Performance of Campus Parking Garages in Preventing Crime

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Abstract: The Ohio State University (OSU) initiated this study in response to campus parking garage crime that persisted at an unacceptably high level in spite of campus-wide efforts to reduce crime. The writers combined crime statistics gathered by the OSU Police Department with results of an on-site survey to model parking using Crime Prevention Through Environmental Design (CPTED) principles. The goal of the study was a group of CPTED-based design changes intended to create an environment that would deter parking garage crime. The analysis included factors such as lighting, visibility, garage color, location of entrances and exits, and design of elevators and stairways. The evaluation showed that lighting was the most significant factors in users' perception of parking garage safety. As a result of this study, OSU implemented the recommended CPTED improvements. In the 2 years following the implementation of CPTED improvements, the average annual incidence of crime in the parking garage where the CPTED improvements had been made fell by more than half of the average annual incidence of crime in that same garage for the four years before the improvements were made.

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Introduction

Unattended motor vehicles serve as magnets attracting criminals with the intent of theft of both the vehicle itself and its contents. It is common to find car compact disc players and other expensive electronics stolen from cars parked in driveways near home, in lots and parking garages, and on the street. About one third of all motor vehicle thefts occur in driveways and lots surrounding homes and apartment buildings. Another third occurs in public parking lots and garages (U.S. Department of Justice, personal communication, 1999). Total incidents of nonviolent crime per 1,000 people in parking lots and garages located in the United States rank second to nonviolent crimes committed near home (U.S. Department of Justice, personal communication, 1999). However, it is the dread of violent crime in parking garages that instills fear in those who must routinely use public parking garages, especially late at night.

In spite of their increased construction expense relative to surface lots, the number of parking garages has been steadily growing in recent years. The tradeoff is a simple one: when the cost of land for surface parking lots rises to the point where it rivals the additional expense of parking garage construction, then developers look to parking garages as a solution. In addition to being driven by the rising cost of land, parking garages with their high density of vehicle storage provide more convenience for users. They shelter both car and driver from the weather and shorten the walking distance from car to final destination. High density parking in garages does have one significant weakness: it serves as even a stronger magnet attracting criminals in the pursuit of vehicle theft and theft of valuables left unattended in parking garages.

Over 48,000 students attend the main campus of The Ohio State University (OSU) located in the heart of Columbus, Ohio, a metropolitan area of over 1 million residents. OSU maintains nine parking garages with space for about 9,000 vehicles. Approximately 17,000 additional parking spaces are available in lots. Very few parking spaces are located on streets.

By surveying students, staff, faculty, and visitors on campus, the University found that 79% of people on campus were not aware of the potential risk of criminal activities or did not have sufficient information about the risks that were associated with parking in the garages. As a result, the University initiated a safety reinforcement program to monitor safety in the campus garages. The OSU Security Services Department was concerned that garages were one of the crime hot spots because of their inactivity relative to other campus buildings. These parking garages were designed so as to fit as many vehicles as possible in the available space. The resultant design was not optimized for the safety of occupants or the protection of parked vehicles from vandalism and theft.

Crime Prevention through Environmental Design

The body of knowledge called Crime Prevention Through Environmental Design (CPTED) has been widely adapted and applied to deter criminal activities. The goal of CPTED is design of an environment that reduces the incidence and fear of crime. CPTED employs two basic strategies that often overlap in their application.

Through the first strategy, access control, CPTED design principles work directly to reduce crime by limiting criminal access to

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property (Crowe 2000); for example, by limiting access to vehicles in the parking garage, crime is reduced. The three principal means of implementing the access control are: guards or intelligent electronic devices that sense criminal intruders and summon help; electronic or mechanical keyed access; and target hardening through physical barriers to access. In limiting access, CPTED design centers around the normal and expected use of the space and predictable behavior of both users and offenders. By carefully examining use and behavior, CPTED design principles lead to the development of less intrusive means of access control, simultaneously permitting free access to intended users and excluding criminals.

In the second strategy, CPTED design principles work indirectly to create an environment that deters criminals. This second strategy differs from the first in that access is not limited by barriers but by creating an environment that is unattractive to criminals, an environment that evokes a perception of risk in offenders. Two principal methods are used to create an environment that deters criminals, natural surveillance and territorial reinforcement. This second CPTED design strategy of creating an environment unappealing to criminals is more complex than the first and relies heavily on the application of criminology, psychology, and sociology to environmental design. For example, criminals who want their crimes to go undetected tend to avoid well-lit areas, occupied by people who know each other and are on the lookout for intruders. CPTED design guidelines include means of maximizing opportunities for surveillance by dwelling occupants; ways of clearly characterizing the boundaries between public and private space; designs for routing entrance and exit to space through an observable area, means of providing sufficient interior and nearby lighting, and ways of eliminating any neighboring building design or ground-level planting that may block the user's view.

CPTED concepts have been widely adapted and applied in many areas to deter criminals and improve the safety and well being of users (Goody 1993; Newman 1995; Smith 1996; Shee et al. 1997; Crowe 2000). Traditional crime prevention methods rely heavily on police intervention, locks, and surveillance methods emphasizing the use of cameras and guards. The use of the physical environment to achieve the same goals was often ignored. CPTED uses a more natural approach with environmental changes to reduce crime in a positive manner (Jeffery 1971; Newman 1972; Titus and Heinzelmann 1995). CPTED principles are used to design environments as small as an office cubicle or as large as a neighborhood or even a city. Parking garages lie between these two extremes. Their functional design limits their variability, making them ideal for CPTED analysis and for development of CPTED applications.

Approach to Parking Garage Safety

This paper addresses the issue of crime in high density parking garages at urban universities. The writers consider both the actual increase in crime and user perception of parking garage safety. Consistent with CPTED principles, this research focused on analyzing facts and observing user behaviors. The CPTED strategies of access control and environmental control through natural surveillance and territorial reinforcement are applied to reduce parking garage crime.

Three approaches were taken when developing a research program to address the increase in parking garage crime on the OSU campus: (1) soliciting experts' opinion; (2) collecting campus crime data from the OSU Police Department; and (3) performing a survey of users' perception of parking garage safety. In taking the first approach, the writers obtained information from experts, previous research in safety evaluation, Internet sources, and CPTED design principles in garage crime prevention. The second approach involved the analysis of crime data collected from the OSU Police Department. These data included the time, location, and type of crime committed and provided information on the distribution of criminal activities on the OSU campus. In the third approach, the writers conducted a survey of campus parking garage users to investigate their experience of personal safety and safety of their belongings in campus parking garages. User experience provided the writers with valuable suggestions that might not have been gleaned from either the experts or crime statistics.

CPTED principles were applied to all three approaches as a strategy to identify and correct design flaws that aided criminals and abetted crime. The implementation of CPTED was based on the theory that the environment could influence both parking garage users' behavior and criminal behavior. By applying CPTED concepts to parking garage design, experts believe that an environment is created where criminals are more fearful of exposing their activity, thus reducing criminal activities.

Table 1. Crime Statistics of Ohio State University from 1995 to 2000 (FBI 2002)

Year	Violent crimes total	Property crimes total	Total
1995	29	1,616	1,645
1996	25	1,644	1,669
1997	37	1,525	1,562
1998	34	1,362	1,396
1999	42	1,294	1,436
2000	27	1,333	1,360

Significance of Parking Garage Crime

The problem of parking garage crime is significant both to the population in general and in particular to urban colleges and universities. According to an analysis of crime investigation in parking garages, there were about 1,400 violent crimes in parking garage facilities each day in the United States in 1992 (Smith 1996). Parking lots and garages ranked as the second most frequent place where nonviolent crimes took place and the third

Table 2. Crime Statistics of Ohio State University (OSU) Parking Garages (OSU Police Department, Personal Communication, 1996)

Offense description	Number of occurrences
Assault	1
Kidnapping	1
Sexual imposition	1
Criminal damaging	26
Criminal mischief	1
Aggravated robbing	1
Theft	49
Disorderly conduct	1
Death invent	1
Administrative information	3
Ill aided	1
Public accident	2

Table 3. Crime Statistics of Northwest and Ohio Union Parking Garages by Day Ohio State University Police Department, Personal Communication, 1996)

Garage	Name	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total
780	9th Avenue	0	2	6	2	0	9	0	19
781	11th Avenue	0	1	0	2	7	3	4	17
782	12th Avenue	0	2	1	2	1	1	0	7
783	Arps	1	0	0	1	2	2	1	7
784	Medical center	0	3	2	0	1	2	0	8
785	Northwest	0	3	2	1	1	0	0	7
786	Ohio union	0	2	7	1	7	2	4	23
Total	—	1	14	18	8	18	19	10	88

most frequent place in which violent crimes occurred (U.S. Department of Justice, personal communication, 1999).

Colleges and universities are particularly susceptible to the perception of adverse effects of criminal activities. The college campus is idealized as an environment that supports learning free from the fear of harm to its inhabitants. Criminal activities on campus not only undermine the quality of the learning environment, but also reduce the positive activities of people associated with the campus. Plus, parents fearful of harm to their children opt to spend tuition dollars at institutions with safe campuses.

In this paper, the investigation of crime in two different parking garages at OSU enabled the writers to compare and contrast the two facilities. One garage, located in the northwest side of the OSU campus, is primarily used by faculty and staff with few students and visitors (Ohio State University 2002). The other garage, the Ohio Union parking garage, is located at the southeast side of OSU and is used by a diversity of people—primarily faculty and staff, but also including students and visitors. The population of visitors and students in both garages is small relative to the number of faculty and staff users, making the user population of the two garages demographically similar.

Table 1 lists the total number of violent and nonviolent crimes on the OSU campus from 1995 to 2000, showing a decrease in the incidence of crime on campus. Although the total number of crimes each year generally decreased over this period, the number of crimes committed in parking garages held steady. The OSU Police Department was concerned about the lack of improvement in parking garage crime statistics at a time when other areas of the campus were responding well to crime prevention measures taken by the University.

In Table 2, theft and criminal damaging are shown to be the most frequently occurring crimes. The offense description on Table 2 is that of the OSU Police Department. Number of occurrences represents the crimes that were reported to the university police.

Criminal activities listed in Table 3 are more prevalent on weekdays than on weekends, as would be expected. Garages with codes 780, 781, and 786 have a relatively higher number of crimes than those of other parking garages.

In 1996, the time period in which crime frequency peaked was from 7:00 to 11:00 am, as Table 4 illustrates. Crime frequency began to taper off from 11:00 am to 3:00 pm, falling again between 3:00 and 7:00 pm and then again from 7:00 to 11:00 pm, with the lowest frequency occurring between 11:00 pm and 7:00 am. The time periods reflect the frequency of use and rise and fall with crime frequency.

According to an investigation in 1992 (Smith 1996), parking facilities rank third in frequency of violent crime occurrence, averaging about 1,400 violent crimes per day in the United States. Smith did not include the probability of a parking facility user being a victim of a nonviolent crime such as theft. The probability of being a victim of a nonviolent crime in parking facilities is much higher than that of a violent crime (U.S. Department of Justice, personal communication, 1999). Furthermore, Smith studied crime in parking facilities that include both parking lots and parking garages.

The crime rate in the Northwest parking garage in the years 1996 through 1999 averaged about 6.5 crimes per year. The average rate of 13 crimes per year for all OSU parking garages for the same period was about double the Northwest parking garage crime rate. The Ohio Union parking garage crime rate for the same period stood at 20 crimes per year, nearly three times that of the Northwest parking garage. As seen in Fig. 1, the rate of crime in the Northwest parking garage dropped from an average of 6.5 crimes per year in the 4-year period from 1996 to 1999 to 2.5 crimes per year in the 2-year period from 2000 to 2001.

Table 5 shows the distribution of criminal activities in the seven parking garages that were studied. The garages with codes 780, 781, and 786 are located on the southeast edge of campus and had a higher number of crimes than the other four parking garages in 1996.

Table 4. Time of Crime Occurrences in Ohio State University (OSU) Parking Garages (OSU Police Department, Personal Communication, 1996)

Garage number	Name	7–11 am	11 am–3 pm	3–7 pm	7–11 pm	11 pm–7 am
780	9th Avenue	3	6	4	3	3
781	11th Avenue	6	6	2	3	0
782	12th Avenue	4	2	1	0	0
783	Arps	0	1	2	3	1
784	Medical center	2	3	1	0	2
785	Northwest	3	3	0	0	1
786	Ohio union	10	6	4	1	2
Total	—	28	27	15	10	9

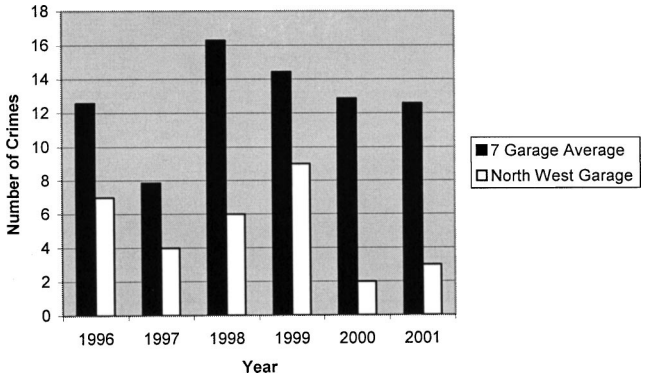


Fig. 1. Crime in Northwest parking garage in comparison with average crime for all seven Ohio State University parking garages

Two garages were the subjects of this study. One garage, the Northwest parking garage, (No. 785 in Fig. 2) is primarily used by faculty and staff, with few students and visitors, and is located on the northwest side of the OSU main campus. The other garage, the Ohio Union parking garage (No. 786 in Fig. 2), is located on the southeast side of the OSU main campus and is used by faculty, staff, students, and visitors. As noted previously, the users of both garages are demographically similar.

Both garages are on the perimeter of the OSU main campus located in an urban area just north of the center of Columbus, Ohio. To the west of the main campus is another campus housing the Colleges of Veterinary Medicine, the College of Agriculture, and the farms used by the College of Agriculture. These farms are also located in urban Columbus, Ohio, and are often photographed with cows in the foreground and skyscrapers in the background. To the north of the OSU main campus is a stable urban residential neighborhood. Deteriorating residential neighborhoods, deteriorating commercial buildings, student housing, and renovated urban neighborhoods are located to the south and to the east of the OSU main campus. The crime in the area adjacent to the Northwest parking garage is significantly less than that in the neighborhoods adjacent to the Ohio Union parking garage (Columbus Ohio Division of Police 2002).

Table 5. Distribution of Parking Garage Location of Criminal Activities at Ohio State University (OSU) (OSU Police Department, Personal Communication, 1996)

Parking garage number	Name	Number of crimes
780	9th Avenue	19
781	11th Avenue	17
782	12th Avenue	7
783	Arps	7
784	Medical center	8
785	Northwest	7
786	Ohio union	23

Research Method

This section describes the research methods used to develop the survey instrument and conduct the survey on the perception of parking garage crime. CPTED safety design principles were used to identify the variables that could influence the safety of parking garages. Variables affecting safety identified through the CPTED concepts were lighting, visibility, garage color, location of entrances and exits, and design of elevators and stairways.

In addition to a study of the garages themselves, the writers also used CPTED principles to examine various aspect of nearby

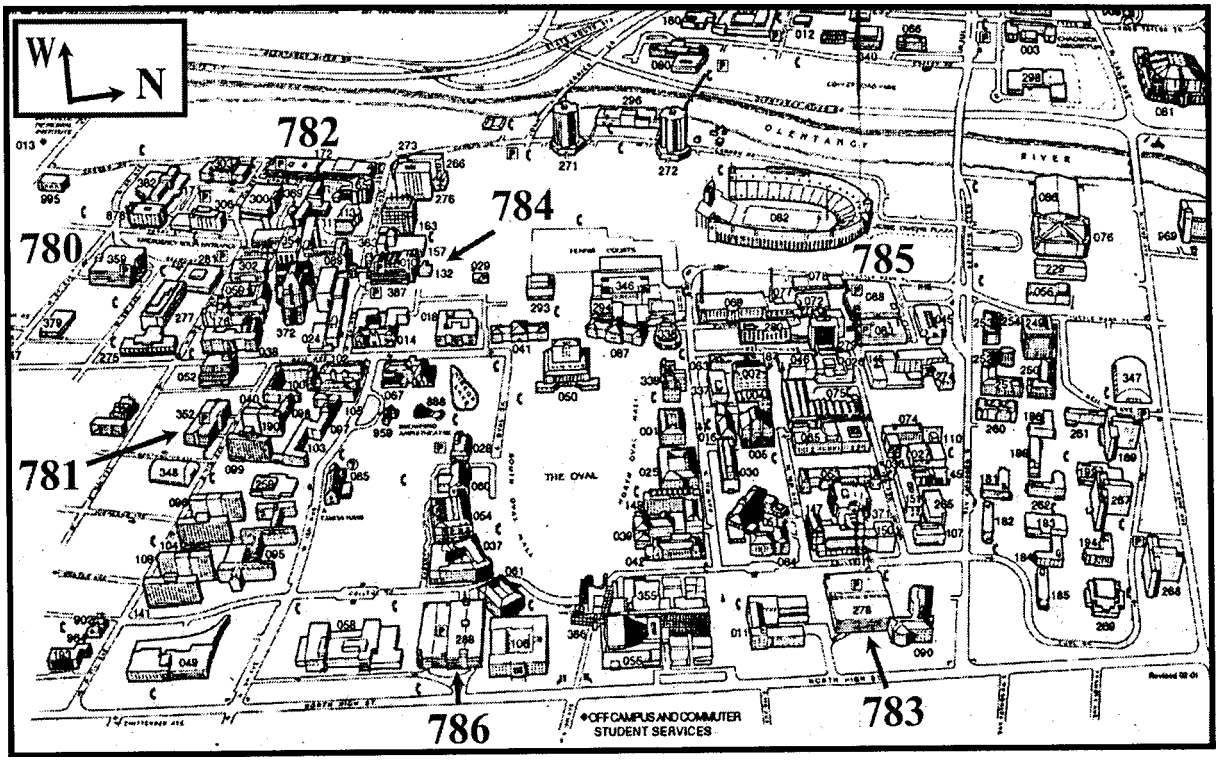


Fig. 2. Map of location of parking garages at Ohio State University

Survey Part 1

Circle 1-strongly disagree, 2-disagree, 3-neither agree or disagree, 4-agree, 5-strongly agree

1. I feel safe while walking to and from my car in this parking ramp. 1 2 3 4 5
2. I think it is possible that persons who might hurt me are hiding in this ramp. 1 2 3 4 5
3. This parking ramp is well lighted. 1 2 3 4 5
4. I feel safe using the stairs in this parking ramp. 1 2 3 4 5
5. I feel safe using the elevators in this parking ramp. 1 2 3 4 5
6. This parking ramp is safer than most. 1 2 3 4 5
7. I feel that I may be accidentally hit by a motorist while walking in this ramp. 1 2 3 4 5
8. I feel that my car may be vandalized or stolen while parked in this ramp . 1 2 3 4 5
9. My car has been vandalized or stolen before. 1 2 3 4 5
10. I have been a victim of crime before. 1 2 3 4 5
11. I always like to park in the same spot. 1 2 3 4 5

Survey Part 2

I park in this garage because (check all that apply)

♦safety ____ ♦proximity ____ ♦weather protection ____ ♦only parking available ____

♦other please specify _____

Survey Part 3

Date _____ Time _____/_____ AM/PM Day of week _____

Student ___ Staff ___ Faculty ___ Visitor ___ Male ___ Female ___ Years on campus _____

Age (years) 0 – 22 _____ 23 – 30 _____ 31- 45 _____ 46 – 60 _____ Above 60 _____

Vehicle year ____ car ____ van ____ truck ____ Vehicle make _____ Model _____

Fig. 3. Survey questionnaire

buildings, including the use of space and landscaping between and around buildings; the relative positions and sizes of adjacent buildings and other structures; and exterior design details, such as color, lighting, entrances, and exits. CPTED principles were incorporated in the design of the survey described in the next section.

The writers developed a survey instrument illustrated in Fig. 3. The first part of the three-part questionnaire solicited opinions of parking garage users on their experience and perception of parking garage safety. These questions incorporated CPTED variables affecting safety and garage users' experience with parking garage safety and criminal activities. Each of the questions had five choices: "1—strongly disagree," "2—disagree," "3—neither," "4—agree," and "5—strongly agree." The second part of the questionnaire asked the parking garage user to state the reason for parking in the garage being studied. The third part of the questionnaire was designed to collect demographic data: time and day of the week the garage user was questioned; gender; age; and identity (faculty, staff, student, or visitor); number of years the user had been parking in the garage; and vehicle type (car, van, or truck), make, and model. The demographic information collected in part three of the survey was used to evaluate the sampling of the survey and to compare different groups of users.

In the first two quarters of 1998, the OSU Police Department conducted the survey. Uniformed police officers surveyed 215 users of the Northwest parking garage and 109 users of the Ohio Union parking garage. The survey was intended to be representative of the population of parking garage users. The police officers were instructed to continually survey parking garage users and to conduct the survey at randomly selected times of the day and evening. All users that were asked to participate in the survey conducted by the police officers agreed to participate in the survey.

Survey Results and Discussion

In this section, survey results according to garage and user demographics are presented and interpreted. Results of the survey in the Northwest parking garage and in the Ohio Union parking garage are shown in Tables 6 and 7, respectively.

In many ways the response from users of both garages was similar. In response to Question 1, as shown in Tables 6 and 7,

Table 6. Survey Results for Northwest Parking Garage (Part 1)

Question number	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2.33	9.77	8.84	49.77	29.30
2	15.81	23.26	24.65	26.51	9.77
3	6.51	22.79	32.09	29.77	10.70
4	4.19	8.84	16.74	44.65	22.79
5	6.05	12.56	29.30	32.56	16.74
6	2.79	7.44	54.42	24.65	6.05
7	13.02	21.86	23.72	32.09	9.30
8	18.14	27.44	23.26	25.12	6.05
9	63.26	9.30	2.79	9.30	15.35
10	59.07	8.84	0.93	12.09	23.72
11	17.21	11.16	26.05	25.12	20.47

Table 7. Survey Results for Ohio Union Parking Garage (Part 1)

Question number	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2.75	5.50	14.68	54.13	22.94
2	12.84	23.85	11.93	41.28	10.09
3	1.83	3.67	21.10	44.95	28.44
4	4.59	13.76	15.60	43.12	22.94
5	17.43	14.68	30.28	22.02	15.60
6	1.83	7.34	47.71	33.94	9.17
7	18.35	22.94	21.10	31.20	6.42
8	18.35	35.78	18.35	22.02	5.50
9	72.48	8.26	3.67	3.67	11.93
10	48.62	4.59	4.59	11.01	31.20
11	16.51	12.84	25.69	21.10	23.85

about 79.1% of Northwest parking garage users and 77.1% of Ohio Union parking garage users agreed or strongly agreed that they felt safe while walking to and from their cars in those two garages, whereas only about 12.1% of Northwest parking garage users and 8.3% of Ohio Union parking garage disagreed or strongly disagreed. In general, users felt safe using those two garages. In this case, user perception of safety did not correlate with actual crime statistics. In 1996, the incidence of crime in the Ohio Union parking garage was more than three times that of the Northwest garage.

In response to Question 2, about 36.3% of the Northwest parking garage users and about 51.4% of Ohio Union Parking garage users felt that a person who might hurt them was hiding in this garage. Of the responders, 39.1% of Northwest parking garage users and 36.7% of Ohio Union parking garage users disagreed or strongly disagreed in response to Question 2. Generally speaking, the response to this question was nearly the same for both parking garages.

In response to Question 7, 41.4% of Northwest parking garage users and 37.6% of Ohio Union parking garage users felt that a motorist might accidentally hit them. This number suggested that the design of traffic patterns was in need of improvement.

Questions 9, 10, and 11 ask about users' past experience with crime and parking habits. They are not specific to either parking garage. When asked in Question 9 whether their car had been vandalized or stolen before, 72.6% of users in the Northwest parking garage and 80.7% of users of the Ohio Union parking garage disagreed or strongly disagreed. This response represented the highest percentage of nonoccurrence that the writers found with any question in this survey. Responses to Question 10 showed that about 67.9% of Northwest parking garage users and 53.2% of Ohio Union parking garage users themselves had not been victims of a crime before. In other words, more than half of the garage users had not had the experience of being personally victimized by crime. The results of Question 11 showed that garage users varied in their preference for a particular parking spot. Some preferred to park in the same spot; some chose to park at random spots in the garage. A similar response to Questions 9, 10, and 11 is to be expected because both groups are demographically similar, representing a mix of faculty, staff, students, and visitors with the main difference between the two being a slightly higher number of students and visitors parking in the Ohio Union garage.

A disparity in results for the Ohio Union parking garage and the Northwest parking garage occurred in response to Questions 3 and 5, as shown in Tables 6 and 7. In response to Question 3, the writers found that 73.4% of Ohio Union parking garage users agreed that the light setting in this parking garage was sufficient; but only 40.5% of the Northwest parking garage users agreed. The illumination in the Ohio Union garage was, in fact, significantly higher than that of the Northwest parking garage.

In the Ohio Union and Northwest parking garages, as in most parking garages, stairs and elevators are adjacent to each other. Although users found the stairs about equally safe in both garages, 32.1% of Ohio Union parking garage users felt using elevator was not safe, while only 18.6% of Northwest garage users felt unsafe while using the elevators. One possible explanation is that the elevators in the Ohio Union parking garage are located in the places that are closed and not open to public view, while the elevators in Northwest were located at the places that could be observed by the public.

Because Part 2 of the survey (Fig. 3) was a multichoice question, users could select more than one answer. Surprisingly, as illustrated in Table 8, 85.2% of users felt that ''proximity'' was the main reason why they parked their vehicles in those parking garages. Also of interest is the fact that 33.3% of the garage users chose weather protection and only 14.5% chose safety as a reason. A possible explanation is that people felt that the chance of being attacked was relatively small, while the weather conditions were so unpredictable that it seemed reasonable to choose weather protection over safety.

The demographic information collected in part 3 of the survey was used to evaluate the sampling of the survey and to compare different groups of users. Table 9 shows the user's gender distribution and university affiliation. This information has been normalized and illustrated in percentage of total response for comparison. For example, data showed that 62.2% of the users were male and 37.8% were female, as seen in Table 9. The demographic information was used to analyze the results of different

Table 8. Reason for Parking at Northwest and Ohio Union Parking Garages (Part 2)

	Reason				
Garage	Safety	Proximity	Weather protection	Only available	Other
Northwest	27	181	77	40	5
Ohio union	20	95	31	18	3
Total	47	276	108	58	8
Total (percentage)	14.51	85.19	33.33	17.9	2.47

Table 9. Survey Statistics: User Demographics (Part 3)

Gender					
Male	Female	Faculty	Staff	Student	Visitor
112	68	56	75	59	21

groups of users. For example, the population distribution from highest to lowest percentage of the parking garage users was staff (including teaching associates and temporary university workers), faculty, and students, with the smallest group being visitors. Using the demographic information, the writers were able to analyze the parking habits of those who used the garage and the frequency of their use.

Furthermore, the writers also found that garage codes 780, 781, and 786, which were located on the southwest side of the campus, had about twice as many crimes per year as the parking garages located on the northwest side of campus. All parking garages on the OSU campus are similar in design and are located on the perimeter of campus. The writers believe that the most significant factor underlying the difference in incidence of crime rate in the garages is crime in the neighborhoods immediately adjacent to the parking garages. Crime in parking garages was directly proportional to crime density in adjacent neighborhoods (Columbus Ohio Division of Police 2002).

Summary and Conclusions

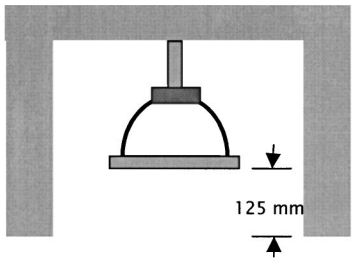
OSU values a campus free from crime. Crime not only detracts from the mission of the university and deters perspective students, it undermines the fundamental quality of university life. Because parking facilities are believed to be a more likely setting for crime than open walkways, security in these areas is one of the major issues facing university officials. Crime Prevention Through Environmental Design (CPTED) is particularly applicable to parking facility design because each of its principles, such as natural surveillance, access control, and sense of territoriality, plays a role in preventing crime in a parking garage.

In this section, the writers describe their recommendations for CPTED improvements to the Northwest garage and discuss crime statistics in the 4 years before the CPTED improvements were made to the Northwest garage and the 2 years following the CPTED improvements.

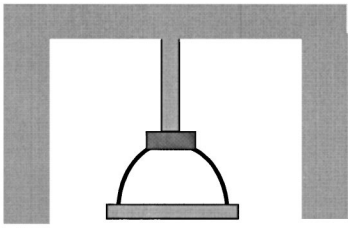
CPTED experts agree that illumination is the most significant factor affecting both user perception of safety and actual incidence of crime in parking garages. Access control is another significant CPTED principal pertinent to parking garage safety. Both lighting and access control were addressed in recommendations for implementation of CPTED improvements to the Northwest parking garage on the OSU campus. In 1999, the year following that in which the survey was conducted, OSU improved both the illumination level of the Northwest parking garage and the access control to the structure. New lights installed in the Northwest garage were both brighter and located so as not to be obstructed by the beams supporting the garage floors. The lights were originally located so that the light diffusion panel was about 125 mm above the bottom of the beams. The new lights were installed having their diffusion panels flush with the lower edge of the floor beams, as shown in Fig. 4. Maintenance personnel also painted the garage ceilings with white, highly reflective paint, further increasing the illumination level (Fig. 4).

Access control was improved by installing black chain-link mesh inserts in the lower level wall openings, as shown in Fig. 5, thereby limiting access to doorways. By using black colored chain-link mesh with relatively large links (50–75 mm) little visibility was lost even during times when the sun was low in the sky. Trimming the shrubs and trees along the perimeter of the garage also limited access to the garage by minimizing the hiding spots around the garage and preventing access to the second floor through the trees. However, 2 years later, the shrubs have begun to grow out of control again. Looking back, a better recommendation might have been to replant with slow growing shrubs rather than just trimming existing shrubs.

In the 2 years following the CPTED improvements made in 1999, crime in the Northwest parking garage fell by more than half (Fig. 1), while crime in other campus parking garages re-



Before: Light diffusion panel 125mm above lower edge of floor beam



After: Light diffusion panel flush with lower edge of floor beam

Photograph (on the left) of lights installed so that the diffusion panel is flush with the lower edge of the floor beam and beams painted with high reflectivity paint as specified by recommended CPTED improvements to lower the level of parking garage and increase users perception of parking garage safety

Fig. 4. Parking garage lighting before and after Crime Prevention Through Environmental Design improvements

Fig. 5. Chain-link inserts in lower level parking garage wall openings

mained unchanged. Because of the relatively low incidence of crime in the Northwest parking garage, 2 years of data is insufficient to conclusively say that the CPTED improvements made to the Northwest parking garage cut the crime rate in half, but certainly the crime rate has been lowered. Furthermore, although this study was limited to certain parking garages at the Ohio State University campus, the writers believe that the results can be applied to other similar campus garages. Finally, as stated by one of the reviewers of this paper, the analysis of cost data would be of interest. If the cost of improvements is relatively small on a dollar per space basis, design guidelines for universal application of CPTED in campus parking garages can be suggested. Such an analysis is recommended for future study.

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References

Columbus Ohio Division of Police. (2002). ''Precinct statistics.'' ⟨http://www.columbuspolice.org/precinctstats⟩ (May 4, 2002).

Crowe, T. D. (2000). *Crime prevention through environmental design: Applications of architectural design and space management concepts*, 2nd Ed., National Crime Prevention Institute, Louisville, Ky.

Federal Bureau of Investigation (FBI). (2002). ''Uniform crime reporting: campus crime statistics, 1995–2000.'' ⟨http://www.campussafety.org/crimestats/index.html⟩ (Apr. 22, 2002).

Goody, J. E. (1993). ''Safe streets, safe homes,'' *Conf. Summary on Secure and Livable Communities: Crime Prevention Through Environmental Design*, National Institute of Justice, Washington, D.C., 38–39.

Jeffery, R. C. (1971). *Crime prevention through environmental design*, Sage, Thousand Oaks, Calif.

Newman, O. (1972). *Defensible space: crime prevention through environmental design*, Macmillan, New York.

Newman, O. (1995). ''Defensible space: a new physical planning tool for urban revitalization.'' *J. Am. Plan. Assoc.*, 61(2), 149–155.

Ohio State University. (2002). ''Directory version of campus map.'' ⟨http://www.osu.edu/units/uts/campus/bigmap.html⟩ (Apr. 22, 2002).

Shee, S. C., Hadipriono, F. C., Duane, W. D., and Larew, R. E. (1997). ''Building simulation for crime prevention in a virtual environment.'' *Proc., Int. Conf. on Engineering Education, (ICEE)*, Session 39, Vol. II.

Smith, M. S. (1996). ''Crime prevention through environmental design in parking facilities.'' *Research in Brief*, National Institute of Justice, Washington, D.C.

Titus, R. M., and Heinzelmann, F. (1995). ''Crime prevention through environmental design.'' *Proc., U.S. Conf. of Mayors: National Conf. on Crime Prevention Through Environmental Design (CPTED)*, National Institute of Justice, Washington, D.C., 1–6.