Road Safety and Highway Design in Public-Private Partnerships

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Abstract

Traditional sources of funding are increasingly incapable of meeting the growing demands of an aging Canadian highway system. With construction, operating, and maintenance costs increasing, road agencies are looking to the private sector for alternative funding schemes. In response to the growth of Canada's infrastructure deficit, provincial governments notably Alberta, British Columbia, New Brunswick, and Quebec are taking advantage of Public-Private Partnerships (PPP or P3) to undertake major highway projects. Road agencies responsible for P3s in Canada have reported direct savings of 15 to 25 percent. More importantly it has been observed that significant increases in technological advancements and innovation are being realized by road agencies as a spin-off benefit of P3s. One concern often raised with P3s is the question of risk management and road safety. This paper explores how road safety risks have been mitigated in the planning and design of major P3 highway projects in Canada and highlights some pitfalls to be avoided with future projects. Recommendations are presented to permit more effective working relationships between the Road Safety Audit Team, road authority and P3 consortiums. Areas where road design standards have been shown to be deficient, largely through the Road Safety Audit process are discussed.

Résumé

Les bailleurs de fonds classiques sont de plus en plus incapables de satisfaire aux exigences croissantes d'un réseau routier vieillissant au Canada. Comme les frais de construction, d'exploitation et d'entretien augmentent, les agences des routes font appel au secteur privé pour adopter d'autres modes de financement. En réaction à l'augmentation des lacunes des infrastructures du Canada, les gouvernements provinciaux, et notamment l'Alberta, la Colombie-Britannique, le Nouveau-Brunswick et le Québec, profitent de partenariats public-privé (PPP) pour entreprendre de grands projets routiers. Les agences des routes qui étaient responsables de PPP au Canada ont fait état de 15 à 25 % d'économies directes. Mais ce qui importe davantage, c'est qu'on a constaté qu'une retombée bénéfique des PPP était que les agences des routes profitaient d'une multiplication importante des progrès et des innovations technologiques. L'une des questions que les PPP soulèvent souvent est celle de la gestion des risques et de la sécurité routière. Dans le présent document, l'auteur examine comment on a atténué les risques pour la sécurité routière lors de la planification et de la conception de grands projets routiers de partenariats public-privé au Canada, et souligne certains pièges à éviter dans les projets futurs. Il fait des recommandations pour permettre de meilleures relations de travail entre l'équipe de vérification de la sécurité routière, l'autorité routière et les consortiums de PPP. Il traite aussi des domaines où l'on a constaté la faiblesse de normes de conception des routes grâce, en grande partie, à la vérification de la sécurité routière.

1. Introduction

The development of major road infrastructure projects in Canada is increasingly being accomplished through private-public partnership (P3) models in an effort to expedite delivery of the facilities. Although the Road Safety Audit (RSA) process is relatively new to North America, it has become a key ingredient in P3 projects to ensure that safety levels are not compromised by profit-conscious developers. The RSA process has effectively been adopted from the United Kingdom, Australia and New Zealand, however, its direct application to P3 projects is not without issue.

This paper reflects on the experiences to date of employing the RSA process to some of the largest and most recent P3 highway projects in Canada. The authors have all served as road safety auditors on very large infrastructure projects developed under the P3 format. Their experiences are synthesized in an effort to explore relationships and linkages between the RSA process and P3 projects. Risk management strategies and areas where the standard RSA process must be modified in order to provide better synergies with the P3 process are discussed. Common difficulties and pitfalls are highlighted in an attempt to streamline future applications of RSAs to P3 projects.

2. Background

Road authorities have traditionally founded road safety strategies on black-spot or collision-reduction techniques that are based on collision frequency histories of existing road networks. Although this approach effectively highlights those locations in need of remedial treatment, it is considered reactive in that it only addresses issues following a history of events. A more proactive approach to mitigating potentially problematic road hazards was developed in the United Kingdom through the publication of the *Accident Reduction and Prevention Guidelines* by the Institution of Highways and Transportation in 1980 [1]. By 1991, the application of RSAs became mandatory for all U.K. trunk roads and motorways (freeways) following the publication of two key documents, namely, the *Guidelines for the Safety Audit of Highways* [2] and the *Road Safety Code of Good Practice* [3]. Within the U.K., an RSA is defined as “a formal procedure for assessing collision potential and safety performance in the provision of new highway schemes, and schemes for the improvement and maintenance of existing roads” [4].

Using the U.K. format as a template, Australia and New Zealand began to develop their own RSA policies in 1990 [5]. In 1993, the association of Australian and New Zealand road transport and traffic authorities (Austroads) developed the *Road Safety Audit Manual* [6]. These guidelines were revised in 2002 in response to the significant increase in experience and understanding of RSAs. This publication focused on two objectives: “to identify potential safety problems for road users and others affected by an existing road or new road project, and to ensure that measures to eliminate or reduce the problems are considered fully” [7]. Subsequently, New Zealand has written a newer version for their own use as has the European Union Road Federation [8, 9].

In 1992, the national roads and transport agency for New Zealand (Transit New Zealand) began conducting pilot projects. The following year, Transit New Zealand made RSAs mandatory for 20 percent of state highways projects and conducted a pilot project at the local government level. A similar approach was undertaken in Australia. In New South Wales, 20 construction projects per local authority and 20 percent of existing road systems are subjected to RSAs. In the State of Victoria all major new construction projects, 20 percent of other projects, and ten percent of maintenance operations are subjected to RSAs.

By 2005 the adoption of an RSA strategy had spread to more than 18 countries as reported by the PIARC Technical Committee [10]. Following an extensive review of audit practices elsewhere [11], by 1998, the United States' Federal Highway Administration sponsored the piloting of the RSA process in 13 states. The most current information indicates that approximately 17 states have now incorporated the RSA process into their procedures pending future evaluations of effectiveness [12]. The Federal Highway Administration has recently published audit guidelines and prompt lists to facilitate/standardize the conduction of RSAs [13, 14].

Although an initial pilot of part the RSA process was first undertaken in 1997 in British Columbia [15], it was not until the development of Highway 407 in Toronto that the need for the process came to the forefront. The 407 was developed under an innovative (at the time) P3 arrangement that saw a private consortia design, build and operate the facility under a 99 year lease while the Ontario government maintained ownership. This was essentially the first very large road project developed under a P3 model in Canada.

Prior to project opening in 1997, the Ontario Provincial Police drove the facility and publicly raised several safety concerns. Consequently, the Ontario Government and Ministry of Transportation for Ontario (MTO) commissioned the Professional Engineers of Ontario (PEO) to undertake an independent safety review of the facility. Upon completion of the study, it was determined that one of the key issues was that the project's organizational structure failed to establish which if any agency had assumed the traditional MTO role as the "guardian of public safety" [16]. It is noteworthy that several separate design firms were included in the consortium which contributed to concern over many design inconsistencies between individual road sections. Perhaps the key outcome of this study was the recommendation for the inclusion of Road Safety Audits in future highway development projects. The concept of RSAs was not well understood domestically at the time. Further, it should be clear that the 407 study was not itself any form of RSA.

Soon after the Highway 407 study, the Province of New Brunswick undertook the development of a 196km section of Trans Canada Highway under a P3 agreement with the Maritime Road Development Corporation. This was the first major road project in Canada to incorporate the RSA process throughout all stages of development (Planning, Preliminary Design, Detailed Design, Pre-Opening and Post-Opening). The subsequent benefits of including the RSA process are documented by Hildebrand and Gunter [17] and Hildebrand and Wilson [18].

A key document was published by the Transportation Association of Canada in 1999 entitled "The Canadian Road Safety Audit Guide" [15]. It has provided a general overview of the RSA process and has subsequently served as a foundation for various provincial policies developed for RSAs (e.g., BC, Alberta, Ontario and New Brunswick).

Highway projects developed under a P3 arrangement have shown several benefits including reduced cost, faster delivery (resulting in quicker realization of safety benefits and improved network efficiencies), transference of risk from government to developer, and development of innovative technologies/methodologies. Recent Canadian [19], U.S. [20] and Australian [21] studies have estimated that P3 highway projects have resulted in12-15, 6-40 and 15-30 percent savings, respectively, over conventional means of delivery. Seizing these benefits, some governments have been quick to adopt P3 road projects across the country. Examples of current highway projects being developed under a P3 format are listed in Table 1.

Table 1: Major Canadian Private-Public Partnership Highway Projects

Province	Project	Completion	Description
BC	Sea-to-Sky Highway	2009	$600 million upgrade
BC	Kicking Horse Canyon (Phase 2)	2009	Park Bridge $130 million. Completion was 16 months early.
BC	Port Mann Toll Bridge	2013	New toll bridge with 100% cost recovery
BC	Golden Ears Bridge	2009	New 6-lane toll bridge across Fraser River
BC	Pitt River Bridge	2009	New bridge and interchange project.
BC	William Bennett Bridge (Lake Okanagan)	2008	New 5-lane replacement bridge.
BC	Sierra Yoyo Desan (SYD)	2005	188km upgrade to resource road.
BC	Canada Line subway	2009	Rapid transit line connecting Richmond to downtown. Ahead of schedule.
AB	Anthony Henday Drive (SERR)	2007	$500 million; 11km ring road project.
AB	Anthony Henday Drive (NWRR)	2011	Currently in bidding process
AB	Calgary Ring Road (Stoney Trail)	2009	21km extension of Stoney Trail from Deerfoot Trail to 17 Ave SE; $408 million
ON	Highway 407	1997+	Phase 1: 36km $930 million Final: 69km $4 billion
QC	Highway 25	2011	7.2km extension including toll bridge $207 million
QC	Highway 30	Unknown	42km extension toll road ($1 billion estimate)
NB	Fredericton-Moncton (MRDC)	2001	193km 4-lane arterial $600 million
NB	Woodstock-Grand Falls (Brunway)	2007	98km 4-lane arterial $400 million
PEI	Confederation Bridge	1997	13km bridge linking PEI to New Brunswick $1.3 billion

3. Integrating the RSA Process with Canadian P3 Projects

The Road Safety Audit process is a natural fit for highway projects developed under a Private-Public Partnership arrangement. It effectively plays the role, as noted in the Highway 407 review, of "guardian of public safety" [16]. In practice, developers have shown a tendency to just meet their contractual obligations as specified by a design-build agreement or prescribed series of design manuals/standards. While design engineers are professionals, the assurance of optimized safety is not necessarily met simply by meeting minimum design standards. Furthermore, most highway design engineers have a limited working knowledge of road safety engineering and are not experienced with the skills required to undertake safety analyses.

A key requirement for the inclusion of an RSA in a P3 project is to explicitly set out the terms under which the audit process will operate. There are often many more players involved in a P3 compared with traditional delivery models and the relationships and reporting lines can become muddied as the project progresses. Some jurisdictions have very explicitly set out guidelines for the conduct of RSAs and, more importantly, how they relate to a P3 project. The British Columbia Ministry of Transportation has established the role of RSAs under the "Road Safety Audit Guidelines" [22] and explicitly stipulate the roles that the audit team, concessionaire and the Province will play within the terms of the P3 agreement. In fact, BC requires that a 'road safety audit certificate' be signed by all parties upon completion of the study at each design stage. Any recommendations not adopted by the concessionaire must be approved in writing by the Province.

A typical P3 project will have, at a minimum, the following parties involved in the project development:

- project owner (road authority)
    - oversee project / approve variances
    - provide expertise
- developer consortium / concessionaire
    - managers
    - design teams
    - contractors
    - operations and maintenance
- financiers
    - sometimes have in-house technical experts for assurance
- independent agent
    - manage progress payments, quality control, assurance and/or compliance
- road safety audit team

Given the number of parties involved, what is often lost is the role of the auditors in the process and a chain of command.

The Transportation Association of Canada defines a Road Safety Audit as "a formal and independent safety performance review of a road transportation project by an experienced team of safety specialists, addressing the safety for all road users" [15]. Furthermore, the objectives are defined as:

- minimize the frequency and severity of preventable collisions,
- consider the safety of all road users (including any vulnerable users),
- ensure that collision mitigation measures aimed to eliminate or reduce the identified safety problems are considered fully, and
- minimize potential negative safety impacts beyond the project limits.

Within the context of a P3 project, RSAs are sometimes mistaken for a system of design standard compliance checking. This likely comes from the misconception that meeting minimum design standards (detailed in manuals or P3 Design-Build contracts) ensures an acceptable level of safety. It should be clear to all parties involved that it is not the auditors' role to ensure compliance. This function should be the responsibility of the design team and/or the independent agent. Relying on the RSA Team for this task would be a misdirection of their skill sets. It is suggested that two elements are crucial to facilitate an RSA process:

1. the policies and guidelines for an RSA process (specifically for application in a P3 project) should be in writing and adopted in policy by the road authority.

2. a start-up meeting with all parties involved should be held to discuss each other's role during the audit.

Similarly, the audit team cannot be considered the 'guarantors of safety'. In fact, some recent P3 projects have required that the RSA team provide a certification letter to ensure that the facility is 'safe' prior to opening. This is an impossibility given that the declaration of a 'safe' road implies that it is without risk. All roads carry risk. The Transportation Association of Canada notes that "it is impossible to make a road completely safe, if by "safe" we mean a road on which we can guarantee that there will never be a collision. We can, however, design a road to provide a reasonable level of safety. Just what is a reasonable level of safety, when we take into account the cost required to build it, is a matter of experience and judgment. In short, the notion of a "safe" (or collision-free) road is a myth. Design should be viewed instead as a process that can result in roads being "more safe" or "less safe" " [23].

While it is understandable that the project owners wish to ensure that the road facility provides an optimal level of safety, guarantees of a "safe" facility of "acceptable levels of safety" are not possible.

An RSA applied on a more traditional in-house design-build project would see an interaction between the audit team and the road authority. Audit recommendations would be discussed with the road authority and formalized responses documented as part of the final report. When the process is extended to a P3 project, there needs to be a reporting system that ensures feedback to the audit team. Typically, the auditors' recommendations are delivered to the consortium's design team who, in turn, provide formal responses as an addendum to the report. It is important that the project owner (road authority) participate in this process as well. Differences in opinion between the designers and auditors or clarifications are usually referred to the owner for decision or input. It will usually be the owner's responsibility to mediate a solution between the auditors and design team. Further, experience has shown that the owners should also participate in documenting their decisions/comments/concerns as a third step in the completion of the audit report. Unfortunately, some P3 projects have had structures where the owners have not been as active in this process resulting in a weakening of the audit team's influence.

Most P3 projects, to date, have made it the responsibility of the developers to identify the RSA Team as part of their bid package. Subsequently, road authorities have made the retention and remuneration of the RSA Team the responsibility of the developer. This practice is inappropriate. Firstly, the RSA Team by definition is meant to be an independent party. Being paid by the client you are often critiquing can create a conflict of interest. It would be more appropriate to have an external fund established to pay the RSA Team. This could be administered by either the road authority or the financiers. Secondly, if the audit team is to be included as part of a competitive bid, there is potential for the developer to include fewer and less qualified members. An RSA can only be as good as the collective experience of its team members. To this end, it may be more appropriate for the road authority to either pre-qualify team members, or appoint the team themselves.

In practice, most P3 projects will tie into existing facilities thereby exposing motorists to temporary work zones or detours for varying periods of time. Traffic Management Plans will need to be reviewed during different construction stages of the project. It is advisable that the RSA Team be involved in reviewing these plans. Although this has not been a stated function for the Team in the various published audit guidelines or in previous Canadian projects, it is a natural fit. A reference of note for the review of work zones is that published by Johnston *et al.* [24].

To facilitate on-time delivery, it has been shown that "preliminary" Pre-Opening audits are necessary in order to give the developer appropriate lead time to correct potential problems. Rather than wait until a more formal pre-opening audit to reveal safety-related issues that must be addressed, it is in everyone's interest to have potential issues identified earlier in the process so that they can be addressed without delaying the opening. It is suggested that these less formal site visits be undertaken outside of the RSA process at the expense of the developer. Furthermore, the construction foreman and representative from the design team responsible for the sections being reviewed should be present so that it is clear what issues would need to be addressed in order to avoid undue delay following the more formal Pre-Opening audit.

A final note is the issue of specifically addressing vulnerable road users (VRU). VRU is a category of road users that are at greater safety risk due to either exposure or consequence. VRUs usually include pedestrians, cyclists, motorcyclists and mopeds although horse riders and operators of farm equipment are sometimes applicable. While the accommodation of VRUs is an implicit objective of any RSA, it is an often over-looked aspect particularly in the contract specifications drawn up for a P3 bid process. Some recent P3 projects have assumed the exclusion of pedestrians and cyclists from the facilities without accommodation being made to prevent their access. Explicit consideration for these users must be provided at all design stages particularly since many design standards often do not accommodate their needs. Guidelines for the safety review of bicycle facilities have been prepared by the Institution of Highways and Transport [24] and more recently by Matwie and Morrall [26].

4. Design Issues and Private-Public Partnerships

An integral part of the tendering of a major P3 road project is the development of a Design-Build (DB) Agreement which lays out the specifications and standards the project shall meet. This document is typically developed by the road authority in-house. Fundamental parameters are established for the project with this document that impacts the consortia bids. Geometric design standards to be met including the project's road classification, typical cross-sections, signing treatments, reference manuals, provincial policies, design speeds, etc. are all set out by this document. The document forms a key reference for the contractual relationship with the builder.

Some of the P3 projects completed have illustrated the need for a careful review of this document at the onset. Typically, by the time the audit team is brought into the project, the base parameters have already been established by the DB Agreement. If the safety audit process finds fault with any of these fundamentals outlined in the Design-Build Agreement, then project costs can escalate since the builder only contractually needs to meet the terms of the DB Agreement. Consequently, it would be highly beneficial if the DB Agreements were to be subjected to a Road Safety Audit prior to issuance to consortia developing their bids. This would minimize conflicts throughout the course of the project.

A recurring issue with P3 projects is the propensity for builders to just meet the requirements set forth in the DB Agreements in the interest of preserving their profitability. While this is an understandable characteristic, it can impede the adoption of safety improvements promoted through the RSA process. In some cases, developers will reject audit recommendations on the basis that they fall outside the terms of the DB Agreement or that they are not required by the design manuals specified. This is probably best illustrated in the case of minimum clear zones. A DB Agreement will specify minimum clear zones to be met on the basis of road classification and design speed limits. For example, a minimum 10m clear zone may be specified for an RAD110 (rural arterial with a divided cross-section and 110 km/h design speed). Inevitably, the builder will just meet this requirement at critical locations such as underpass structures, deep cuts, and near roadside hazards (utility poles, culvert headwalls, etc). Naturally, to provide a wider clear zone would increase the project costs. Examples of instances where developers have just met minimum clear zones are shown in Figure 1. There seems to be a mentality fostered that reasons if a roadside hazard is located 9.9m form the travel lane it is unsafe, whereas, one located at 10.0m is safe. The underlying relationships that are used to predict an errant vehicle's probability of encroachment to specific offset distances from the travel lane are tenuous at best. There are many other site-specific factors which seem to be overlooked when considering the adequacy of clear zone provision. For example, characteristics such as side slope drivability, upstream geometry, upstream traffic operations (merge lanes, etc.), traffic composition, and hazard characteristics such as drainage devices should all be considered when evaluating whether a given clear zone is adequate. In fact, the Transportation Association of Canada's 1999 Geometric Design Manual simply provides 'ranges' of clear zones to be considered by the designer for various road classifications and design speeds [23]. The onus is on the designer to consider all site factors when providing clear zones.

The propensity for a developer to follow the DB Agreement to the letter can work against them (from a profitability perspective) as well. For example, there have been instances where the DB Agreements have made blanket specifications for safety treatments when they would be ineffective at some specific locations. For example, energy attenuation devices were installed at a recent project on some side roads and interchange ramps where they would be ineffective given the relatively low operating speeds. These were installed because they were specified by the DB Agreement, not because they had any net benefit.

Figure 1: Examples of Hazards Placed at Minimum Clear Zone Offsets

While not all RSA report recommendations have an incremental cost, many do. Typically, the recommendations developed in the earlier design stages can be incorporated with little or no extra cost. As the project nears completion, changes or additions inevitably have a direct attributable cost (although most tend to be minor in latter stages). Hildebrand and Gunter [18] found that on the $600 million Fredericton-Moncton project, the extra cost associated with the adoption of the Road Safety Audit recommendations added approximately $2.5 million (or less than ½ percent).

In order to diffuse resentment on the part of the builder for having to incorporate audit recommendations (sometimes outside of contractual terms), a contingency fund could be established in recognition that there will be small overruns in order to take advantage of cost effective safety countermeasures. There are many low cost and cost-effective treatments on the market that are extremely beneficial on a site-specific basis. An RSA is the proper vehicle to initiate the application of these measures, however, if the developer is constrained to the point where they will not go beyond the minimum requirements of a DB Agreement, then a contingency fund would permit the adoption of these measures. For example, there are several very good retro-reflective delineation tapes and markers now on the market that are not used in standard practice. A Pre-opening RSA can identify those locations where application of such a product would be highly beneficial to the motorist for relatively little extra cost.

Given the contractual nature of a P3 project, the developer and road authorities have a tendency to establish a cordon line around the project often with little thought given to the integration of the project with existing connecting roads. Proper signage, pavement markings, geometric transitions, etc. need to be fully considered on side and connecting roadways. Even if these upgrades are undertaken by the road authority, outside of the P3 developer's mandate, the plans should be included as part of the RSA process as they are integral to the overall safety of the project.

A further issue is the upgrading of small sections of existing roads such as service roads and cross roads adjacent to the P3 project. There are examples of short sections of intersecting roads being upgraded in the immediate vicinity of a new P3 road project. It is important to maintain a consistent character for the local road. Some projects have improved the sections of local roads to a much higher design standard than what exists up and downstream resulting in an inappropriate transition for drivers. This can result in a choice of inappropriately high operating speeds. Careful consideration of design standards for adjacent roads should be made during the development of the DB Agreement.

4.1 Deficiencies in Canadian Design Standards

The following design topics are highlighted by the authors to illustrate many deficiencies in the existing Canadian design guidelines. These deficiencies have come to light during the conduct of recent Road Safety Audits. They are suggested as research topics for the Transportation Association of Canada's Geometric Design Standing Committee: Revisions and Additions Sub-Committee. Note that TAC section references relate to the relevant Geometric Design Guide for Canadian Roads section number [23].

i. Clear Zones (TAC 3.1.3)

- More documentation on where off-road collisions occur is required. The only Canadian research on this topic has been a recent UNB project [27] and research done by Cooper in the 1980s [28].

- Recently, an Australian has shown diminishing returns between safety benefits and clear zone width, with more than 85% of benefits from a 9m clear zone captured in the first 6m [29].

- There is a need to define trade-offs between clear zone width and barrier-free roadside design. For example, it may be more cost-effective to shorten a bridge span and shield the piers/abutments with a barrier than provide a barrier-free roadside (i.e. clear zone) with a longer bridge span.

- A number of Highway jurisdictions in the United States now require 23m (75') clear zones for medians for rural freeways. This is likely the result of findings by Knuiman *et al.* [30] who found that accident rates continued to decrease as median widths increased up to about 80' (25m). It is unclear whether such a design requirement would have a net economic benefit within the Canadian context.

- Large sign support bases just outside the clear zone present a roadside hazard to errant vehicles. Guidelines are required with respect to shielding versus grading to deflect an errant vehicle.

ii. Vertical Alignment (TAC 2.1.3)

- TAC and AASHTO do not have design guidelines for the maximum grade change which may be used without a vertical curve. This can arise in the following situations such as profile reconstruction near fixed objects such as bridges; profile tie-ins in overlay sections; and temporary vertical tie-ins. The following are examples from other Design Guides;

Design Guide (DS = 80 kmh)	Maximum Change of Grade without a Vertical Curve
CalTrans	0.50%
Ohio	0.45%
Georgia	0.60%
Austroads	0.60%
Transit NZ	0.50%

iii. Accommodation of Bicycles at Intersections (TAC 3.4.7.4)

- Guidelines are required to resolve conflicts of vehicles and bicycles at intersections. For example the options are: shared lane; bike lane or bike lane on shoulder. The conflict problem is exacerbated with a right turn lane. This is a signing as well as a design issue.

iv. Left-lane Entrances and Exits (TAC 2.4.1.2)

- In general, left-lane entrance and exit ramps are not commonly used as they violate driver expectations. However, due to constraints such as interchange spacing, designers are required to consider left-hand entrances and exits. A synthesis of practice is required to assist designers. For example length of merge, lane-away or barrier is mitigation measures for a left-hand entrance. TAC does not address this issue adequately other than note that "left-hand exits and entrances should only be considered under special conditions".

v. Cross-Slope (TAC 2.2.8.4)

- TAC states that normal cross-slope is 0.02m/m under Best Practices. However research by Glennon [31] has noted that AASHTO should consider recommending 2-2.5% minimum cross slopes to minimize the propensity for hydroplaning, particularly for high-speed roadways. The authors note that the recently completed NB TransCanada Highway Project used a cross slope of 0.03m/m and that many agencies recommend cross slopes greater than 0.02m/m. Austroads for example states that unless well controlled during construction, pavements with less than 0.025m/m will hold small ponds on the surface. Austroads guidelines for crossfall are 0.025-0.03m/m for asphaltic concrete pavement.

vi. Lane Widening on Curves (TAC 2.1.2.5)

- TAC guidelines for curve widening do not include widening on 3-lane roads. AASHTO, however, suggests that the values shown in Exhibit 3-47 be multiplied by 1.5 to determine the curve widening for a 3-lane road. The values obtained by equation or table method appear to give unreasonable results. The authors suggest that this be checked with off-tracking software such as AutoTURN. It is an important topic for Canada which has an extensive 2+1 highway system.

5. Discussion and Recommendations

The RSA process is becoming an integral part of highway development in Canada, particularly within a P3 funding structure. Experience to date has revealed that the following points are crucial to ensure that benefits are optimized from this process:

- The design-build agreement developed by the project owner (Province) should be subjected to an RSA before it is released to proponents at the onset of the bid process.

- A mechanism to provide funding for safety-related treatments that reach beyond minimum design standards should be incorporated in the design-build agreement. Otherwise, developers can be reluctant to adopt strategies that increase project delivery costs.

- A written document should lay out the roles and responsibilities of all parties including the RSA Team, the developer and the road authority. Furthermore, the road authority (Province) should be actively and formally involved especially to mediate instances where audit recommendations are rejected by the developer.

- The audit team should not be named by a P3 consortium as part of their bid package. A more at-arms-length relationship needs to be established.

- Traffic Management Plans and “preliminary” Pre-Opening audits are not conventional components of the RSA process that typically need to be included in P3 projects.

Finally, deficiencies in a number of design standards have been exposed through the critical review of recent Canadian P3 projects. Recommendations to improve these standards have been presented in this paper.

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