Influencing Road Safety: Critical Factors during the project life cycle
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Introduction:
Australia is the continent with 21.9 million habitants, 7.6million sq kilometers of area and 811443 kilometers of road network (Statistics June 2009). In the current economic condition, the country is facing the economic contractions. The key challenges on the Australian economic condition are; increasing in the unemployment rate (5.7%), contraction in gross domestic product (-0.1%), lowest consumer price index and rising government budget deficit. On the other side, booming population growth has put tremendous risks on the existing infrastructure to co-up with designed level of service. Study conducted by Bureau of Transportation Economics (2000) measured the willingness to pay costs on road accidents during the operation phase of the transportation infrastructure projects. It is estimated that social costs of an accident (based on discounted valuation approach using 7% discounted rate) Government has record of paying approximate costs AU$15 billion. Valuing the costs of accidents in the 2009 economic turbulent times will be more on the given amount. This justifies that, in today’s economic environment, where government is facing higher budget deficit, high pressure to pour money on transportation projects to reduce unemployment, growth of population, declining in consumer confidence and increases in the costs of road accidents to the economy. In this situation, government needs to deliver the design solution that is economically viable, socially acceptable and reduce the life cycle costs to its operation phase by reducing the expenditure on road crashes.

Objectives: The main objectives of this paper are;
- Identifies the critical factors affecting the road safety from the fatal road crashes.
- Draws the focus on how the key road safety factors(critical and as well as non critical) were incorporated at preliminary design phase of sub-arterial project by identifying the existing crash pattern and providing the solution that can minimize or reduce the road side crashes on given case study.
- Provides the risks management approach by identifying the existing road side crashes and strategies to reduce the road crashes using innovative design solution using the advance software packages on given case study.

Project Case Study : (Sub-Arterial Corridor Project, Brisbane)
Over the last five years, the project has more than 32 accidents along the corridor that consisted of 1 Fatal, 10 hospitalized, 10 injured and 11 property damaged. The project had crash rate of 0.42/km consisting of 14 accidents were on road section and remaining accidents were at intersection. The highest numbers of two vehicle accidents were at intersection from adjacent approaches that covers; head on, rear ends, lane changes and entering carriageway. The highest numbers of single vehicle accidents were off carriageway, on straight, hit object, hit animals and out of control on straight.

The existing roundabout had high crash history and connected to the south part of the Motorway that runs from north to south side of Brisbane city. The accidents on the round about covers;
- Approximately 56% are entering/circulating vehicle accidents (failure to give way accidents), of which most occur on the eastern approach leg.
- Approximately 23% are approaching rear-end vehicle accidents (rear-end accidents on the entry curve), all of which occur on the corridor leg.
- Approximately 13% percent are single vehicle accidents, of which most occur whilst traveling on or from the roundabout western approach leg.

Analysis on critical factors contributing to fatal crash:
Literature reviews in the areas of road safety and fatal crash investigation reports, the critical factors affecting the road safety are given as;

Roadside environment:
1. Speed:
   - Drivers attempt to traverse curves at speeds greater than the design speed; this requires more side friction to keep them from sliding off the road. When they attempt to decelerate in the curve, a portion of the available friction at the tire-road interface is devoted to the deceleration, leaving less for side friction demands. These two elements combine to erode the margin of safety provided by using a lower than maximum coefficient of friction (f) to calculate super elevation and curve radius. (Ronald W. Eck October 2002).
   - Geometric design provides higher differences in the operating speed of successive road segments for both car and truck. (Road Planning and Design Manual).
   - Difference between the desirable speed and posted speed limit is higher than required. This may lead to differential speed environment and erode the safety. ((Turner December 2007).
   - Proposed signalised intersection’s geometry doesn’t have provisions to reduce the relative speed of vehicles.

2. Vertical Grades:
   - Grades don’t meet the requirement of the operating speed and higher length of the grades contributes reduction in the operating speed of heavy vehicle (based on weight to mass ratio). (ZHUANG Chuanyi 2009).
   - Grades will allow in inadequate drainage of kerb and channel and table drains that can create an issue of aquaplaning. (Kidd 16 June 2005)

3. Pavement:
   - Variation on the pavement skid resistance. (Ronald W. Eck October 2002).
   - Demanded friction is more than available value. (Roads)

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Human Behavior:
- Geometry doesn’t driver’s readiness to respond to situations, events, and information in predictable and successful ways.
- Lack of reaction time to visualize the information and react it.
- In appropriate Decision Sight Distance is the distance required for a driver to detect an unexpected or difficult-to-perceive information source or hazard in an environment that may be visually cluttered.

Analysis of road safety factors at design stages of sub-arterial project:

Roundabout: The improvement in the sub standard geometry of the existing roundabout requires it to move east side that means an existing geometry could not be retained. At preliminary design phase, decision was taken to replace the roundabout with signalized intersection. Three different options were consider at preliminary design phase to improve the safety as given below.

Intersection design: At Network level the road geometry, human and vehicle factors were considered as:
- The effect of adjunct intersection was considered during the design phase to enhance the intersection capacity and reduce the vehicle delays.
- Performance of an intersection design to be improved significantly by considering the day to day traffic volume, vehicle to vehicle performance, road geometry, vehicle acceleration/deceleration, design speed, weaving, volume of commercial vehicles, lane utilization factor for heavy vehicles, future growth of the traffic from adjacent network.
- Preferred option reduces the land acquisition costs and provides high capacity/performance during the pick hours. The proposed design will reduce the long vehicle queuing length and fatigue of driver by providing higher level of service.

Geometric design of road elements: Proposed alignment and road reserve design will enhance the safety by;
- Taking into consideration of effect of bicycle route, pedestrian.
- Designing road geometry will minimized the difference between operating speed and desirable speed of design vehicle and heavy vehicle this will reduce the rear-end types of accidents.
- Designing geometric elements that will reduce the difference between the operating speed and posted speed limit and will minimize chances of head on and rear-end accident at intersection.
- Proposed U-turn facility along the corridor will reduce the conflict for right turning vehicle and enhance the safety.
- Dedicated bus-stop will minimize the side-swap and rear-end crashes.

Geometric design based on traffic analysis along the corridor (Intersection Design): Proposed alignment and road reserve design will enhance the safety by;
- Planning of corridor is based on the future traffic growth along corridor as network level. This will enhance the corridor capacity and reduce the delays and congestion of traffic.
- Planning of corridor is based on the through movement of traffic in future, higher capacity in long future, design of lower saturation and optimistic traffic generation rate.

Pavement Design: Proposed pavement design will enhance the safety by;
- Designing for higher strength with low CBR value. These will enhance the design life by minimize early age cracking.
- Used of Stone Mosaic Asphalt as surfacing material will beneficial to enhance the skid resistance by using higher size of aggregate.
- SMA will provide the textured, durable and rut resisted wearing course this will help to reduce the loss of control types of crashes.
- Design Number of Equivalent Standard Axles was based on the overall damage, asphalt fatigue, rutting and shape loss.

Hydraulic design:

Hydraulic design will consider the flood event of 100 year ARI and will minimize the overtopping of water in the event of flooding. Design will reduce the ingress of water into pavement and help to maintain the skid resistance and early age cracking.

Conclusion:

The literature review in the area of road safety suggests that the key factors affecting the road crashes are Human behavior, vehicle dynamics and roadside environment. These factors can never be looked separately but to enhance the sustainable delivery one should looked combine effect of all the factors at delivery phase.

The proposed case study on sub-arterial corridor project indicates that how best considering human behavior, vehicle dynamics and road side environment can help to achieve sustainable delivery and road safety.

To enhance the road safety, the key elements were considered during the preliminary design phases are;
- To reduce the crashes at roundabout, replaced the existing roundabout with signalized intersection. Due consideration was given at network and corridor level performance on proposed options analysis using the micro simulation model to enhance the capacity and safety at operation phase.
- To reduce the crashes on road alignment, replaced the existing geometry with high standard geometry. Due care was taken during preliminary design phase such that provided road geometry does not have any inconsistency in roadway design. This will help to driver do not make speeding error or unsafe driving maneuvers leading to high collision risks.
To reduce the runoff the carriage way (loss of control), rear-end crashes; it was avoided to provide the long straights. The proposed road geometry was combination of horizontal and vertical curves. The proposed design layout was checked for speed difference between the successive elements (the speed difference wasn’t more than 10km/hr).

- Proposed pavement design was effectively considered heavy vehicle speed of 50Km/hr design speed. During the detail design phase due consideration was given to the speed reduction of heavy vehicle at an intersection to reduce the rear-end and head on types crashes.

- To reduce the hit the object and hit by animal types of crashes; due consideration was given at preliminary design phase that provided road geometry will able to achieve stopping sight distance criteria, maneuvering sight distance criteria along the corridor for design speed of 90km/hr.

- Corridor that was passing through the bush land where high density of Koalas resides both sides of road reserve. The high density area was decided to be fenced to restrict the movement of Koala across the road. The through movement of Koala was facilitated by designing the under pass and overpass structure along the corridor.

References:

Long A.D.Kloeden, C. N. H., T.P&McLean, A.J "Reduction of Speed Limit from 110km/hr to 100km/hr on Certain Roads in South Australia: A Preliminary Evaluation." Centre for Automotive Safety Research.


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