Effectiveness of Do Not Block Intersection Signs

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On higher-volume streets the traffic queues that form at signalized intersections may back up and block access into or out of side streets and driveways. Owners of abutting businesses and residents whose access is repeatedly denied by these blockages sometimes complain to municipal officials and request police action or a sign prohibiting blocking the intersection. In response to a request from city officials, research was conducted to evaluate the effectiveness of Do Not Block Intersection/Drive signs at four sites. The signs were installed not at signalized intersections, as mentioned in the *Manual on Uniform Traffic Control Devices*, but at unsignalized intersections located in advance of signalized intersections. The number of blockages caused by arterial street traffic was observed at two street intersections and at two commercial driveway intersections. Then, Do Not Block Intersection/Drive signs were installed, and the number of blockages was again recorded. The data indicated that at three of the four sites the sign had no effect on driver behavior: the proportion of blockages did not decrease after the signs were installed. At the fourth site, a higher-volume shopping center driveway, a minimal impact was associated with the installation of the sign. These findings may help officials faced with intersection blockages and citizen complaints avoid unproductive and ineffective remedial actions.

Intersection traffic conflicts are often addressed with devices that assign right-of-way: yield signs, stop signs, and traffic signals. Occasionally, however, situations that these devices do not address arise at intersections. One such situation is through street traffic queue upstream from a traffic signal and blocking access into and out of side street and driveway intersections.

Norman, Oklahoma, a city of about 80,000 population, was experiencing the problem of arterial street traffic, queued from signals, blocking side street and driveway intersections. This problem occurred more often during the peak-volume hours. Side street residents and the patrons of business establishments along the arterials had problems getting into or crossing the arterial street traffic during those hours. Occasionally such inconvenience manifests itself in complaints to municipal officials and demands for the city to do something about it with signs or police activity.

Recognizing the problem, the city asked the researchers to test the effectiveness of Do Not Block Intersection/Drive (R10-7) signs at sites experiencing blockage. The Do Not Block Intersection/Drive sign requires through street motorists to leave the intersection unblocked. Although the *Manual on Uniform Traffic Control Devices* (*1*) discusses the use of this sign as a part of Section 2B-37, Traffic Signal Signs, it was thought that the nature of the problem and the message conveyed by the sign were such that the sign could be understood in an unsignalized intersection environment. The sign may be found at unsignalized intersections in other cities, such as Dallas, Texas, Springfield, Missouri, and Fayetteville, Arkansas.

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LITERATURE REVIEW

In literature search little information about the Do Not Block Intersection sign was found. However, the search produced relevant literature addressing the problem of intersection blocking.

An *ITE Journal* article (*2*) discussed the management of damaging queues, queues that interfere with traffic progression, block intersections, or block access. The report suggested a number of remedies.

In general, any action that improves the operation of the downstream intersection will reduce the length of a damaging queue. Intersection widening, geometric improvements, and bus stop removal are among the measures that could be considered. Signal timing modifications offered as remedies included increasing the green-to-cycle length ratio or reducing the cycle length (at intersections not experiencing cycle failure).

When it is not possible to improve the rate of discharge from the head of the queue, the article suggested reducing the length of the queue by reducing the rate at which vehicles arrive at the tail of the queue. A slight reduction in the upstream through green could accomplish this.

When the queue fills all the available street length, reverse progression can be tried. Standard, forward progression provides green at the upstream signal before it appears at the downstream signal. But when the downstream link is filled with standing vehicles, allowing the upstream vehicles to enter the link only blocks the upstream intersection and leads to gridlock. When the entire link is filled with standing traffic, reverse progression can allow downstream traffic to clear before upstream traffic arrives.

If a driveway or side street is a short distance upstream from a traffic signal, a presignal may be appropriate. The presignal, located on the arterial at the blocked side street or driveway intersection, causes arterial street vehicles to stop in advance of the upstream blocked intersection, leaving the street between the upstream and main intersections clear.

In a study of driver recognition of traffic controls in work zones (*3*), 80 percent of those interviewed understood that the Do Not Block Intersection sign indicated that "the driver must leave room for traffic crossing at the intersection." The authors noted that 74 percent of the respondents in a previous study in another city (*4*) had correctly identified the sign's meaning.

STUDY METHODOLOGY

The steps in evaluating Do Not Block Intersection/Drive sign effectiveness included selecting sites, devising study procedures, making traffic behavior observations, and analyzing data. Statistical methods were used to analyze the data.

Selecting Sites

The researchers observed intersections to identify candidate sites with high traffic volumes and queuing backups. After observing traffic during peak hours, the following four sites were determined to be suitable for study:

Site A: Main Street westbound, east of Buy-for-Less at the median opening;

Site B: 24th Avenue W northbound, south of the Texaco on Main Street and north of Homeland;

Site C: Main Street westbound, east of Sherry Avenue; and

Site D: Main Street eastbound, west of Gatewood Drive.

Sites A and B are at driveways serving neighborhood shopping centers (i.e., a large grocery store, a branch bank, and a few smaller stores); Sites C and D are at minor streets serving residential areas. Figures 1 through 3 illustrate the study sites.

Developing Study Procedures

Traffic was observed at the study sites during the day to identify periods during which the intersections were experiencing queuing and intersection blocking. Data were collected during the identified peak periods for a total of 134 hr. The data recorded for each site included the name of the intersecting streets; the approach direction (e.g., northbound); the type of intersection (e.g., tee intersection) and number of lanes; and the date, day, start time, and end time of each data collection period.

There were five possible types of blockage conditions. The occurrence frequency of each condition was recorded.

1. One lane blocked and the other lanes not occupied: the queue that formed in one of the lanes blocked the intersection, and the queues in the other lanes were not long enough to extend into the intersection.
2. One lane blocked and the other lanes open: the queues that formed in all the lanes were long enough to extend into the intersection, but the vehicles in only one of the lanes had blocked the intersection and the remaining lanes were unblocked.
3. More than one lane blocked: the queues in two or more of the lanes were long enough to extend into the intersection, and the vehicles in two or more of the lanes had blocked the intersection.
4. One lane unblocked and the other lanes not occupied: the queue that formed in one of the lanes was long enough to block the intersection, but the vehicles had left the intersection unblocked, and the queues in the other lanes were not long enough to extend into the intersection.
5. More than one lane unblocked: the queues that formed in all the lanes were long enough to extend into the intersection, and the vehicles in all of the lanes had left the intersection unblocked.

The first three traffic conditions all involved the through street blocking the side street, and the last two traffic conditions involved the through street not blocking the side street.

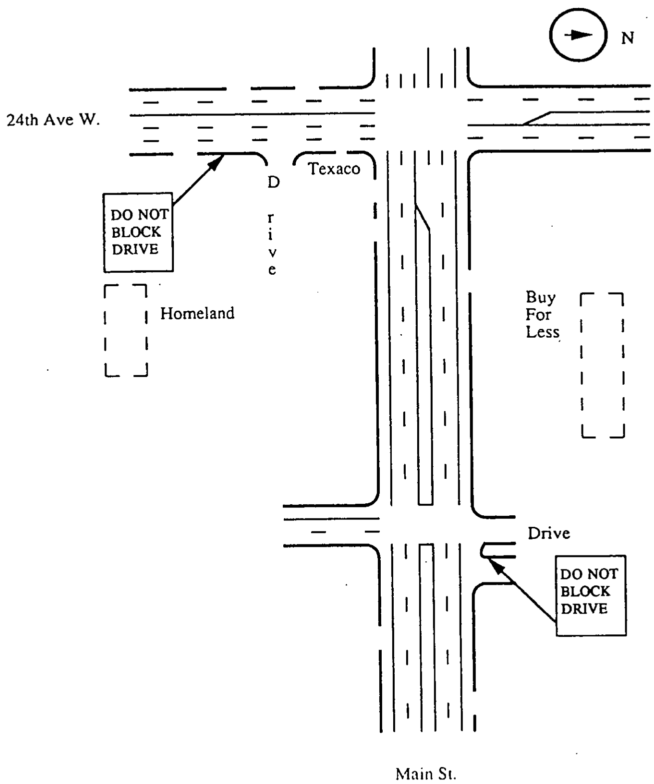

FIGURE 1 Sites A and B.

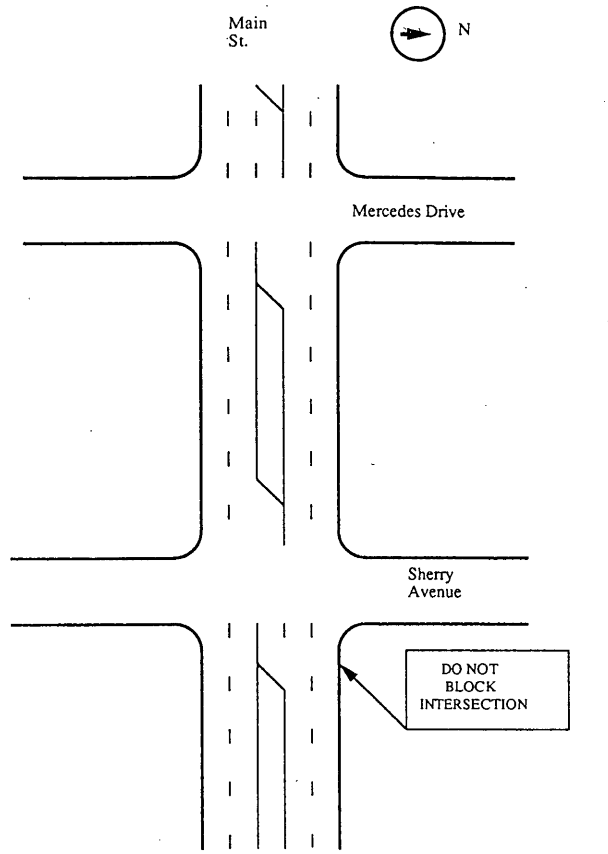

FIGURE 2 Site C.

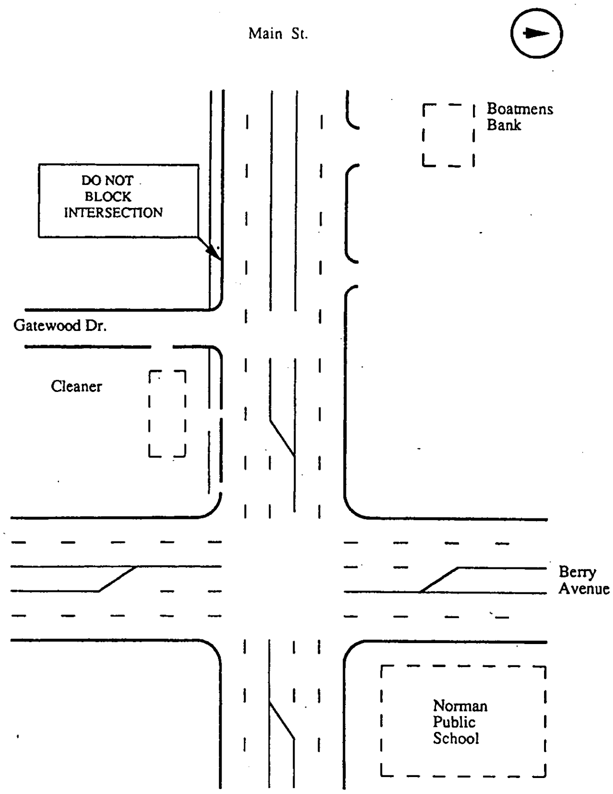

FIGURE 3 Site D.

FIGURE 4 Queuing after sign installed.

Conducting the Studies

The before studies were carried out at the sites. At all sites the traffic stream was composed almost entirely of passenger vehicles; trucks and buses were seldom present.

Initial data analyses revealed that the proportions of the motorists leaving the intersection open or unblocked at Site A were different from the proportions at the other three sites. One possible explanation for the difference was that the Site A driveway appeared to have more traffic than the side streets or drive at the other three sites. In response to the difference in proportions, the data collection form was modified by noting the following for each of the five blockage conditions:

1. Whether vehicles were present on the side street before the through street queue backed up to the side street, and
2. Whether vehicles were not present on the side street before the through street queue backed up to the side street.

The change was made to see whether the presence of vehicles on the side street before the queue backed up to the intersection caused more drivers to leave the intersection open. The modified data collection form was used in a before restudy at Site A and in all of the after (i.e., signs in place) studies.

After collecting the before data city officials were notified that they could install Do Not Block Intersection/Drive signs at the study sites. The word *drive* instead of *intersection* was used on the signs placed near the two driveway intersections. Figure 4 shows one of the study sites after the sign was installed. The approximate distances from the signs to the near side of the signalized intersections are as follows: Site A, 203 m (665 ft); Site B, 79 m (260 ft); Site C, 105 m (345 ft); Site D, 113 m (370 ft).

The before studies were conducted from late April through mid-September 1992. The signs were installed on September 24 and 25. The after studies were conducted from October 8 through early November 1992. The studies were conducted during the midday (11:25 a.m. to 1:30 p.m.) and evening (4:30 p.m. to 6:00 p.m.) peak periods.

A sign should be placed so that motorists can see the sign and have adequate time to respond; signs blocked by vegetation or other signs lose effectiveness. At each site a place for sign installation was proposed, and then test drives were made to verify that the sign placement would allow drivers to see the sign and respond, Signs were placed about 6 to 15 m (20 to 50 ft) in advance of the applicable street or drive.

Statistical Procedure

A statistical test for comparing two binomial proportions can be used to compare before and after performance. This test determines whether the proportion of occurrence in one sample (before period) differs significantly from the proportion of occurrence in a second sample (after period).

In the present study the event of vehicles blocking the intersection was compared with the event of leaving it unblocked (open). The proportion of the intersection blockages at each site in the before period was compared with the proportion in the after period, and a z-value was computed.

The sample sizes n_1 and n_2 must be sufficiently large to ensure that the sample distributions of p_1 and p_2, and hence of the difference $(p_1 - p_2)$, are normally distributed. For this the rule is that the intervals

$$p_1 \pm 2\sqrt{\frac{p_1 q_1}{n_1}} \quad (1)$$

and

$$p_2 \pm 2\sqrt{\frac{p_2 q_2}{n_2}} \quad (2)$$

should not contain 0 or 1 (*5*).

If the sample sizes are sufficiently large, then the test proceeds with calculation of sample proportions p_1 and p_2, where

$$p_1 = \frac{x_1}{n_1} \tag{3}$$

$$p_2 = \frac{x_2}{n_2} \tag{4}$$

$$p = \frac{x_1 + x_2}{n_1 + n_2} \tag{5}$$

and

$$q = (1 - p) \tag{6}$$

where x_1 and x_2 are the number of successes from the sample size of n_1 and n_2. The following test statistic is found:

$$z = \frac{p_1 - p_2}{\sqrt{p * q\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \tag{7}$$

If the calculated $|z| \geq z_{\alpha/2}$, where $z_{\alpha/2}$ is the α-level critical value from the standard normal distribution, the difference in the proportions is statistically significant. If the difference is not significant, then the null hypothesis

$$H_0: p_1 - p_2 = 0 \tag{8}$$

is accepted. If the difference is significant, the null hypothesis is rejected, and the alternative hypothesis

$$H_{alt}: p_1 - p_2 \neq 0 \tag{9}$$

is assumed to be true (*4*).

DATA ANALYSIS AND RESULTS

Table 1 shows the field observations made at the four sites. In addition to the field totals proportions of both before and after blocked and not blocked lanes are shown.

Table 2 shows for the after studies a comparison between the number of times that side street vehicles were present and were not present when the queue backed up. From this it is evident that vehicles were present on the side street/driveway at Site A much more often than at the other sites.

Binomial proportions tests were used to compare the proportion of times the intersection was blocked during the before study (i.e., no sign present) with the proportions during the after study (i.e., signs in place). This comparison was modified for Site A: here, the comparison was made between the proportion of the time the intersection was blocked when vehicles were present on the side street before the through-street queue backed up to the side street and the proportion of the time that the intersection was blocked when vehicles were not present on the side street before the through-street queue backed up to the side street. The researchers made five before-and-after study comparisons:

TEST A1: The proportion of the time the intersection was blocked when vehicles were present on the driveway before the through-street queue backed up to the driveway at Site A.

TEST A2: The proportion of the time the intersection was blocked when vehicles were not present on the driveway before the through-street queue backed up to the driveway at Site A.

TEST B: The proportion of the time the intersection was blocked at Site B.

TEST C: The proportion of the time the intersection was blocked at Site C.

TEST D: The proportion of the time the intersection was blocked at Site D.

An initial step was to confirm that the sample sizes were large. This was done by the procedure described previously. The values in Table 3 were calculated as shown in the following equations:

$$E = p_1 + 2\sqrt{\frac{p_1 q_1}{n_1}} \tag{10}$$

$$F = p_1 - 2\sqrt{\frac{p_1 q_1}{n_1}} \tag{11}$$

$$G = p_2 + 2\sqrt{\frac{p_2 q_2}{n_2}} \tag{12}$$

$$H = p_2 - 2\sqrt{\frac{p_2 q_2}{n_2}} \tag{13}$$

Because neither the E through F intervals nor the G through H intervals contained 0 or 1, it was assumed that the distributions were normal and the sample sizes were sufficiently large.

The statistical tests for comparing before compliance with after compliance were performed, and the values are given in Table 4. For all tests, $\alpha = 0.10$, so the critical $z_{\alpha/2} = 1.645$. Because a binomial distribution was involved, the statistical test values for the intersection being blocked were the same as the values for the intersection remaining open.

For Tests A1, B, C, and D, H_0 was accepted because the observed or test z-value was less than the critical $z_{\alpha/2}$. In other words the tests indicated that there were no significant differences between the proportions of vehicles blocking the intersection with or without the Do Not Block Intersection/Drive signs. Even without the tests inspection of the data leads to the same conclusion.

Test A2 (when the intersection at Site A was blocked and vehicles were not present on the driveway before the through-street queue backed up to the driveway) showed that there was a significant difference between the before and the after blockage proportions. After the sign was installed there were 10 percent fewer (0.92 versus 0.82) blockages when driveway vehicles were not present when the queue backed up. Even with the sign, under these conditions the intersection was blocked 82 percent of the time. When vehicles were waiting on the driveway before the queue backed up the intersection was blocked only 43 percent of the time. At this site the presence of an exiting driveway vehicle was much more effective in preventing driveway blockages than the sign was.

OBSERVATIONS

While conducting the studies and analyzing the data, the researchers made the following qualitative observations:

TABLE 1 Field Data Totals

Site	Blocked/Unblocked	Combined Before	Combined After	Vehicles present Before	Vehicles present After	Vehicles not present Before	Vehicles not present After
A	BLOCKED						
	1 lane blocked, other unoccupied			26	30	63	42
	1 lane blocked, others open			8	6	17	6
	> 1 lane blocked			10	13	3	12
	Total of blocked			44	49	83	60
	Proportion blocked			0.43	0.43	0.92	0.82
	NOT BLOCKED						
	1 ln unblocked, others unoccupied			41	39	5	13
	> 1 ln unblocked			18	26	2	0
	Total of unblocked			59	65	7	13
	Proportion not blocked			0.57	0.57	0.08	0.18
B	BLOCKED						
	1 lane blocked, other unoccupied	211	137				
	1 lane blocked, others open	4	1				
	> 1 lane blocked	80	98				
	Total of blocked	295	236				
	Proportion blocked	0.91	0.92				
	NOT BLOCKED						
	1 ln unblocked, others unoccupied	25	12				
	> 1 ln unblocked	3	7				
	Total of unblocked	28	19				
	Proportion not blocked	0.09	0.08				
C	BLOCKED						
	1 lane blocked, other unoccupied	81	100				
	1 lane blocked, others open	5	10				
	> 1 lane blocked	76	35				
	Total of blocked	162	145				
	Proportion blocked	0.86	0.86				
	NOT BLOCKED						
	1 ln unblocked, others unoccupied	7	14				
	> 1 ln unblocked	20	10				
	Total of unblocked	27	24				
	Proportion not blocked	0.14	0.14				
D	BLOCKED						
	1 lane blocked, other unoccupied	101	93				
	1 lane blocked, others open	1	7				
	> 1 lane blocked	90	87				
	Total of blocked	192	187				
	Proportion blocked	0.91	0.94				
	NOT BLOCKED						
	1 ln unblocked, others unoccupied	9	5				
	> 1 ln unblocked	10	7				
	Total of unblocked	19	12				
	Proportion not blocked	0.09	0.06				

NOTE: "Vehicles present" means vehicles were present on driveway before through street queue had backed up to the driveway intersection
"Vehicles not present" means vehicles were not present on driveway before through street queue had backed up to the driveway intersection

TABLE 2 Comparison of Presence of Vehicles on Side Street/Driveway

Site	Number of times present when queue backed up	Number of times not present when queue backed up
A	114	73
B	56	199
C	18	151
D	9	190

TABLE 3 Confirmation of Large Sample

Test	Interval E	F	G	H
A1	0.5246	0.3297	0.5226	0.3371
A2	0.9787	0.8658	0.9115	0.7324
B	0.9446	0.8820	0.9584	0.8926
C	0.9081	0.8062	0.9117	0.8043
D	0.9494	0.8705	0.9734	0.9059

TABLE 4 Statistical Test Values

Test	p_1	p_2	p	q	z
A1	0.4272	0.4298	0.4286	0.5714	0.0392
A2	0.9222	0.8219	0.8773	0.1227	1.9409
B	0.9133	0.9255	0.9187	0.0813	0.5319
C	0.8571	0.8580	0.8575	0.1425	0.0228
D	0.9099	0.9397	0.9244	0.0756	1.1386

p_1 = proportion of intersection blockage in the "before" study,

p_2 = is the proportion of intersection blockage in the "after" study,

$p = (x_1 + x_2)/(n_1 + n_2)$,

x_1 = number of times the intersection was blocked in the "before" study,

x_2 = number of times the intersection was blocked in the "after" study,

n_1 = sample size of the "before" study, and

n_2 = sample size of the "after" study.

1. Motorists exhibited a greater tendency to leave the intersection unblocked if there were vehicles present at the side street before the through street queue backed up to the side street.
2. The motorists in the inner lane, that is, the lane that is farther from the side street, paid less attention to the sign placed at the side of the road than did the motorists in the outer lane.
3. When the queue was very long and all vehicles were not cleared during a single green period, then the drivers were more reluctant to leave the intersection unblocked.
4. When queues were blocking or threatening to block side street and driveway access, impatient motorists to and from side streets and driveways sometimes made maneuvers that caused arterial street motorists to make evasive maneuvers.

SUMMARY AND RECOMMENDATIONS

The effectiveness of Do Not Block Intersection/Drive signs was evaluated at four sites: two at streets and two at driveways to smaller shopping centers. Studies were conducted to record the number of times the intersections were blocked by vehicles on the arterial street and the number of times the intersections remained open or unblocked. Then the signs were installed, and blockage observations were again made. The effectiveness of the Do Not Block Intersection/ Drive sign was determined by comparing the before study blockage proportions with the after study blockage proportions.

The Do Not Block Intersection/Drive sign did not prevent intersection blockages, and the sign did not even produce reduction in blockages at three of the four sites. Only at Site A was the sign associated with a reduction in intersection blockage; it was the only site where the arterial street had a median, and there was an opening in the median for the driveway. Compared with the other three sites, this site had heavier volumes into and out of the driveway/side street. The combination of the setting and the median opening appeared to make this site more visible to approaching arterial motorists.

The vehicles at the study sites were almost exclusively passenger cars. From the present study it is not known whether significant amounts of truck or bus traffic would affect the proportion of the time an intersection remained unblocked.

Two conclusions were made. First, the research suggest that the effectiveness of the Do Not Block Intersection/Drive sign is minimal. The study indicated that installation of the sign may be a waste of time and effort in many situations. Second, to prevent undesirable traffic patterns from arising in the first place, the study reinforced the need to have access controls that prevent side streets and driveways from being located too close to arterial street signalized intersection approaches. The distance D from the signalized intersection to the upstream side street or driveway should be estimated by the equation

$$D = nL \tag{14}$$

where n is the number of queued vehicles per lane, and L is average vehicle length. The number of vehicles n will depend on the traffic volume and the signal cycle length; the n value should be the higher of the existing volume or the future anticipated volume.

Officials involved with municipal traffic may be faced with intersection blockages and complaints from inconvenienced residents and business owners. It is hoped that these findings will help officials avoid unproductive and ineffective remedial actions.

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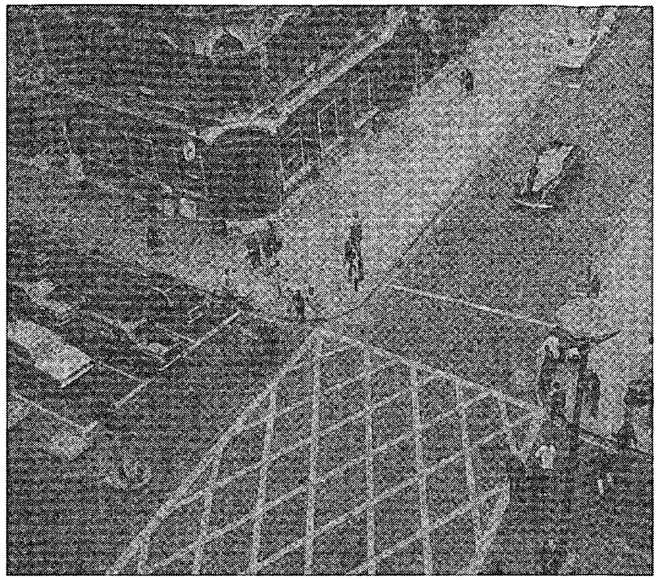

FIGURE 5 Yellow box pavement marking, Oxford Street, London.

DISCUSSION

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The authors found Do Not Block Intersection signs to have little or no effect. Perhaps a more conspicuous method may produce better results. For example, New York and some cities in Europe use the yellow box pavement marking to indicate the area to be kept free (Figure 5).

However, intersection blockage cannot always be avoided even with better driver behavior. When a stream of vehicles passes through an unsignalized intersection, as was the case described in this paper, or when a platoon is discharged into a signalized intersection during the green phase, drivers are not always able to see whether vehicles farther ahead will be held up by a queue that backs up from a downstream signal. The remedy, refraining from entering an intersection unless the exit is clear, could reduce the capacity of that intersection and cause a bigger congestion problem than it was trying to prevent.

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