**Redesign of Existing Motorway Sections to Increase Capacity: A Pilot Evaluation of Safety-related Impacts in Israel**

**1.2. Literature survey**

Good quality, standard hard shoulders and road lanes are believed to play an important role in ensuring efficient and fluid traffic flow along with the safety of all road users (FHWA, 2007; RISER, 2005; Stamatiadis et al., 2009). For example, the right (outside) shoulder of a motorway has a significant function in providing a stopping area for vehicles in the event of an emergency or breakdown; enabling vehicles to maneuver in order to prevent collision, helping drivers to successfully contend with situations of momentary loss of control or correcting driving errors; serving as an area for requisite roadside maintenance; supporting the pavement structure, and water drainage, as well as others (MOT, 2018). Numerous studies have shown that the width of the road shoulder has a direct impact on the occurrence of road accidents and reducing the width of a road shoulder has been seen to correlate with an increased risk of accidents (e.g. Council and Stewart, 1999; Gitelman et al, 2018; Stamatiadis et al, 2009).

However, due to steadily-increasing congestion on the main road network, extra uses of the motorway space were introduced in the past decades, e.g. bus running on shoulders (FHWA, 2016; Gitelman et al, 2016).

Based on the accumulated experience of developed countries, in all functional states of a motorway: the typical cross-section, the as-built cross-section or the operation of preferential lanes, it is important to ensure that the right shoulder is at least 3m wide or more (e.g., Caltrans, 2018; CEDR, 2012; FHWA, 2016).

**1.1. The pilot: redesign of motorway sections**

A redesign of the road layout was applied on two sections of a motorway (Road 1) which connects two major cities of the country, Tel-Aviv and Jerusalem. The redesign aimed to provide three travel lanes instead of two, in both travel directions, within the existing roadway, by means of narrowing both shoulders and two traffic lanes. The redesigned sections were:

Section 1 – between the Anava and Latrun interchanges, between the 25 km and 33.6 km markers, along an 8.6 km length of road;

Section 2 – between the Latrun and Shar HaGay interchanges, between the 33.6 km and 38.5 km markers, along a 4.9 km length of road; a total road length of 13.5 km, in both travel directions.

We should point out that the motorway, both before and after the sections in question, comprises three lanes in each direction. Due to heavy traffic congestion (such as an AADT [annual average daily traffic] of 112,000 vehicles in 2016), a change in the lateral cross-section was carried out to increase the roadway capacity. A third travel lane was added to each travel direction at the expense of reducing lane and shoulder width. For example, in Section 2, on the Jerusalem-bound carriageway, the new cross-sections included: a 3.0–3.2 m wide shoulder; a 3.6 m wide right-hand lane; two additional 3.3 m wide lanes; a 0.6 m wide left shoulder; and on the Tel-Aviv-bound carriageway: a 1.2–2.2 m wide right shoulder; a 3.6 m wide right-hand lane; two additional 3.3 m wide lanes; and a 1.2 m wide left shoulder. Figure 1 displays a photo of the new section, with 3 travel lanes in each direction.

The dates for operation of the redesigned road cross-section were: in Section 2, late November 2017; in Section 1, late January 2018.

Due to a restricted layout, the speed limit on the redesigned sections was reduced to 90 km/h, while on the adjacent sections the speed limits remained 110 and 100 kph.

**2. Follow-up evaluation: data and methods**

The redesign was introduced by the Ministry of Transport as a pilot and was followed-up by an evaluation, to examine capacity changes and safety-related impacts.

The redesigned road layout is designed to improve the traffic flow, to increase travel speeds and reduce transit times within the section, especially during rush hour traffic. Moreover, it is imperative to ensure that the new road layout does not adversely affect the level of safety in this section.

The evaluation included after-before analyses of traffic volumes, travel speeds and road accident occurrences. In total, the evaluation included two "after" periods: 1) first half-year of the operation and 2) two-years of the operation, which were compared with a "before" period, prior to setting changes in the road layout.

We should point out that no orderly research with a predefined, uniform measurement framework in both the “before” and “after” periods was requested for the purpose of the evaluation, but a number of accompanying checks were carried out, in short time periods, for the purpose of Ministry of Transport monitoring. Despite the lack of a uniform framework, the findings of the checks conducted during the pilot monitoring period enabled us to draw conclusions regarding the effect of the redesigned road layout on traffic flow and safety.

For Section 2, before construction of the new road layout and during the initial monitoring period, video footage was filmed for a week-long period, to carry out traffic counts and measure traveling speed, in each lane, at all hours of the day. Furthermore, from the total number of vehicles passing through this section, sampling was carried out (based on license plate numbers), while entry and exit times to and from the section were recorded, during rush hour traffic: between 7–10 am and 4**–**7 pm. Consequently, transit times were measured and transit speeds in the section were calculated accordingly. The “before” measurements were made in November 2017 and the “after” measurements in January 2018. In addition, for those same months, Google data was obtained from the Ministry of Transport (Jerusalem Division) database on the section transit speeds in both travel directions, for various hours of the day.

For Section 1, the travel speed data was obtained from NTIC, representing the transit speeds of vehicles moving between sensors located along the route. In total, in the evaluated sections, six identification sensors were installed to enable monitoring of speeds in five sub-sections, three of which were adjacent to the interchanges and two were between the interchanges. The data was obtained for January–July 2018 and enabled us to make a comparison between the “before” period (January 2018) and the “after” period (the remaining months). We conducted evaluations of the average speed when passing through the road section, for various hours of the day, on weekdays. Another issue arising, under the conditions of the new road layout, was that of the representative speed for vehicles traveling through the redesigned sections, in order to examine their suitability for the maximum speed limit that had been set for 90 kph. The assumption made was that the average speed estimates during the non-rush-hour daytime hours reflect the representative speed – the drivers’ selection of traveling speed.

During the second monitoring period, speed data for the redesigned road section was obtained for weekdays during February and July 2020 (both before and after the first lockdown in the COVID-19 pandemic period). For each of the five sub-sections mentioned above, estimates were obtained from NTIC of the average speed during transition of the section, for various hours of the day. The issues examined were: changes in travel speed compared with previous measurements; identification of the representative travel speeds in the redesigned road layout sections, some two years after it had been opened. The speed estimates were used only for those hours in which the measurement was based on the identification of 30 or more vehicles. Moreover, the speed estimates were weighted over a number of days, while taking into account the size of the measurement samples during the appropriate hours.