non-track-guided vehicle to compensate for driving and steering uncertainties as well as a safety distance for projecting parts like mirrors and overhangs. Lateral moving space is also dependent on traffic composition, speed and volume.

As researched for AASHTO, vehicles travelling between 50 and 80 km/h require 0.7 m to 1.0 m of lateral space. This implies that lane-width needs for a design truck are between 3.3 m and 3.6 m as illustrated in the table below.

Vehicle	Vehicle Width (m)	Lateral Moving (m) Space	Basic Lane Requirement (m)
Truck	2.6	0.7 – 1.0	3.3 – 3.6
Passenger Vehicle	1.8	0.7 – 1.0	2.5 – 2.8
Bicycle	1.0	0.2 – 0.5	1.2 – 1.5
Pedestrian	0.6	0.2 – 0.4	0.8 – 1.0

Further lateral space is required for vehicles to safely pass fixed objects such as barriers, walls and poles (this is not a recovery distance). The recommended lateral safe distance to intermittent walls and poles is 1.0 m for speeds under 70 km/h and 1.2 m for speeds over 70 km/h. The safe lateral distance to continuous barriers or curbs is 0.5 m.

Lateral Moving Space has been intuitively derived by standards committees in countries such as the USA and Germany since the 1930s (Reference 9). In his review of lane widths in 1998 (Reference 10), Hauer considers these values as surrogates. He relates the results of thirty research studies between 1953 and1994 that consistently demonstrated the benefits of wider lanes, but only up to a certain point, after which there is a decrease in safety. Specifically, 3.3 m (11 foot) lanes display lower crash modification factors than 3.7 m (12 foot) lanes.

Both TAC and AASHTO prescribe the basic travel lane for high speed arterial roads as 3.7 m. Many road authorities are using narrower lane widths in urban areas. This results in slower operating speeds with no appreciable impact on safety.

Designers should be encouraged to consider a design domain of 3.3 m to 3.7 m for travelled lanes. A wider outer lane may be more conducive to heavy vehicle use while passenger vehicles can operate comfortably on 3.3 m lanes at speeds up to 80 km/h.

7.3 Bicycle Facilities

The continuous provision for cyclists on all new and upgraded arterial roads should be bicycle lanes adjacent to and configured with the right-hand travelled lane. This is the least expensive form of cycling infrastructure. These bicycle lanes can double as emergency stopping lanes for motorized traffic. They can be clearly marked with coloured asphalt or luminous marking tape. Shoulder rumble strips (Reference 11) will provide further segregation of motorized and cycling traffic. Arterial cycling lanes can be maintained with conventional sweeping equipment in the same way as the rest of the road.

The width of the bicycle lane is a function of the envelope created by the bicycle and the rider. This is 1.0 m in width and 2.2 m in height. For cyclists to ride comfortably, they need 1.5 m width. For cyclists to overtake one another or operate on hills, 2.0 m width is required. For cyclists to share a facility with pedestrians, a width of 2.5 m to 3.0 m is desirable.

One-way bicycle lanes on both sides of the road, instead of a single, two-way bicycle lane, provide the most direct access with the expectation that cyclists follow the rules of the road and ride on the right. This is also the least expensive arrangement, negating the need to provide a structure to overpass or underpass cyclists to their correct side of the road. Two-way bicycle paths require more than double the width of one-way facilities.

Providing a barrier to protect cyclists from other road users appears to be unnecessary and requires extra maintenance. Motor Vehicle Acts consider bicycles as vehicles of the road and cyclists should ride in conformity with the rules of the road. This applies not only to the longitudinal road sections but also to high-speed right turn lanes at interchanges, intersections and roundabouts.

Municipalities that provide, operate and maintain park-like, off-road trails through public property should appreciate that such facilities are recreational and are not a substitute for road cyclists who are seeking the most direct routing similar to other vehicles. Furthermore, park-like links often involve either one-way or two-way bicycle path which would be shared with pedestrians. Crashes between cyclists and pedestrians (children, dogs and skaters) are often as serious as those involving other vehicles.

7.4 Pedestrian Facilities

The attractiveness of pedestrian facilities is a function of their walkability. This implies safe and attractive pathways, free from noise, dirt and fumes. Pedestrians may choose to walk along busy roads in temperate conditions if the sidewalks are planted with trees or foliage that also provide safety from criminal activity.

All pedestrian facilities must be designed to incorporate the ambulatory, auditory and visibility needs of disabled users. This requires accommodation of wheelchairs on sidewalks and at intersections, as well as audio crossing facilities. Where sidewalks are provided, they should be a minimum of 2.0 m wide in order to accommodate non-road vehicles such as wheelchairs. Cyclist should be discouraged from using sidewalks. Pedestrian needs are different from those of cyclists who travel much faster.

7.5 Edge Treatments – Medians, Lane Markings and Shoulders

Edge markings are a standard 0.1 m in North America. In Europe, these are 0.25 m and can be as wide as 0.5 m. USA research has shown no appreciable improvement in safety by using wide lane markings. Highly visible, wet-night delineation materials should be considered for all pavement markings.

Medians serve primarily as structural separators of travelled lanes in opposite direction. They may also serve a landscaping function. Raised medians are usually suitable for urban and limited speed arterials.

Medians should be raised and their widths should be 3.0 m to 4.0 m wide. A 4.0 m median allows provision of a 1.0 m median at left-turn intersection lanes of 3.0 m wide. Where considered necessary, as on a bridge crossing, the median may incorporate an aesthetic form of barrier such as a modern cable system. Concrete barriers are not aesthetic and are subject to snow accumulation.

Lane markings adjacent to medians can be provided with rippled surfaces to give a “rumble” effect. A 300 mm wide rumble strip can be considered on the right side of the outside traffic lane as an audible separator between the travelled and bicycle lanes.

Paved shoulders are primarily intended for safe emergency stopping. They are recommended on rural highways that are not continuously patrolled and where a stranded vehicle could be hit by a fast-moving vehicle from behind. Paved shoulders do not have the same purpose on urban roads where speeds are moderate and surveillance more frequent. Bicycle lanes can be used for emergency stopping on urban roads.

Clear zone is usually provided on high-speed facilities with operating speeds in excess of 80 km/h. Clear zones of 6.0 to 7.0 m offset to fixed objects and use of 6:1 embankment or ditch slopes where barriers are not provided.

In urban and semi-urban areas, edge treatments can include consideration of landscaping, street art, sound barriers and right-of-way safety barriers.

8. Speed Reducing Countermeasures

Crash severity is highly related to speed. Some studies have found that the probability of injury collision is four times greater at speeds over 70 km/h compared to speeds under 60 km/h (Kloeden, 1997). The road message as given by the width of the cross-section and the degree of curvature are the two primary determinants of speed. Other factors such as the presence of slower vehicles, cyclists and the number of driveways all determine the speed at which a driver will operate.

Drivers usually speed up on tangent sections. Curves increase the driver's work rate and have a reducing affect on speed. Other measures such as narrower traveled lanes and rumble strips are also affective on drivers. The most affective speed countermeasure appears to be transverse lane markings that have the affect of attracting the driver's peripheral vision in the same way as drivers slow when in tunnels.

Signing does not reduce speed. A number of other countermeasures such as the presence of portals and artificial narrowing of lanes are often ignored by regular road users. The best way of reducing speed is to design horizontal curves that are recognized by the driver as requiring slower operating speeds.

9. Applying Context Sensitive Design – The Way Forward.

9.1 Overcoming Resistance

CSD requires innovation, new procedures and the opinions of professionals other than engineers. Inevitably, there has been resistance to the application of CSD. This has come from three quarters; designers, lawyers and decision-makers.

Designers show resistance to applying design domains that require a lot of judgement and critical engineering decisions. Such requirements demand a knowledge of geometric design principles and this is often beyond the confidence level of designers. It is much easier to apply the dimensions from a book of standards which appears to contain all the answers rather than a text book of principles. Standards can be used authoritatively as justification for decisions.

Lawyers prefer specifications and design requirements that relate to legislated standards. They make no attempt at understanding critical engineering analysis. It is much easier to refer to a commonly acknowledged set of national design standards that can be quickly explained by a professional engineer.

Decision makers usually want to take the path of least resistance. What is safe, what is legally defendable and what is acceptable to the public? Safety is a real motherhood issue. Who would not be safe in the public interest even if it is only a nominal inference to safety. Bigger and wider has always been implied to be safer, how come narrower and slower is now explicitly safer?

It is only in the last 50 years that standards have been in use. Earlier engineering always demanded critical engineering judgement and reference to text books and creditable research. As engineering research has improved and safety assumptions have been challenged, there has been a return to the need for engineers to understand first principles and to apply physics in the interests of the public good.

To overcome doubters, engineers need to embrace fully the precepts of the 1999 TAC Guidelines. The Guidelines do represent safe engineering practice. This requires

- willingness to explore the background reasons for which parameters have been adopted,
- to rationalize them with respect to the project requirements and
- place them before a peer review.

Engineers also need to embrace the contemporary road design tools in the way they have embraced analysis and quantities software. These include:

- safety models like the IHSDM that provide practitioners with modules for analyzing various components, together with the backgrounds of current practice ;
- crash prediction modelling correlated to the local conditions and project specifics;
- simulation modelling that demonstrates to decision makers and the public the engineering intensions of the designer.

When designers document their decisions in a design report which explains the reasons for making design selections, they take the first step to confronting threat of legal action for not applying a legal standard. Submitting and defending their report at a peer review session or to a safety audit further mitigates legal liability and keeps engineers in charge of engineering design.

The precepts of Context Sensitive Design are not new, only the tools and methods of undertaking the design are contemporary. By being prepared to apply creative solutions to the design of roads in demanding and sensitive areas, the engineer maintains respect, the technical challenge and enables the design profession to advance.

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