Accident Analysis and Prevention 66 (2014) 147–157

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Red light running and close following behaviour at urban shuttle-lane roadworks

Saad Yousif*, Mohammed Alterawi[1], Ralph R. Henson[2]

University of Salford, Manchester M5 4WT, UK

ARTICLE INFO

Article history:
Received 3 July 2013
Received in revised form
22 November 2013
Accepted 27 January 2014

Keywords:
Shuttle-lane
Work zone
Dilemma zone
Tailgating
Red light running

ABSTRACT

Roadworks (work zones) are a common feature of our urban environment. They have a considerable impact on reducing roadway capacity, causing interruptions and imposing substantial delays to road users, which in turn adds to the cost to society and adverse impact on road safety. Shuttle-lane (alternate one-way working) is one of the most commonly used traffic management arrangements at urban roadworks as most of the urban road network is built up from single carriageway.

Despite the importance of this topic, little attention has been paid to studying drivers' behaviour in terms of close following (tailgating) and amber crossing/red light violations at temporary traffic signals. This paper reports on factors affecting aggressive drivers' behaviour using observations from six sites within Greater Manchester, United Kingdom with over 25 h of video recordings of traffic data from around 1500 signal cycles.

The findings show that 24% of drivers violate the "two-second rule" of safe following, as recommended in the Highway Code, before approaching the roadworks site compared to 38% violations after crossing the roadworks site. These results of increased tailgating behaviour are consistent across all sites and for both traffic streams and have a direct effect on rear-end collisions or near accidents. Also, the percentages of drivers' non-compliance with temporary traffic signals are higher compared to those for normal signalised junctions. The results show that around 30% of cycles were violated where drivers cross the stop line on the onset of amber and red (18.9% pass through amber and 11.3% run through red lights). Red light violations were categorised under four categories as observed on site (dilemma zone, dilemma zone follower, single violation and group violations). Factors such as site visibility, traffic signals operation (i.e. fixed time or VA) were also reported.

Introduction

In order to be able to keep up with the increase in vehicle travel demand in urban areas and to provide a good level of service, roadworks become an unavoidable aspect of the urban road network (Benekohal et al., 2003). When roadworks take place in any urban road network, they cause an obstruction to traffic, which increases the risk of accidents, reduces the capacity, reduces vehicle speed and increases delays/congestion and influences drivers' behaviour.

In the United States, it was estimated by the Federal Highway Administration (2004) that work zones cause around 10% of overall congestion. It was reported by Tang (2008) that the Texas Transportation Institute report (2007) stated that the cost of congestion in the United States in 2005 was $78 billion. In the United Kingdom, it was estimated that the congestion caused by roadworks in London alone is around £750 million/year (London First, 2012). Furthermore, in the United States, 1010 people were killed and around 40,000 injured in 2006 because of traffic accidents in work zones (Tang, 2008).

Many studies, driving codes of practice and drivers training programmes (UK Highway Code, 2012; National Safety Council, 1992; Tennessee Department of Safety, 1991) state that a two seconds gap referred to as the "two-seconds rule", is the minimum time gap for safe following on a dry road surface (where gap is defined as the elapsed time between the back of the leading vehicle ($n-1$) passing an imaginary datum line (x) on the road and the front of the following vehicle (n) passing the same point). On wet roads, the equivalent gap is increased to 4 s and could increase further for icy roads. Various studies have reported that based on everyday driving experience in both urban and motorway environments, it has been noticed that many drivers attempt to follow with time headways significantly lower than two seconds. This is commonly referred to as "tailgating" (Michael et al., 2000; Brackstone et al., 2002; Rajalin et al., 1997).

* Corresponding author. Tel.: +44 161 2953835.
E-mail addresses: s.yousif@salford.ac.uk (S. Yousif), m.t.alterawi@edu.salford.ac.uk (M. Alterawi), r.r.henson@salford.ac.uk (R.R. Henson).
[1] Tel.: +44 161 2953835.
[2] Tel.: +44 161 2954498.

0001-4575/$ – see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.aap.2014.01.021

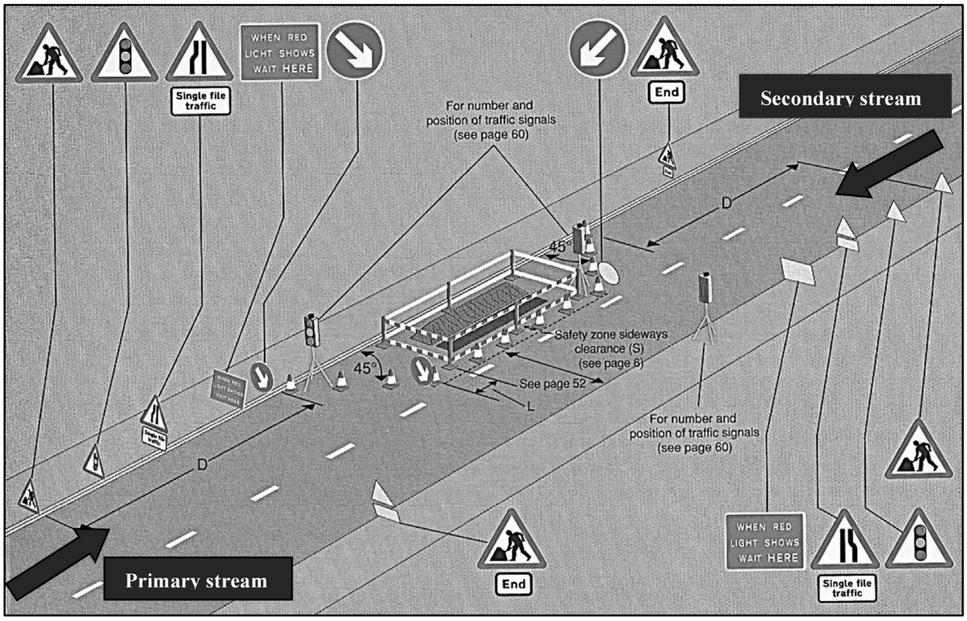

Fig. 1. Typical site layout of shuttle-lane roadworks operated by temporary traffic signals (Department for Transport, 2011).

Tailgating is a very dangerous phenomenon of drivers' behaviour and contributes to a high percentage of the road traffic accidents (mainly rear-end collisions). For example in China it contributes to nearly 16% of all road traffic accidents (Duan et al., 2013). According to Michael et al. (2000), tailgating contributed to 1835 fatalities and 653,000 injuries in 1996 in the USA alone.

Considerable laboratory research using simulation techniques has investigated the factors associated with following distance and braking reaction time (e.g. Van Winsum and Heino, 1996; Van Winsum and Brouwer, 1997; Evans et al., 2010). These studies examined how the drivers estimate time to collision and braking performance which are linked to the drivers' chosen headway.

According to Shrestha and Chang (2005), there are very few studies on close following "tailgating" with no standard criteria (clear definition) or effective system to observe and reduce tailgating. The factors that influence tailgating behaviour can be grouped under three main categories: Driver's Profile, Driver's Behaviour and External Conditions. The parameters under driver's profile include (but are not limited to) age, gender and intoxication. The parameters that are under driver's behaviour include speeding, braking and maintaining minimum headway and the parameters under external conditions include traffic density, weather, speed limit, number of lanes, tyre and brake efficiency and enforcement.

Red light running violation at signalised junctions is a widespread and growing phenomenon which has a significant cost to society. In the US, red light running contributes to around 260,000 crashes each year of which about 750 are fatal. Red light running crashes were also found to be more severe than other types of crashes (Retting et al., 1998, 1999).

A wide range of countermeasures has been studied and implemented to reduce this red light running behaviour and its frequency. A study by Retting et al. (2007) has shown that both countermeasure categories (i.e. engineering and enforcement) are effective in reducing the frequency of red light violations. According to Bonneson and Zimmerman (2004), guidelines on which countermeasure (i.e. whether engineering or enforcement should be used) are scarce in identifying junctions with the potential for safety improvement.

Most of the available research is focused on the effect of implementing either engineering or enforcement countermeasures on signalised junctions using actual counter measures on site or utilising micro-simulation approach (see for example Porter et al., 2013; Bell et al., 2012). However, there is a clear lack of research on both drivers' behaviour and red light running violations on shuttle-lane urban roadworks operated by temporary traffic signals.

The aim of this paper is to observe and investigate the factors influencing dangerous drivers' behaviour which affects safety and capacity at urban shuttle-lane roadworks. The results of this study will form a major part of the input used in the development of a micro-simulation model which is being developed to study shuttle-lane roadworks in urban areas. The study objectives are to carry out various site visits of shuttle-lane roadworks with different site lengths and signal operations (i.e. fixed time (FT) and vehicle actuated (VA)) to observe, investigate and analyse the close following behaviour (before approaching and after crossing the roadworks sites) and drivers' compliance with temporary traffic signals.

Definition of shuttle-lane roadworks

Most urban road networks are built up from single carriageway roads, and when roadworks take place, they are usually carried out by closing one lane and leaving the other lane for both directions to use in alternate one-way working (shuttle-lane). The typical site layout is as shown in Fig. 1 (Summersgill, 1981; Department for Transport, 2009).

When applying shuttle-lane operation, an appropriate type of control is required depending on site and flow characteristics (Department for Transport, 2011). These types of control should achieve the following goals:

(1) Minimise delays for road users and disperse queues effectively;
(2) Maximise safety for road users (drivers, pedestrians and workers).

In order to differentiate between the two traffic streams that use a shuttle-lane roadworks site, the following terms have been used, as suggested by Summersgill (1981), and as shown in Fig. 1:

- *Primary stream*: is the traffic stream which is running in the obstructed path (by the works);