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# Capacity of Freeway Work Zones in Germany

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**Abstract**
Work zones considerably influence the traffic flow quality on freeways. In work zones, the capacity can be significantly reduced due to narrower lanes, a reduced number of traffic lanes, and unfavorable roadway geometry. In order to evaluate the impact of work zones on congestion occurrence and resulting delays as well as to allow for a consideration of alternative work zone layouts in the planning process, models to estimate the capacity of work zones are required. The paper presents results from a comprehensive study of work zone capacity on German freeways. In the analysis, a large number of short-term work zones with temporary lane closures as well as long-time work zones with and without a reduction of the number of lanes were covered. Data from loop or radar detectors upstream of the work zones were analyzed. For the capacity estimation of long-term work zones, both deterministic and stochastic approaches were used. For short-term work zones, valid capacity estimates could only be determined for the post-breakdown congestion outflow. The estimated capacities were analyzed regarding the influence of the traffic, geometric, and control conditions in the work zone. Relevant parameters are the number of lanes, the lane widths, the existence of divided lanes, the longitudinal gradient as well as the share of commuters and heavy vehicles. For short-time work zones, also the side of the lane closure (left or right lane) has an influence on the capacity. As a result of the study, capacity estimation models for both short- and long-term work zones, which can be applied in work zone planning procedures, are provided.

*Keywords:* work zone, capacity distribution function, lane closure

## 1 Introduction

Work zones considerably influence the traffic flow quality on freeways. The ex-ante evaluation of the impact of work zones on congestion occurrence is an important instrument to allow for a consideration of alternative work zone layouts in the planning process and hence reduce the extent of congestion.

In freeway work zones, the capacity can be significantly reduced due to narrower lanes, a reduced number of lanes, and unfavorable roadway geometry. In contrast to work zones on U.S. freeways, narrowing of lanes is usually preferred to lane closures in Germany. Particularly on heavily trafficked freeway sections in urban areas, lane closures at long-term work zones are avoided where possible.

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Traffic flow and capacity at work zones were analyzed in a number of studies (e.g. Kim et al., 2001, Sarasua et al., 2004, Yeom et al., 2015). The capacity of work zones on German freeways were investigated by Ressel (1994), Ober-Sundermeier and Zackor (2001), Suemmermann (2012), and others. However, the analyzed types of work zones as well as the applied capacity estimation methods differ in these studies, so that a comparison of the estimated capacities is hardly possible. Ressel (1994) derived theoretical capacities based on headway models for congested flow conditions. Ober-Sundermeier and Zackor (2001) defined the capacity as the mean value of the post-breakdown congestion outflow. Suemmermann (2012) adopted the method by Brilon and Geistefeldt (2010) and estimated work zone capacities by fitting the model of van Aerde (1995) to speed-flow data and determining the volume at the apex of the speed-flow curve.

In this paper, results from a comprehensive study of work zone capacities on German freeways are presented. The aim of the study was to derive standard capacities for both short- and long-term work zones, which shall be implemented in a new traffic analysis tool provided for application by German road authorities. The capacity estimation methods applied in the study are based on the methodology used for the derivation of the design capacities given in the German Highway Capacity Manual HBS (FGSV, 2015). Hence, the standard capacities for freeway work zones can directly be compared with the HBS design capacities.

# 2 Capacity of Long-Term Work Zones

## 2.1 Data Samples

The capacity of long-term work zones was estimated based on traffic data from loop and radar detectors. Traffic breakdowns typically occur at the beginning or at a lane closure directly upstream of a work zone. Hence, traffic data measured in the approach of the work zone are required for the estimation of work zone capacity. In addition, speed and flow data covering a longer period including several traffic breakdowns are needed in order to receive valid capacity estimates. Due to these restrictions, data from traffic detectors upstream of work zones on heavily trafficked freeways in Germany were selected. From a large number of work zones, however, many data sets could not be used due to a blackout or deactivation of the detector during the work zone period, a lack of traffic breakdowns or implausible flow or speed data. The determination of work zone capacities was carried out separately for each direction where possible. In total, capacities for 38 directional work zone layouts with different characteristics could be determined. The characteristics of these work zones are given in Table 1. The data samples include:

- 22 work zones in urban und 16 work zones in rural areas,
- 1 one-lane, 23 two-lane, 11 three-lane and 3 four-lane carriageways,
- 24 directional work zone layouts without crossover on the opposite carriageway, 5 with crossover of all lanes and 9 with partial crossover, i.e. a lane separation,
- 10 directional work zone layouts with lane reduction,
- minimal lane widths between 2,50 m and 3,75 m of the lanes used by passenger cars only and between 3,00 m and 3,75 m of the lanes used by heavy vehicles,
- 10 work zones with longitudinal grades of more than 2 %.