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Abridgment

Opportunities for Small-Car Parking

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The reduction in automobile size provides an important opportunity for more-efficient use of parking space through a corresponding reduction in the dimensions of parking facilities. Many types of classifications have been offered for the classification of vehicles by size; however, guidelines suggested by the National Parking Association appear to be the most reasonable for a two- or three-group classification. There is still considerable room for additional effort in this area. Due to the wide range of existing parking-area dimensions and layouts, it is very difficult to recommend criteria for redesign without analysis of the specific parking facility in question. The problem is further complicated by the uncertainty in trends in vehicle preference. However, by using a two-group classification of vehicles, a recommendation is made for small-car stalls to be 16.5 ft long x 8.0 ft wide for 90-degree parking. A layout for parking at angles other than 90 degrees can be determined by simply rotating the basic stall for 90-degree parking to the desired angle and using geometry to determine the associated dimensions. Two alternatives discussed for the design of new parking facilities are to accommodate the present population of cars or to give more consideration to inevitable increases in the percentage of small cars. Of the several types of parking facilities evaluated, those that have the greatest potential for redesign to accommodate small cars have rigid control over the users. Included are employee parking areas provided by employers and a variety of special-use parking areas. Many college and university campuses have particularly high potential for implementation of small-car parking.

The reduction in the size of automobiles provides an important opportunity for more-efficient use of parking space through a corresponding reduction in the dimensions of parking facilities. The shift toward smaller cars has been brought about by several factors, most related to a diminishing supply of oil. Dramatic increases in the price of gasoline and a sudden shift in driver preferences have increased the number of small cars significantly. Statistics reported by the National Parking Association show that the percentage of small cars in the traffic stream has increased from 25 percent in 1975 to 45 percent in 1980 (1). This trend is expected to continue, and the percentage of small cars will increase to 75 percent by 1985 (1). Another factor that enters into the projected increased use of small cars is the mandate by the federal government that requires automobile manufacturers to produce a fleet that can achieve an average of 27.5 miles/gal by 1985. This probably cannot be achieved without additional reduction in vehicle size and weight.

Obviously, the opportunity and need exist to reduce the sizes of parking stalls, which will result in more-efficient use of available space. Escalating costs of land and construction have increased the expense of providing adequate parking, especially in urban areas. The cost per parking space frequently ranges up to $5000 for some parking structures; therefore, the potential for savings brought about by reduced stall and aisle dimensions is considerable. Unfortunately, substantial reductions in the sizes of all parking spaces would not be practical. Large cars currently comprise about one-half of the average traffic stream, and provisions must be made to ensure adequate stall dimensions for these vehicles. A solution to this problem is to reduce the size of some spaces but allow others to remain full-size. This approach allows the creation of additional spaces through stall size reduction while larger cars are still accommodated.

WHAT IS A SMALL CAR?

Before we can attempt to make special provisions for small cars, we must determine just what is a small car. First, consideration is usually given to some dimension of the vehicle. Overall length, overall width, wheelbase, and height are often included. Some classifications of automobiles are based on the overall weight. The U.S. Environmental Protection Agency's Gas Mileage Guide is based on the interior capacity of the vehicle (2). The Motor Vehicle Manufacturers Association annually produces a list of domestic vehicles and their respective dimensions (3). Another compilation of vehicle statistics is published by Road and Track Magazine for each model year (4). Road and Track presents a more-comprehensive list, which also includes most of the foreign-made automobiles. Still, these lists classify vehicles as minicompact, subcompact, compact, intermediate, medium, standard, full-width, and luxury, and it becomes difficult to decide what is small and what is large. The National Parking Association has provided guidelines to classify automobiles into either two or three groups, based on overall length and overall width (5). By multiplying the overall length times the overall width and converting to square meters, a number is obtained that can be used to easily classify a vehicle based on either the two- or three-group classification. The accepted procedure is to drop the decimal part of the measurement and use only the integer portion for classification. In the two-group classification, any car that covers an area less than 9.0 m^2 is considered small, and anything greater than or equal to 9.0 m^2 is large (6).

Table 1. Summary of small-car categories for 1976-1981 model years.

Manufacturer	Model
Alfa Romeo	All models
American Motors Corporation	Concord, Eagle, Gremlin, Hornet, Kammback, Pacer, Spirit, and SX4
Aston Martin	All models
Audi	All models
Avanti II	All models
BMW[a]	All models except 1979 and 1980 733I
Bricklin	All models
Buick	Skyhawk and 1980 and 1981 Skylark[a]
Capri	All models
Chevrolet	1978 and 1979 two- and four-door and all 1980 and 1981 Chevelle[a] and Malibu[a], Chevette, Citation, Corvette, Monza, and Vega
Datsun	All models
DeLorean	All models
Dodge	Aries, Challenger, Colt, and Omni
Ferrari	All models
Fiat	All models
Ford	Escort, Fairmont, Fiesta, 1981 Granada[a], Maverick, Mustang, and Pinto
Honda	All models
Jaguar[a]	All models except 1977-1979 XJ6L and XJ12L
Jensen	All models
Jensen-Healey	All models
Lamborghini	All models
Lancia	All models
Lincoln Mercury	Bobcat, Capri, two-door Comet[a], Lynx, and 1979-1981 Zephyr[a]
Lotus	All models
Maserati[a]	All models except 1980 and 1981 Quattroporte II
Mazda	All models
Mercedes Benz	All models except four-door 280S, 280SE, 300SD, 380SEL, 450SEL, and 6.9
MG	All models
Oldsmobile	1980 Omega[a] and Starfire
Opel	All models
Peugeot	All models
Plymouth	Arrow, Champ, Horizon, Reliant, and Sapporo
Pontiac	Astre, 1980-1981 Phoenix[a], and Sunbird
Porsche	All models
Renault	All models
Rover	All models
Saab	All models
Subaru	All models
Toyota	All models
Triumph	All models
TVR	All models
Volkswagen	All models
Volvo	All models

[a]Appears in both small- and large-car categories.

In an effort to provide a comprehensive source of car dimensions, a list of American and foreign-made automobiles manufactured as 1976 through 1981 models was produced (for the 1981 model year, some large cars were omitted). This list includes the make, model, body style, engine size, weight, wheelbase, overall length, overall width, and area occupied for 1339 different automobile types. In the two-group system of classification, 856 cars were classified as small, and 483 were classified as large. The list is too long to include in its entirety. A more concise summary of automobiles categorized as small in presented in Table 1. To attempt to classify vehicles into more than two groups for the purpose of parking segregation would be impractical.

LAYOUT OF PARKING AREA

Existing parking facilities have a wide range of designs, which range from the typical rectangular-shaped module with 90-degree parking to a variety of shapes with angle parking. In the modification of an existing facility to one with reduced stall dimensions, three factors must be considered: the dimensions of the reduced stalls, the number of stalls to be reduced, and the location of the reduced stalls. For 90-degree parking, a typical parking area has stall widths of 8.5-9.5 ft, depending on the type of parking facility in question and the availability of land. Based on a minimum door opening width, 10 in is needed between each side of the vehicle and the respective stall edgelines. Therefore, an additional 20 in should be added to the vehicle width in order to determine the minimum stall width. By using the comprehensive list of vehicle types and dimensions, the National Parking Association's method of classification has been used to divide the vehicle types into categories of large and small cars. If a stall width of 8.0 ft is used, only 9 models of cars classified as small would exceed the allowable width (all 9 are models of the American Motors' Pacer). This is also the case for a stall width of 7.75 ft. If the stall width is decreased to 7.5 ft, 134 vehicle models classified as small exceed the allowable width, although all but 9 of these models exceed the allowable width by 3.0 in or less. A stall width of 8.0 ft should be used, then, if we are to accommodate the classification of small cars that meet the requirements of having an area less than 9.0 m^2. However, this can be reduced to 7.75 ft without seriously hampering performance, and even 7.5 ft could be accepted if space was sufficiently critical. In addition, a stall width less than 8.0 ft could be used comfortably if coupled with a more-stringent definition of a small car. A recent study reported that the incidence of large cars in violation of small-car stalls was substantially lower for 7.5-ft stalls than for 8.0-ft stalls (1). This suggests that 7.5-ft stalls may be advantageous in at least some applications. Whichever stall width is selected for a particular application, a small car can then be defined so that it will fit comfortably into the design stall.

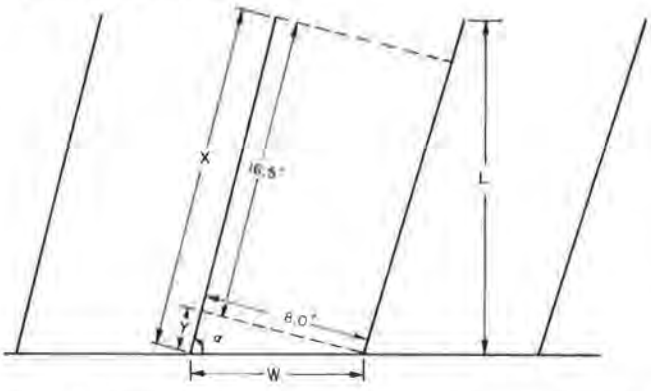
The minimum stall length is another factor that must be taken into consideration when attempting to downsize 90-degree parking. Again, from the comprehensive list of vehicle dimensions grouped by small and large cars, the longest vehicle in the small category was 197 in long. If the stall length was selected to be 16 ft, 79 small vehicles would exceed this length. In order to accommodate all vehicles classified as small, the stall length would have to be at least 16.5 ft. Therefore, if we use the two-group classification of vehicles, parking stalls to accommodate small vehicles for 90-degree parking should be 16.5 ft long x 8.0 ft wide.

Small-car parking may also be provided at angles other than 90 degrees. In general, a layout for parking of this type can be determined by simply rotating the basic stall for 90-degree parking to the desired angle and using geometry to determine the associated dimensions. Examples of this are shown in Figure 1. Parallel parking is not discussed in this paper, but additional research is needed in this area. Existing facilities that have stall angles different from 90 degrees and one-way circulation aisles can often achieve a higher proportion of gain by converting to a two-way circulation pattern and 90-degree parking. Some limitations regarding minimum module width are involved and the overall savings are related to the type of parkers to be accommodated.

If an entire lot or an entire section of a lot is to be restricted to small cars, then aisle widths and other dimensions in addition to stall sizes may be reduced. However, a thorough discussion of this would require an analysis of turning capabilities, which is beyond the scope of this paper. Further research is needed into the turning capabilities and door-opening characteristics of large versus small cars.

Along with the decision on the size of the reduced spaces, a decision is required regarding the

Figure 1. Angle parking calculations.



$\sin\alpha = \frac{8.0'}{W}$ $\quad W = \frac{8.0'}{\sin\alpha}$

$\cos\alpha = \frac{Y}{W}$ $\quad Y = W\cos\alpha$

$X = 16.5' + Y$

$\sin\alpha = \frac{L}{X}$ $\quad L = X\sin\alpha$

1 foot = 0.3048 meters

α	90°	75°	60°	45°
W	8.0'	8.28'	9.24'	11.31'
Y	0.0'	2.14'	4.62'	8.0'
X	16.5'	18.64'	21.12'	24.5'
L	16.5'	18.01'	18.29'	17.32'

number of spaces to be reduced and the number to be left full size. Since small cars can use full-size spaces but large cars cannot use reduced spaces, a safe excess of full-size spaces should be provided. To decide how many spaces to reduce, the characteristics of the users of a parking area must be considered. Drivers in some sections of the United States have traditionally bought more small and foreign-made cars than in other areas. Therefore, for any proposed redesign, counts should be conducted to determine the mix of vehicles that use the lot.

In the design or redesign of any parking facility, the question is raised as to whether to design for the present population of cars or give more consideration to inevitable increases in the percentage of small cars. There seem to be two practical alternatives to this possible dilemma. The facility could be designed with 60-degree parking to accommodate only large cars at present but with the option to change some or all of the facility to 75- or 90-degree parking for small cars. This change, when made, could result in a 20-25 percent increase in the capacity of the parking area. The other alternative is to design the facility to accommodate an appropriate percentage of both large and small cars now and an option to alter some of the larger spaces at a later date. The exact details of any design should be worked out individually so as to gain optimum use of available space.

The location of the reduced stalls is also of primary importance. They must be placed in a prime location in order to encourage their use. If small cars park in the full-size spaces first and leave only reduced spaces vacant, then late-coming drivers of large cars will have no place to park except in reduced spaces. To avoid this situation, the reduced spaces must be placed in an attractive location. However, this should not be carried to such an extreme that the drivers of large cars are punished by being forced to park in undesirable locations.

CONTROLLING THE USE OF DOWNSIZED SPACES

One of the difficulties with having both reduced and full-size parking stalls is preventing the use of reduced stalls by large cars. If large cars are allowed to park in reduced stalls, the adjacent stalls may become unusable. Even if the adjacent stalls can still be used, dents, nicks, and angry drivers may result. Therefore, the use of reduced spaces must be restricted to small cars. For this to be accomplished, the driver must know where the reduced spaces are located and whether he or she is permitted to park in them. The placement of signs in the area designated for small-car parking should be one of the first steps in communicating the location of the reduced spaces to the driver. Special pavement markings can also be used for this purpose. It is more difficult to inform the driver whether his or her car is a small car or not. One technique that is often used is to merely post a message to the effect "small cars only" and depend on driver judgment and honor. Under this system, the parker should be given considerable room for judgment, and enforcement should take place in only the most blatant cases of misuse.

For any of the above methods, enforcement would be difficult to provide. If enforcement officers were required to carry a list of qualifying vehicle types and check parked cars against it or to carry a tape measure and measure the cars, this would be very time-consuming and tedious. In any case, strict enforcement of parking regulations would be very difficult as long as drivers have no easy way of knowing whether or not their vehicles qualify as small.

Locations that require a sticker for parking have a built-in solution to the communication and enforcement problems. Rigidly controlled parking areas such as employee parking provided by employers and college or university parking are examples of this type of location. In these cases, an application for a parking permit should include a description of the vehicle on which the permit is to be placed. The agency or employer that issues the sticker could use a list of automobiles categorized as small or large. A list of small cars similar to that presented in Table 1 would be ideal for this purpose.

APPLICATION ON A COLLEGE CAMPUS

The types of parking that have the most potential for redesign to small cars are those with rigid control over the users. These types would include employee parking provided by employers and a variety of special-use parking areas, such as hospitals, airports, and colleges or universities. College and university campuses have some of the more heavily used parking areas, and the potential for improvement is significant. Increased use of small cars in general, and particularly on college campuses, has prompted some parking authorities to consider drastic redesign seriously. At the University of Kentucky, which has approximately 24 000 students and 8000 parking spaces, a survey of users of parking areas was made. The percentage of small cars was sought in order to determine the potential for increasing the number of parking spaces. The percentage of small cars on campus was found to be considerably higher than on one of the primary routes in a rural section of Fayette County, where the university is located. In the university parking areas, 59 percent were small cars as compared with 38 percent at the rural location. The University of Kentucky is a prime example of a location where redesign of the parking area could have significant benefits. The high percentage of small cars, the intense demand for parking, and the strict control by permit over parking in university lots make the idea of reducing stall sizes very attractive.

SUMMARY AND CONCLUSIONS

The opportunities for improved efficiency in the design and redesign of parking facilities appear certain to increase as the percentage of small cars increases. Our abilities to take advantage of these opportunities will vary by section of the country and type of parking facility in question. There is still considerable room for additional thought and effort in the classification of vehicles by size. The list referred to in this discussion of parking opportunities includes 1339 vehicles manufactured as 1976-1981 models, but it may not be comprehensive enough for many purposes.

With the wide range of existing dimensions and layouts of parking areas, criteria for redesign are difficult to recommend without detailed analysis of the special parking facility in question. However, by using a two-group classification of vehicles, a recommendation was made for small-car stall dimensions to be 16.5 ft long x 8.0 ft wide for 90-degree parking. Alternatives for the design of a new facility are to accommodate the present population of cars or to give more consideration to the inevitable increases in the number of small cars. A safe excess of large stalls is required because some small cars can be expected to park in large stalls, but large cars cannot park in reduced stalls. In addition, it is crucial that reduced stalls be located in a prime spot so that they will never be the last spaces to be filled.

Of the several types of parking facilities, those that have the greatest potential for redesign to accommodate small cars have rigid control over users. Included in this group are employee parking areas provided by employers and a variety of special-use parking areas. Many college and university campuses are particularly well-suited to small-car parking because of their high percentages of small cars, intense parking demand, and strict control over users.

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New Directions in Central Business District Parking Policies

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Several North American cities have recently adopted innovative approaches to central business district (CBD) parking requirements to manage the supply and location of downtown parking. Traditional zoning ordinances require sufficient parking in downtown developments to accommodate automobile access by building tenants and visitors. Some new approaches to parking involve the provision of an enhanced parking supply as an incentive to the economic development or redevelopment of an urban area; these approaches are generally being pursued in areas whose goals and objectives relate to economic development and new employment opportunities. Other new approaches to parking are directed at reducing the supply of downtown parking or redirecting new parking supply to the CBD periphery; these techniques generally are being pursued in areas where alternatives to automobile commuting exist or can be created. This paper reviews innovative parking policies in selected cities and describes and assesses the range of tactics for off-street parking supply that can be used in activity centers.

Policies to manage the supply and location of downtown parking are receiving renewed attention from many older cities that seek to revitalize their central business districts (CBDs) as well as from developing cities that are actively shaping their urban development. The traditional approach to CBD parking is a zoning requirement on developers to provide a minimum number of spaces, depending on the size of the building. However, limitations on the number of automobiles that can be accommodated in a CBD without serious congestion and pollution problems have prompted many cities to manage automobile use by controlling parking opportunities.

This paper examines the policies adopted by several North American cities to regulate the supply of CBD parking and, in some instances, to direct the construction of new spaces to areas on the CBD periphery. Most of the policies reviewed are directed at reducing the total available supply of CBD parking, although several cities are also pursuing programs to increase short-term parking opportunities and reduce long-term parking in the CBD. Efforts to reduce total available parking are most evident in cities where feasible alternatives to automobile commuting exist.

DOWNTOWN PARKING POLICIES IN SELECTED NORTH AMERICAN CITIES

Several cities in both Canada and the United States have implemented parking management policies to manage automobile access to their downtowns. These communities have adopted various zoning and related parking control measures that address their individual circumstances. The survey of downtown parking policies conducted in this study showed that no one approach to downtown parking will be universally successful (1). Parking is only one aspect of larger transportation management activities, and we must consider the other actions that the cities described below have taken to understand the framework for their parking policies.