



2+1-roads Recent Swedish Capacity and Level-of-Service Experience

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Abstract

The first Swedish 2+1 median barrier road was opened in 1998. The concept was to retrofit the standard existing two-lane 13 m paved width cross-section at 90 and 110 kph posted speed limit without widening. This design has one continuous lane in each direction, a middle lane changing direction every one to three kilometres with a median barrier separating the two traffic directions. Today over 2 700 km 2+1 median barrier roads are opened for traffic. AADT's vary from some 3 000 to 20 000 with an average just below 10 000 nowadays normally with 100 kph.

The concept has lately been enhanced also to cover the existing 9 m paved width cross-section. The design concept is the same from a driver's viewpoint, one continuous lane in each direction with a middle lane changing direction and a separating median barrier. This is created by introducing a continuous median barrier and adding overtaking lanes within an overtaking strategy. The differences are the existence of 1+1-sections, less overtaking opportunities and a slightly more narrow cross-section. Some 15 projects are opened.

The purpose of this paper is to summarize present knowledge on level-of-service issues as they are presented in Swedish design and assessment guidelines and to give an overview of field measurements and theoretical analytical and simulation studies supporting the recommendations.

Keywords: 2+1 median barrier roads, capacity, level of service

1 Introduction

The Swedish trunk road system was extended and improved rapidly from the early 50'ies until the late 90'ies using basically four road types:

- normal two lane roads (8-9 m paved width) with at grade intersections with posted speed limits 70 or 90 kph and sometimes in Northern Sweden 110 kph
- wide two lane roads (12-13 m paved width) with grade-separated intersections, full access control and pedestrians, bicyclists and slow moving vehicles forbidden, denoted semi-motorways normally with posted speed limits 110 kph
- wide two lane roads (12-13 m paved width) with grade-separated intersections, a lot of accesses and pedestrians, bicyclists and slow moving vehicles allowed normally with posted speed limits 90 kph in Southern and 110 kph in Northern Sweden
- motorways normally with 110 kph

Truck speed limits are 80 kph with the exception 90 kph on motorways and semi-motorways. Bus speed limits are 90 kph and for seat-belt equipped buses 100 kph. Shoulder bearing capacities on wide two lane roads varied due to age with full strength from the mid 80'ies constructions. Two cross-section designs were used, with 2.75 m wide hard shoulders and 3.75 m lanes and with narrow hard, 1.0 m, shoulders and wide lanes, 5.5 m. There were some 3 600 km representing 14 % of the trunk road system in length and 26 % in mileage with AADTs from 2 000 to some 20 000.

More reliable accident data by road type became available during the 80'ies revealing wide two-lane roads and especially semi-motorways to have the worst safety records of all road types in terms of fatalities and severe injuries. Almost 100 out of a total toll of 400 per year on state roads were killed on these wide two-lane roads with an extreme fatality risk especially at 110 kph around 0.015 per Million axle pair km (including intersections excluding wildlife accidents).

Steadily higher political focus on safety created an in-house Swedish Road Administration proposal to improve safety using a low-cost 2+1 median barrier concept on these wide two lane roads, see Figure 1. The central median barrier winds between the traffic directions with a central lane changing traffic direction on average every one to three km and one continuous lane in each direction squeezed into the 13 m formation. This challenged more or less all traditional highway engineering paradigm. Intersections are normally located at transitions. Some parallel roads are added to take away some accesses and to improve conditions for pedestrians and bicyclists. The 0.75 m hard shoulder is considered acceptable for bicyclists and pedestrians.

The same road type without a median barrier had been used occasionally in Sweden and elsewhere, e.g. France, New Zealand and Australia. Germany developed this concept in parallel to a standard design.

Similar road designs with single lane road segments and periodic overtaking lanes have later been proposed and applied around the world including two-lane expressways (Catbagan and Nakamura, 2006) and super 2 highways (Brewer et al., 2012, Brewer et al., 2011).



Figure 1: Typical 2+1 median barrier design on 12-13 m road

There were a lot of critical views on the proposal concerning among other issues different aspects of level-of-service. The first road was opened in the autumn 1998. Today there are more than 2 700 km 2+1 median barrier roads in Sweden covering some 14 % of the total Swedish state mileage with a

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