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## Safety Comparison of Angle and Parallel Parking

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### SUMMARY

Recently, the Traffic Engineering Services Unit was asked to review the research on the safety differences between types of on-street parking, specifically parallel and angle parking. This document is a summary of those findings.

In general, the study of the safety effects of on-street parking has been focused on the type of parking arrangement since it is clear that any on-street parking "decreases through capacity, impedes traffic flow, and increases crash potential (1)". Much of the research on the comparison of on-street parking (angle and parallel) was conducted prior to the 1980s with a few more recent studies in the 1990s. Conclusions of the early research were consistent in that urban sections with angle parking had higher crash rates than comparable sections with parallel parking, although they were criticized for failing to account for different levels of parking activity(2). These studies can be divided into two types, before and after comparisons of changes in parking arrangement and cross sectional studies of similar roadway sections with different parking arrangements. The before and after studies found crash rate reductions of 19% to 63% when converting from angle to parallel parking. None of these studies, however, included sites where parking was changed from parallel to angle. Cross sectional studies found differences in crash rates of 50% to 70% lower for parallel than angle. In recent research, McCoy et al conducted a before and after study in Lincoln, Nebraska. The researchers found no statistical evidence in the difference between the crash rate of angle and parallel parking when the increase in parking activity was included in the analysis(3). The researchers concluded that while angle parking clearly has a higher crash rate and frequency it is more likely due to the increased activity of parking rather than the characteristics of either type of parking and that if ample parking supply exists, parallel parking should be used.

While parallel parking is generally preferred for safety and operational considerations, the drawbacks include: 1) driver and passengers may have to exit vehicle into the traveled way; 2) the parking maneuver takes more time than angle; 3) some drivers must execute maneuver multiple times; 4) interruption of through movement depending upon width of cross section. Angle parking is generally less desirable because: 1) the driver leaving the space has limited visibility to the rear; 2) empty spaces are hard to detect by approaching drivers resulting in stop and go movements; 3) through drivers decrease speed in anticipation of conflict movements. However, angle parking is desirable because of 1) less time required for parking maneuver; 2) greater number of stalls; 3) driver and passengers exit vehicle outside of the traveled way.

Based upon the review of the research and in agreement with AASHTO *A Policy on Geometric Design of Highways and Streets* (1994) and the ODOT Highway Design Guide (1996) **parallel parking is preferable to angle parking whenever possible.**

## DESIGN GUIDES

The AASHTO *Policy on Geometric Design of Highways and Streets* (1994) recommends that the type of on-street parking selected "should depend on the specific function and width of the street, the adjacent land use, traffic volume, as well as existing and anticipated traffic operations." Parallel parking is preferred and angle parking is allowable under certain circumstances.

The *Oregon Department of Transportation Highway Design Guide* (1996) states that on-street parking is appropriate for different types of roadways. For example, parking is not appropriate for expressways, suburban arterials, and urban business areas. For special transportation areas, the necessity of on-street parking is recognized but only parallel parking should be used on a state highway and other types of parking requires an exception. Design exceptions should be granted in cooperation with the State Traffic Engineer and Roadway Section.

## RESEARCH SUMMARIES

### **Safety Evaluation Of Converting On-Street Parking From Parallel To Angle (1991) (3)**

A case study of converting on-street parking from parallel to angle in Lincoln, Nebraska was conducted by McCoy et al. Beginning in September of 1987, 27 block faces in Lincoln were converted from parallel to angle parking to increase the supply of downtown parking. All of the conversions were to 9 foot stalls with 55 degree parking angle. Four of the sites were two-lane, two-way the rest were three-lane, one-way streets. Because of data concerns, only 11 of these block faces were included in the study. For comparison, 8 block faces that had not been converted were included in the study.

All of the study and comparison block faces had posted speed limits of 25 mph. The utilization of the study sites ranged from 2.97 to 8.05 cars per 8 hour day with an average utilization rate of 85-100% per 8 hour parking days on the study sites and 92-94% on the comparison sites. The average daily traffic (ADT) on the study sites ranged from 1,000 to 5,730 vehicles per day (vpd) and 11,600 to 15,200 (vpd) on the comparison sites. Data on crashes were collected that occurred on weekdays between 9 am and 5 pm for a period from 3 months after the conversion to the end of 1989. The number of crashes in the study sites increased from 2 to 11 but the comparison sites also increased from 3.5 to 6.7 (average). Given this increase, the expected crashes on the study site should have been from 2 to 4 so the increase over the expected number of crashes that was attributed to the change in parking arrangement was from 4 to 11 (175 percent)

Crash rates were calculated for the study sites in crashes per million vehicle miles and in crashes per million space-hours per 1,000 parkers per million vehicle miles as a measure of exposure of parking activity. Adjusted rates were calculated based upon the increase of crashes at the control sites. Before and after rates were compared for the study sites for both rates. In all cases the before and after crash rates were significantly higher at the 5 percent level of confidence. When the before and after rates per million space-hours per 1,000 parkers per million vehicle miles were compared, there was no significant difference at the 5 percent level of confidence. There also was no statistical change in the severity of crashes.

The researchers concluded that while angle parking clearly has a higher crash rate and frequency it is more likely due to the increased activity of parking rather than the characteristics of either type of parking. The researchers summary was that "when the supply of parking is sufficient, the conversion of on-street parking from parallel to angle should *not* be considered because the number of accidents will increase as a result of more parking activity because of more spaces."

#### **Safety Comparisons of Types of Parking on Urban Streets in Nebraska (1990) (4)**

The objective of the research was to determine the safest type of parking on urban sections of the state highway system in Nebraska. Using the Nebraska Department of Roads's (NDOR) road inventory, 491 sections in 126 cities were identified as possible study sites. 260 of the sites were surveyed in a field visit and 162 sites were mailed surveys to answer questions that could not be answered by examining the video log. Altogether, 171 miles of roadway with on-street parking were included in the study. The study sections included 28,886 stalls of which 22,214 were not painted. A majority of the unpainted stalls were for parallel parking. Of the painted stalls, 3,036 were for parallel and 3,636 were for angle parking. Parallel parking was the most common and most of the angle parking occurred on two-way, two-lane roadways.

Crash data from 1985 to 1986 were obtained for all sections in the study. Stepwise regression was conducted to determine a relationship between safety and type of parking. Dependent variables of type of parking, parking use, number of stalls, speed limit, ADT, roadway alignment, roadway width, block length, land use type and land-use density were tried in the model but none produced a statistically valid model.

Instead of the statistical model, the mean crash rates were used to determine the relationship between highway safety and the type of parking. Crash rates were calculated using only those crashes that included parked vehicles and parking maneuvers. Rates were calculated in terms of crashes per million vehicle-miles of travel and in terms of billions of vehicle-mile-hours per stall. Rates were compared by type of parking (angle, parallel, painted, unpainted) and type of street (major streets, two-way, two-lane streets). In almost all cases, the rates for angle parking were found to be statistically significantly higher than parallel parking. Additionally, low angle parking may be safer than high angle parking but the difference in crash rates were not statistically significant.

The research concluded that "when parking must be allowed on urban sections of the state highway system, parallel parking should be used instead of angle parking whenever feasible."

#### **Synthesis of Safety Research Related to Traffic Control and Roadway Elements (1982) (2)**

Chapter 9 of this research synthesis documented the results of many studies conducted prior to 1982. Many of the studies mentioned are empirical studies. Almost all of the studies summarized do not take into account the increased parking exposure as result of changes from angle to parallel and most included no treatment of crashes on nearby streets. None of the studies included changes from parallel to angle parking.

A series of before and after studies found crash reductions from 19% to 63% in a range of years from 1947 to 1967 when changing from angle to parallel parking. One such study was of eight cities in Utah and found a 28% reduction in total crashes, a 57% reduction in parking related crashes, and a 29% reduction in the overall crash rate (5).

A series of cross sectional studies reported differences in crash rates between similar sections of roadway with parallel and angle parking in the range of 50% to 71%. One these studies by the Arizona Highway Department reported a mean crash rate of 4.9 per million vehicle miles for a section of US101 with angle parking and a rate of 1.4 for a similar section of US101 with parallel parking (6). Another study of 1,523 urban sites in Maine found an 88% lower crash rate for parallel parking as compared to angle parking (7).

## **Safety Considerations in the Use of On-Street Parking (1979) (8) and Safety Aspects of Curb Parking (1978) (9)**

In this comprehensive research published in the Transportation Research Record and as a FHWA Final Technical Report parking data were collected in five states and ten cities for 170 miles of urban streets. The study sites were geographically distributed and generally had consistent land use along each side. Both one and two-way streets were selected for analysis. Field visits were made to each site to determine parking activity in terms of annual space hour use (hours space was occupied per year). Crash data were obtained for two years for all sites.

To make safety comparisons between parking types, streets were defined by street classification, parking arrangement, land use and parking use. Six types of parking arrangements (parallel parking, parallel parking with skips, low angle parking, 30 degree angle parking, and high angle parking) were used in the analysis. Land use was classified as retail, office, single-family residential, apartments, motel, industrial, and school/park. Four levels of parking use were assigned. Combinations of the streets, parking, land use, and parking use yielded 2700 potential configurations.

Using statistical techniques (ANOVA, Bonferroni, Scheffe) the researchers drew the following conclusions by comparing the data:

- 1) parking use level is a significant factor for all street categories (crash rate increases with use until 1.5 million space hours per mile per year where the rate is constant);
- 2) all streets show an increase in crash rate for changes in land use: 1) from single family to apartment; 2) from apartment to office; and 3) from office to retail (again suggesting that increase parking use contributes to increase in crash rate)
- 3) parking configurations were not found to have any statistical effect on crash rate when land use and type of street were included in the analysis.
- 4) parking use above 1,000,000 space-hours per mile per year angle parking was no more hazardous than parallel parking given similar land use.

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## SOURCES

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