Design proposals for accessibility to the skywalk system at Des Moines, Iowa

by

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CHAPTER 1. INTRODUCTION

Skywalks are being increasingly used in large cities as a solution to separate pedestrians from vehicular traffic. The skywalks have been found successful in attracting pedestrians, however, the system tends to remove people from the sidewalks. The most pressing problem is the tendency of the skywalks to exert a negative effect on the streets. Even if the buildings and the skywalks pulsate with people, the lack of human traffic on the street level creates a barren city center, thus, contradicting the very essence of a vital downtown.

During the past two decades, off-grade pedestrian systems have been constructed in numerous downtowns of America. A skywalk can be defined as a network of elevated interconnecting pathways. The network consists of bridges over streets which connect two buildings and various activity hubs. For the most part they are enclosed and climate controlled. Besides their physical manifestations, skywalk systems are contributing to a major economic and social transformation of downtown spaces. Economically, they cause shifts in where and how people shop, entertain and conduct businesses, this in turn affects land use and investment patterns.

The concept of skywalk system was first introduced in 1490 by Leonardo da Vinci in his ideal city plan, where he proposed a two level circulation in the city

(Rowe, 1978). The modern skywalk as a system was first introduced in the city of Minneapolis, in 1962. Lack of protection from the rigorous Minnesota climate, vehicular-pedestrian conflict and air-pollution were the three major problems affecting pedestrian circulation in downtown Minneapolis which resulted in the desire to provide an enclosed pedestrian skyway system. Off-grade pedestrian systems have since been initiated in several mid-western cities like Cedar Rapids, Sioux City and Des Moines, Iowa; Lincoln, Nebraska; Kansas City and St. Louis, Missouri (Bednar, 1989) (see Table 1.1).

Several reasons help explain, why many cities have chosen to employ skywalk systems. Skywalks have been widely praised. One reason is that they segregate the pedestrian from vehicular traffic, thereby relieving automobile congestion, reducing accidents, and improving the flow of both people and automobiles. They are also used as a tool in downtown revitalization. They improve links between development projects, helping business people and city officials to promote the downtown area. The development potential of this system now outweighs the advantages of climate control, as shown by the increasing number of skywalks in cities with mild climates, such as Charlotte, Dallas and Portland.

Although, many of the skywalk systems were undertaken to provide pedestrians a means to escape from wintry streets, more recent constructions has been largely motivated by economics rather than weather. A 1986 survey of U.S. skywalk systems conducted by the City of St. Paul reported that economic development was the main motive for building such systems in eleven of the twenty three responding cities. Weather on the other hand was primary in only five (Robertson, 1988).

Table 1.1: Grade separated pedestrian networks in North American cities

		Number of Blocks	Number of Bridges	Number of Tunnels	Year Begun	Ownership
1	Calgary	42	41	0	1970	Public
2	Cedar Rapids	10	12	0	1978	Joint
3	Cincinnati	15	18	0	1970	Joint
4	Dallas	36	15	26	1965	Joint
5	Des Moines	21	27	0	1982	Joint
6	Duluth	13	17	0	1974	Public
7	Edmonton	24	9	16	1970	Joint
8	Fargo	7	7	1	-	Public
9	Ft. Worth	31	16	10	1968	Private
10	Houstan	60	21	51	1947	Private
11	Lexington	6	6	0	-	Private
12	Milwaukee	13	11	0	1961	Joint
13	Minneapolis	32	34	2	1962	Private
14	Montreal	32	1	3	1962	Joint
15	Rochester	18	6	1	1972	Joint
16	Rome, NY	8	2	0	1977	Public
17	St. John	3	2	0	1983	Joint
18	St. Paul	33	39	1	1956	Public
19	Sioux City	11	13	0	1975	Joint
20	Spokane	13	16	0	1961	Private
21	Syracuse	8	6	1	1966	Joint
22	Toronto	20	3	13	1960	Private
23	Waterloo, IA	4	3	0	1983	Public

Cities funded skywalks with the objective to thwart the exodus of downtown stores to suburban malls. The skywalks, which proliferated during the 1970s, have indeed became a major generator of retail activity. The skywalk system in U.S. downtowns link a variety of different uses, including office buildings, convention centers, hotels, apartment buildings and railway stations. Most commonly, however, they link retail establishments. As skywalk systems mature, they attract more and more retailers attempting to take advantage of heavy pedestrian traffic flows.

Gradually, they take on the character of multi-block urban shopping malls.

Skywalks are popular with downtown workers, shoppers and visitors, who welcome the protection from unpleasant weather and who find them convenient, safe and comfortable. But the skywalk system is not without its failings. Cities may be adapting skywalks as a panacea for solving mobility without first assessing their positive and negative attributes, and more importantly, their long term impact on the environment.

Skywalk Issues

Skywalks have inherent problems that planners, designers and city officials must address. Some of the issues are privatization and economic stratification, access, orientation, design and aesthetics (Robertson, 1988). Another area of concern is that the skywalk system changes street level activity. Stores and businesses relocate on the skywalk level to take advantage of heavier pedestrian traffic. In St. Paul, for example, it is estimated that over three-fourths of the downtown retail business occurs on the skywalk level. The various issues are:

1. The skywalks have a tendency to separate people on the basis of economic class. A survey conducted on the skywalk users in Des Moines indicated that over ninety percent of the respondents felt that workers used skywalks more than shoppers, white-collar workers more than blue-collar ones and the people of high income more than modest income ones (Lee, 1989). The higher rents on the skywalk level attract expensive stores, whereas the less expensive stores are relegated to street level. People entering the skywalk from the parking garages are mostly car owners who use the garages on a regular basis.

On the other hand people on the streets ride the buses. This social stratification is ironic, particularly in cold climates. Those who can afford overcoats are on the skywalk in short sleeves, while the poor are left out in the cold. Victor Caliandro similarly concludes:

> Internal pedestrian systems limited to commercial facilities ... are, I believe, ultimately counterproductive in relation to the whole urban fabric. They segregate a range of activities and, therefore, function for only part of daily and weekly cycles. They do not act as social condensors associating people interested in many different goals and thereby they also diminish the potential for access, interchange and accidental encounter (Bednar, 1989, p. 177).

The fact that the majority of users are perceived to be white middle-class office workers, together with the fact that the majority of structures linked by the skywalk are office buildings, upscale stores, luxury hotels and expensive condominiums, may hint that people with low incomes and perhaps to some extent minorities are less than welcome. One cannot help but observe the beginnings of a dual-level downtown. This economic stratification leads to a social stratification resulting in more whites using skywalks and more blacks on the streets below.

2. The aesthetic issue has two major design related issues in the context of the visual impact of the skywalk systems: integrating the skywalk bridge and blocking landmarks and vistas.

   An aesthetic critique of the skywalks is generally severe. Skywalks detract from the visual quality of urban architecture in form, color, scale and material. In cities with large skywalk systems, this detraction has been extensive, in fact, many building facades have been defaced by obtrusive bridges.

Integrating a skywalk bridge with the building it connects is frequently a problem. Even if the skywalk co-ordinates perfectly with one building, chances are that the building on the other end will receive the skywalk awkwardly. The issue is even more sensitive when the buildings in question are older and of historical value. Stone or brick buildings of the nineteenth century were obviously not designed to receive the modern-looking skywalk bridges made of steel and glass. Historic facades do not blend gracefully with contemporary bridges, hence, these visually incompatible intrusions have been termed *skewering* (Bednar, 1989).

Skywalk bridges also seriously damage the streetscape of a city. For example, vistas to landmarks or distant views are blocked. This is critical in a city of highrise buildings, where distant views are cherished. One skywalk bridge visually damages a vista but several virtually destroy it. While skywalks do provide people with a new second-level vantage point, these new perspectives are at the expense of the street-level pedestrians and drivers who have had certain vistas interrupted. For instance, in Des Moines a spectacular view of the Iowa State Capitol from the Locust Street is interrupted by the skywalks.

3. Since skywalk systems are seen as public or semi-public space similar to side walks and streets, one might expect them to be open round the clock. Unfortunately, this is not the case since skywalks have restricted hours.

   The ownership of the skywalk system in the various cities varies from being public to private to joint ownership. The skywalk system in St. Paul is public, whereas in Minneapolis it is private and in Des Moines it is joint. But in none of the cases can the whole or any part of the skywalk system claim to be open twenty four hours, not even in St. Paul's where the skywalk system passes through departmental stores and other private spaces.

Most problematic is Minneapolis where the hours are set block-by-block by the private building owners. The inconsistencies on weekends are even greater. People are never quite sure exactly when the skywalk system or parts thereof are open, and thus may be reluctant to use it.

The greatest problem in reaching a skywalk system from the street is the difficulty in locating the entrances to a skywalk. Direct access is not available from the streets. Often, pedestrians cannot easily see skywalk entrances, particularly those embedded inside the buildings. People may feel uncomfortable venturing too far into a private space especially if they have to walk deep into a building's interior to locate a skywalk entry.

Accessibility needs of the physically handicapped constitute another concern. Most of the skywalk systems do not have elevators provided to the ground level (Parab, 1991).

Problem Statement

With skywalk systems playing a leading role in the development of downtowns, not only may streetscapes evolve into pedestrian-less urban spaces, but the very essence of a downtown itself may be dramatically altered. Whereas skywalks commonly connect peripheral parking facilities used by automobile commuters, direct entrances from the street level are scarce and connections to public transit facilities are rare. At the same time that business is flourishing on the skywalks, street-level retail sales are often plummeting. If this trend continues, there will no longer be any street life in our downtowns. This syndrome is partly a result of physical design and the failure to provide direct links between the skywalk system and city streets. The Des Moines downtown has been selected for study of this accessibility issue. Several studies conducted in the past have revealed that the skywalk system of Des Moines has an accessibility problem at entry points. Direct access is not available from the streets and the available indirect access forces people through private environments (Parab, 1991).

Consequent to these studies, guidelines have been proposed for the skywalk systems. It is my intention to work within this framework of guidelines and propose design solutions to the problem of accessibility from the street level to the skywalk system.

Methodology

Firstly, downtown Des Moines was selected in order to study the skywalk system. The selection was made based on the existing problem of accessibility to the skywalk system that surfaced in previous studies.

Secondly, the bridge ends in the study area are prioritized to provide design solutions for the most inaccessible bridge ends. Extensive data was collected on the skywalk system in order to study numerous variables related to the skywalk system. The variables for which data was collected are: 1) Retail at the skywalk level, 2) Active retail at the street level near the bridge ends, 3) Passive retail at the street level near the bridge ends, 4) Daily pedestrian volume across the bridge ends, 5) Hourly traffic count under the bridge ends, 6) Bus stops near the bridge ends, 7) Street parking near the bridge ends, 8) Parking garages near the bridge ends and 9) Wayfinding hurdles of the bridge ends. These variables were then ranked using a half-matrix method and a weight was assigned to each of these. Each variable was compared to every other variable to establish its relative importance to accessibility from the sidewalk to the skywalk. The half-matrix method has been explained in Appendix A. The bridge ends were then prioritized using complete worth method which is explained in the Chapter 3.

Lastly, a retrofit typology was formulated. Design recommendations based on the typology are proposed for each of the bridge ends in the study area. Five bridge ends were selected from the priority list for proposing retrofit solutions. The thesis provides recommendations and identifies possible areas to be explored for further research.

Organization of the Thesis

1. The first chapter is an introduction to the skywalk system, it includes skywalk issues, problem statement and the methodology.

2. The second chapter reviews the literature on skywalk systems.

3. The third chapter describes the existing skywalk system in Des Moines. Based on the available data the bridge ends are prioritized for design retrofit using half-matrix and complete worth methods.

4. The fourth chapter states the fire exit design requirement and the skywalk

guidelines for design retrofits for the skywalk bridges. A retrofit typology is formulated and design recommendations based on the typology are proposed for all the bridge ends in the study area. Five bridge ends are selected for proposing design solutions. The chapter ends with recommendations and possible areas to be explored for further research.

CHAPTER 2. LITERATURE REVIEW

The literature comprises various skywalk related case studies. Some studies are pro-skywalk while the rest are quite critical of designs and economic impacts associated with these systems. Architects and planners from early times were interested in the physical separation of pedestrians from vehicular traffic. One of the earliest of these elevated skywalk passages was that leading from the vatican to the Casttello Sant Angelo. It was a structure, unprotected from rain or sun, which was used by Pope Clement VII, in May 1527, to save himself from the international army that was to attack the city.

Single skywalk bridges were often constructed in earlier days in order to carry people from one point to another in the city and to provide a refuge from the outside world. But the concept of skywalk as a system providing another level of circulation was first conceived by Leonardo da Vinci in his ideal city plan dated 1490. Unfortunately, his two level city plan did not realize until the present century.

John J. Fruin, a research engineer at the Port Authority of New York and New Jersey, says that Minneapolis has the distinction of developing the first major elevated pedestrian walkway system in the U.S. (Fruin, 1973). Michael J. Bednar, AIA, writes that it all began in 1962, when the late Leslie Park connected the Cargill Building, the Roanoke Building and the Northwest National Bank with two skywalk bridges crossing the intervening streets. Other businessmen, noting the leasing success, built additional bridges and thus the system evolved (Bednar, 1989).

Many cities took Minneapolis as a model and used it in their downtowns. As cities grow, off-grade pedestrian systems often develop in a piecemeal fashion resulting in a chaotic system of menial dimensions. The parallel nature of public streets, sidewalks and storefronts has been fragmented as primary pedestrian systems have been moved indoors and to off-grade levels (Findlay, 1990).

Architects and planners soon began to realize that a critical evaluation was necessary before the next generation of skywalks could be planned and designed. Relocating vital retail and commercial functions to the skywalk level changes street life in both quantity and quality. With the development of inward-oriented urban shopping centers - linked by skywalks, shops with street frontage have suffered and have been forced to close or relocate.

The most often voiced concern at a 1985 conference, held at Walker Art Center and the University of Minnesota that focussed on the benefits and problems of the skywalks, was that skywalks represent an anti-urbanistic, anti-democratic privatization of the street, the one remaining realm in American cities, which has the potential to be a truly heterogenous public sphere. Numerous issues related to pedestrian system, with particular attention to the existing systems of St. Paul, Minneapolis, Dallas, Cincinnati, Charlotte and Calgary, were discussed at this conference. This conference was inspired by a long-term study by Bernard Jacob and Carol Morphew. Their research (Jacob and Morphew, 1984) brought to attention the enormous impact these systems have exerted on the urban fabric of our cities.

Kent A. Robertson, Director and Associate Professor of Local and Urban Affairs at St. Cloud University in Minnesota, studied skywalks in five midwestern cities. The research (Robertson, 1988) describes and evaluates skywalks on the basis of usage, access and orientation, safety, economic activities, design and aesthetics and use as a downtown redevelopment tool. These issues have been summarized as skywalk issues in Chapter 1.

Sunil Parab, in his study (1991), analyzed bridge ends in Des Moines downtown. He identified the bridges with accessibility problems using Prof. Passini's "Wayfinding Method" (Passini, 1984). Wayfinding is defined as a task of finding one's way through an environment so as to reach a desired destination. Since wayfinding ability varies from person to person, a designer has to identify the type of people solving the wayfinding problem. Knowledge of the setting and the wayfinding ability are key factors in consideration. The wayfinding ability would change drastically from an experienced user to a totally inexperienced user. Users can be classified into three broad categories:

1. Expert users who are well conversant with the skywalk system.

2. Acquainted users who have some knowledge about the skywalk system.

3. New users who are visiting the downtown for the first time.

Sunil Parab applied Passini's "Wayfinding Method" to analyze wayfinding tasks from the sidewalk level to the skywalk level, assuming the role of a new user. The results on one of the ends of the skywalk bridge, (6D-5D), which connects the two blocks of the "kaleidoscope at the Hub" are summarized in Figure 2.1 and Figure 2.2.

GRAPHIC SYMBOLS USED IN DECISION MAKING CHARTS.

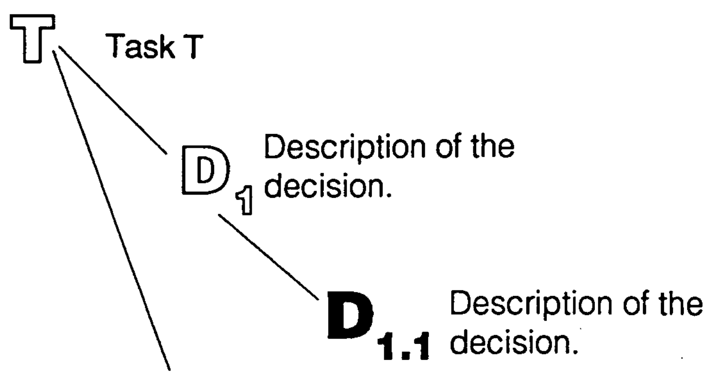
1. Bridae-end identification:

6D(6D-5D) = Side 6D of the bridge 6D-5D
5D(6D-5D) = Side 5D of the bridge 6D-5D

2. Decision identification symbol:

D_1 Decision D_1 which do not initiate any physical action.

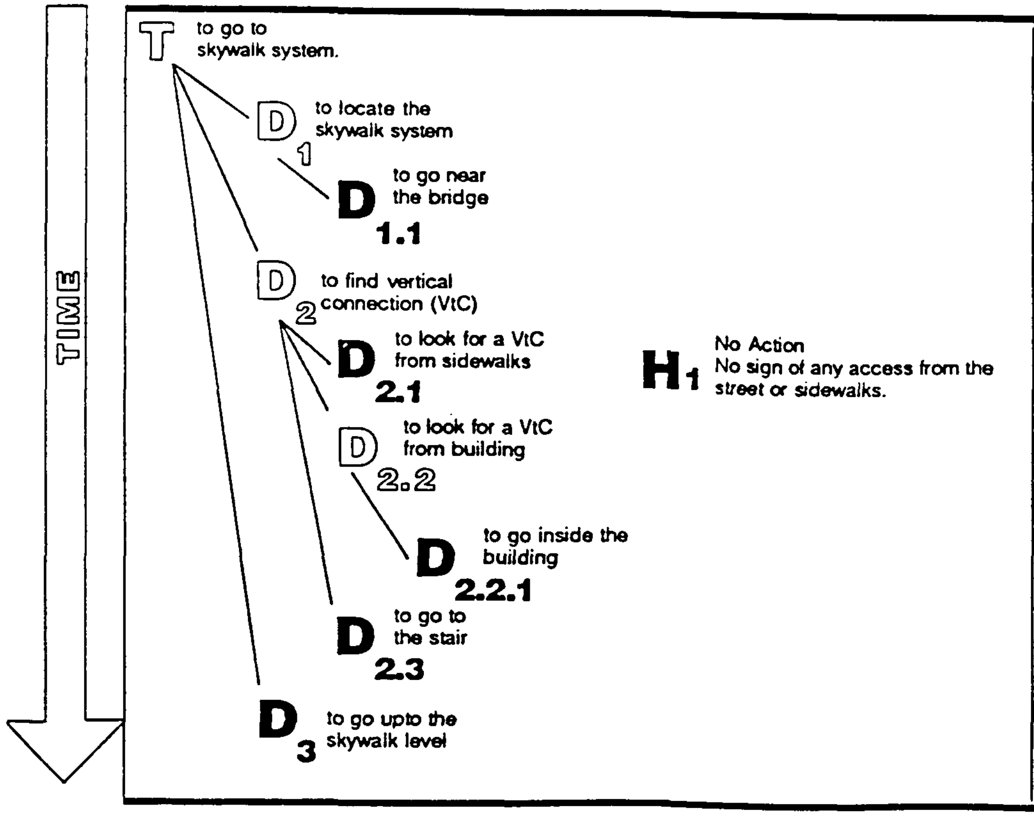
$D_{1.1}$ Decision $D_{1.1}$ which is executed in the form of a physical action. These decisions can be traced on the map.



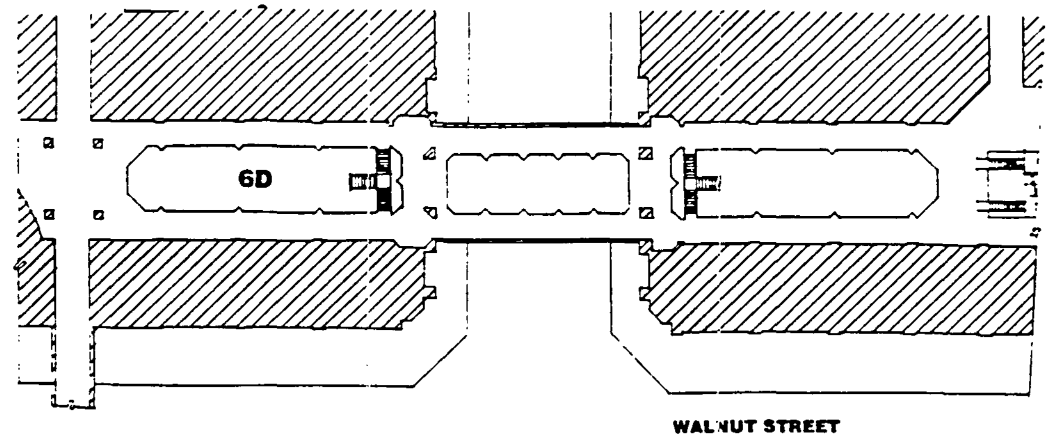
Typical form of decision chart.

Figure 2.1: Graphic explanation of decision charts (Parab, 1991)

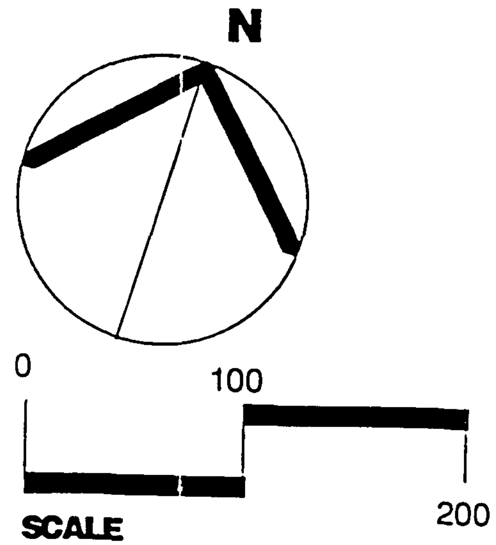
6D-5D KALEIDOSCOPE AT THE HUB.

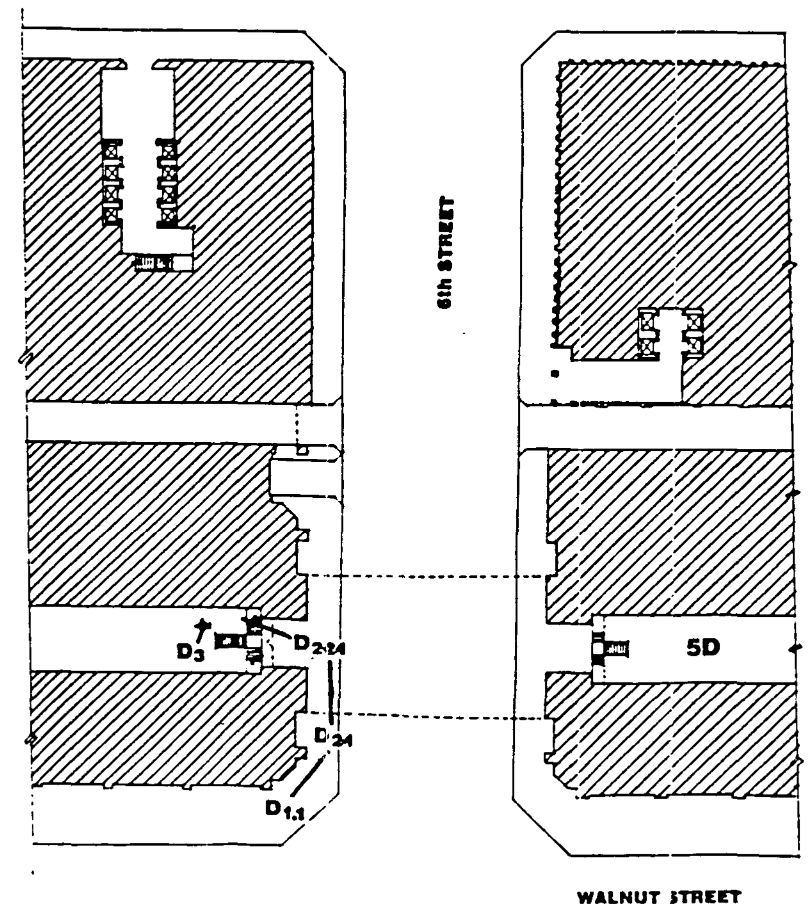


Memory	Space	Signs, Maps
Skywalk system is in downtown.	View of the Skywalk bridge.	
	View of the Skywalk bridge.	
Skywalks run at second floor lvl.	View of the elevated bridge.	
Public access from a public space.		
Buildings may have internal VtC to skywalk passages.	View of the Skywalk bridge entering the building.	
	View of the entry door below bridge.	
	View of the stair going up.	
	View of the Skywalk passage at upper level.	



WAYFINDING AT BRIDGE '6D-5D' (SKYWALK LVL.)





WAYFINDING AT BRIDGE '6D-5D' (STREET LVL.)

Figure 2.2: Wayfinding analysis of the bridge connecting the two blocks of the "Kaleidoscope at the Hub" (Parab, 1991)

"T" means the task is "to go to the skywalk level" from the street level. "D_s" are the various decisions to be made. For instance "D_1" means "to locate the skywalk system. " These decisions are taken on the basis of the information from memory (I_{memory}) and the information provided by the environment (I_{space}) (see Figure 2.1). When the visitor encounters a situation where the decision is not implemented due to the inability of the desired environment to provide the necessary spatial information, then the situation is referred to as an "architectural barrier or a hurdle." This hurdle or barrier can force a wayfinder to abandon the wayfinding process or it can force the wayfinder back to their memory information and to use an alternate wayfinding strategy (Passini, 1984). The probability of abandoning the process is likely to be found more with the new user, than with the expert and the acquainted user.

In the (6D-5D) bridge, when the wayfinder cannot see a vertical connection from the sidewalk, he then proceeds to go inside the building to locate the connection, this has been defined as an "architectural barrier." The wayfinding analysis is that the bridge (6D-5D) has one hurdle on the 6D block end.

This analysis was carried on all the thirty eight bridge ends of the nineteen bridges in the selected study area. Four bridge ends for which the wayfinding hurdles are not available have been marked "NA." The study area with all the bridge ends is shown in Figure 2.3. The number of hurdles at each bridge ends are given in Table 2.1.

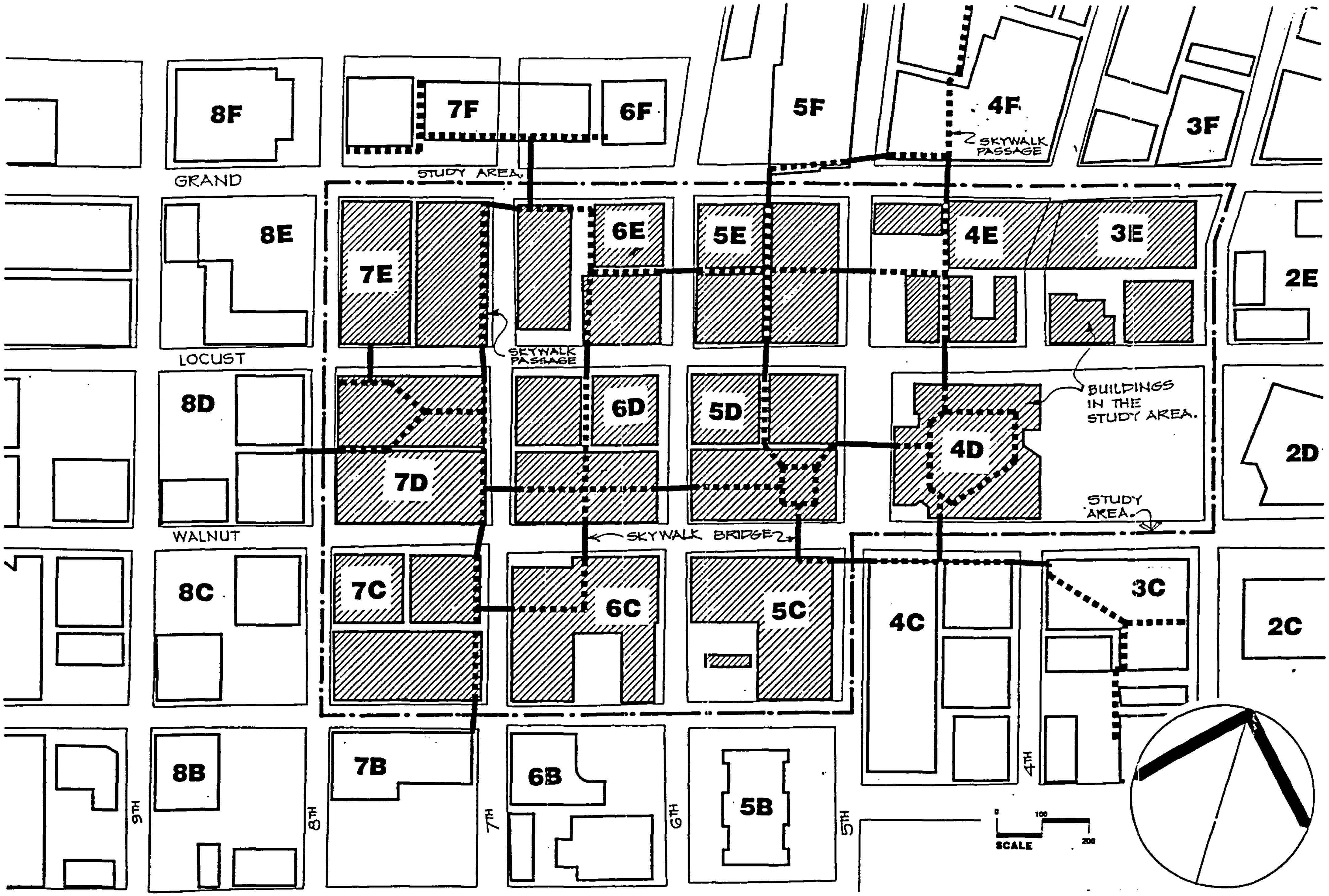


Figure 2.3: Study area in downtown Des Moines

The conclusions from Sunil Parab's thesis are as follows (Parab, 1991):

- The skywalk system in Des Moines is not accessible from the sidewalk level as all bridge ends but two have one or more hurdles in the wayfinding process. Also a large number of them have three, four or an infinite number of hurdles.
- Many entrances of the skywalk system are located in privately owned and controlled spaces. These spaces are not designed as public entrances and reduce the publicness of the system.
- No direct access is available from the street level for approximately eighty two percent of the bridge ends.
- Office buildings, departmental stores and hotels have higher wayfinding indices than retail malls and parking ramps.

The variables for the skywalk system are ranked using "Half-matrix method". The half-matrix method has been explained by an example in Appendix B. This example has been developed by Dr. R.D. Shinn (Shinn, 1988). For the purpose of designing retrofits all the bridges in the study area are prioritized by "Complete worth method". The complete worth method has been referred from the Rand Corporation Memorandum, RM-5869-DOT. This is the work of a team of nine authors working for the Northeast Corridor Transportation project (Kraemer, 1969).

Some of the vertical connections for accessibility to the skywalk system also serve as fire exits. The design of these exits have to comply with the requirements of the fire exit code laid down in the Uniform building code, Section 3309 (Bush, 1988). The requirements of the building code for fire exits has been stated in Chapter 4.

Conclusion

In spite of their role as a public pedestrian system, the skywalks vary in their degree of publicness. Those skywalks located in high-use retail areas are reasonably public and readily acccessible, whereas those near residences or businesses are at best semi-public and are marginally accessible. Different police-patrolling standards are utilized in these areas, leading to differing standards of acceptable public behavior. Only the streets of the city remain truly public because access to skywalks can be controlled by guards and limited by owners. The location of public functions on the skywalks, as was done in St. Paul with the branch library, science museum and city hall, increases use by all section of the population. In the case of Minneapolis, exterior stair towers greatly improve public access between the two pedestrian level (Bednar, 1989). Therefore, as seen the majority of problems associated with the skywalk system is due to the failure to provide a direct link between the sidewalk and the skywalk level.

Table 2.1: Bridge chart with names and number of hurdles (Parab, 1991)

	Bridge ends	No. of hurdles
1	6F(6F-6E)	0
2	6E(6F-6E)	4
3	5F(5F-5E)	1
4	5E(5F-5E)	2
5	4F(4F-3E)	4
6	3E(4F-3E)	1
7	6E(6E-5E)	4
8	5E(6E-5E)	4
9	5E(5E-4E)	1
10	4E(5E-4E)	N
11	7E(7E-7D)W	4
12	7D(7E-7D)W	3
13	7E(7E-7D)E	N
14	7D(7E-7D)E	3
15	6E(6E-6D)	4
16	6D(6E-6D)	4
17	5E(5E-5D)	1
18	5D(5E-5D)	N
19	4E(4E-4D)	4
20	4D(4E-4D)	3
21	8D(8D-7D)	NA
22	7D(8D-7D)	NA
23	7D(7D-6D)	N
24	6D(7D-6D)	3
25	6D(6D-5D)	1
26	5D(6D-5D)	1
27	5D(5D-4D)	N
28	4D(5D-4D)	4
29	7D(7D-7C)	N
30	7C(7D-7C)	1
31	6D(6D-6C)	4
32	6C(6D-6C)	1
33	5D(5D-5C)	1
34	5C(5D-5C)	N
35	4D(4D-4C)	2
36	4C(4D-4C)	N
37	7C(7C-6C)	N
38	6C(7C-6C)	N
39	5C(5C-4C)	N
40	4C(5C-4C)	0
41	7C(7C-7B)	NA
42	7C(7C-7B)	NA

CHAPTER 3. DES MOINES SKYWALK SYSTEM

This chapter describes in brief the existing skywalk system in Des Moines. Based on analysis of the various available data, the bridge ends have been prioritized for design retrofitting to provide access from the sidewalks to the skywalks.

The Existing Skywalk System

The concept for the skywalk system in Des Moines downtown was developed in 1975, and later developed in 1978 for submittal to the Iowa Department of Transportation and the Federal Highway Administration for approval to utilize federal highway funds for design and construction. Barton-Aschman Associates, Inc., of Minneapolis were commissioned to study the volume of pedestrians anticipated to use the skywalk system, the resultant savings in vehicular delay, the reduction of vehicle-pedestrian accidents and a benefit/cost ratio of the proposed skywalk system (Heglund, 1982). See Table 3.1 for a percentage distribution of persons trips by purpose.

On June 23, 1980, the Des Moines City Council adopted a skywalk ordinance to co-ordinate, regulate and integrate the development of the proposed skywalk system. The ordinance stated that the City of Des Moines and the private owners together should bear the construction cost and the private owners should bear the

Table 3.1: Percentage distribution of person trips by purpose

	Noon Hour			P.M. Peak Hour		
Purpose	Work	Home	Shop	Work	Home	Shop
Work	9	30	14	7	50	17
Home	6	10	9	77	0	42
Shop	15	0	43	3	38	25
Business	21	20	9	9	0	4
Eat	43	40	18	1	0	4
Other	6	0	7	3	12	8

maintenance cost (Heglund, 1980). Three basic options were considered regarding ownership status of the skywalk system. These are:

1. publicly owned skywalks.

2. a combination of public and private ownership.

3. completely private ownership.

Based on the experience of the skywalk system in Minneapolis and St. Paul, Minnesota, there are distinct advantages to both private ownership and public ownership. Strong points of private ownership include: no assessment problems, ingenuity of design and security. Public ownership advantages include: uniform hours of operation, system continuity, better signs and minimum design standards. For Des Moines, a combination of public and private ownership was recommmended (Heglund and Thompson, 1980).

The skywalk system is located in the central business district, CBD. The district comprises a nine block core area bounded by the Mulberry Street, 8th Street, Grand Avenue, and the 2nd Street. The skywalk system also extends its services to other buildings such as the Capitol Square, the Plaza and the

Convention Center. Two bridges were later added to the system to link the Veterans Auditorium on the north and 801 Grand on the east (see Figure 3.1 and Figure 2.3).

The total number of bridge ends in the study area is forty two. In order to prioritize the bridge ends for design retrofitting for accessibility from the sidewalk to the skywalk level, a number of variables are taken into consideration. Extensive data was collected from the Planning and Zoning and the Department of Traffic and Transportation, City of Des Moines (see Figures A.1, A.2, A.3, A.4, A.5, A.6 and A.7).

The variables on which the bridges are analyzed are:

	Variables
A	Retail at skywalk level
B	Active retail at street level near the bridge ends
C	Passive retail at street level near the bridge ends
D	Daily pedestrian volume across the bridge ends
E	Hourly traffic count under the skywalk bridges
F	Bus stops near the bridge ends
G	Street parking near the bridge ends
H	Parking garages near the bridge ends
I	Wayfinding hurdles of the bridge ends

The first task is to prioritize these nine variables in order to assign a weight to each of them. Half-matrix method is used for this. This method is used to prioritize among a set of variables. The first step is to list all the variables and prepare a graph, a half-matrix.

Figure 3.1: Downtown Des Moines

Given below is a half matrix with the variables A through F.

	F	E	D	C	B	A
A						
B						
C						
D						
E						
F						

Two variables are taken at a time and compared to find the important of the two. Read across the rows and compare variables in rows to that of in each column. The variable which is more important of the two is put down in the half-matrix. After having compared all the variables a count is made of the number of occurences of each variable in the half-matrix. The higher the number of occurences for a variable, the more important it is. The half-matrix method has been explained in detail with the help of an example in Appendix B.

The nine variables can now be prioritized based on the above method. The method is applied four times and then a composite sum of the occurences is taken for prioritizing. The priority test is done by four different people, the author and three others. The results of the respondents are shown in Figures 3.2 - 3.5. A composite sum of the responses is shown in Table 3.2.

	I	H	G	F	E	D	C	B	A
A	I	A	A	A	A	D	A	B	
B	I	B	B	B	B	B	B		
C	I	C	G	F	E	D			
D	I	D	D	D	D				
E	I	E	E	F					
F	I	F	F						
G	I	G							
H	I								
I									

Variables	No. of occurences	Rank
A	5	4th
B	7	2nd
C	1	1st
D	6	3rd
E	3	6th
F	4	5th
G	2	7th
H	0	9th
I	8	1st

Figure 3.2: Results of the first respondent

	I	H	G	F	E	D	C	B	A
A	I	A	A	A	A	D	A	A	
B	I	B	B	F	B	D	B		
C	I	H	G	F	E	D			
D	I	D	D	D	D				
E	I	E	G	F					
F	I	F	F						
G	I	G							
H	I								
I									

Variables	No. of occurences	Rank
A	6	3rd
B	4	5th
C	0	9th
D	7	2nd
E	2	7th
F	5	4th
G	3	6th
H	1	8th
I	8	1st

Figure 3.3: Results of the second respondent

	I	H	G	F	E	D	C	B	A
A	I	A	A	A	A	A	A	A	
B	I	B	B	F	B	B	B		
C	I	C	G	C	C	C			
D	D	D	D	D	D				
E	I	E	G	F					
F	I	F	G						
G	I	7							
H	I								
I									

Variables	No. of occurences	Rank
A	7	1st
B	5	3rd
C	4	5th
D	5	3rd
E	1	8th
F	3	7th
G	4	5th
H	0	9th
I	7	1st

Figure 3.4: Results of the third respondent

	I	H	G	F	E	D	C	B	A
A	I	A	A	A	A	D	A	A	
B	I	H	B	F	B	D	B		
C	I	H	C	F	C	D			
D	I	D	D	D	D				
E	I	H	E	F					
F	I	H	F						
G	I	H							
H	I								
I									

Variables	No. of occurences	Rank
A	6	3rd
B	3	6th
C	2	7th
D	7	2nd
E	1	8th
F	4	5th
G	0	9th
H	5	4th
I	8	1st

Figure 3.5: Results of the fourth respondent

Table 3.2: Sum of the occurences and ranking

Variables	Sum of the occurences	Ranking
A	24	3rd
B	19	4th
C	7	7th
D	25	2th
E	7	7th
F	16	5th
G	9	6th
H	6	9th
I	31	1st

The final ranking is:

Ranking	Variables
1st	Wayfinding hurdles
2nd	Daily pedestrian count across the bridge ends
3rd	Retail at skywalk level
4th	Active retail at street level near the bridge ends
5th	Bus stops near the bridge ends
6th	Street parking near the bridge ends
7th	Hourly traffic count under the bridge ends
7th	Passive retail at street level near the bridge ends
9th	Parking garages near the bridge ends

Thus, we see that "Wayfinding hurdles for the bridge ends" ranks to be the first. The wayfinding hurdles of the bridge ends are laid down by "Passini's method" in which a new user tries to reach the skywalk from the street. "Parking garages" is the last because they do not require a sidewalk to skywalk connection.

The parking garages are well marked inside and there are connections inside from the parking garages to the skywalk.

The variables are now assigned weights. The maximum number of times a variable could have been selected by all of the four respondents is 32 and the minimum number of times is 0. Normalize by setting 32=1.00. This will result in an interval scale for the variables that has values of 0.00 to 1.00 (see Table 3.3). The raw data for each of the bridge ends is assigned a score between 0 to 10. For

Table 3.3: Weights for the variables

Rank	Variables	No. of occurences	Weights
1st	I	31	0.96
2nd	D	25	0.78
3rd	A	24	0.75
4th	B	19	0.59
5th	F	16	0.50
6th	G	9	0.28
7th	E	7	0.21
7th	C	7	0.21
9th	H	6	0.18

example in the case of the variable "Bus stops near the bridge ends" the number of bus stops associated with any bridge end are either 0, 1 or 2. Thus, the scores assigned for these raw data are 0, 5 and 10 respectively. For the variable "Hourly traffic count under the bridge ends" the highest raw data is 2285. Thus, 2285 is assigned a score of 10 and the score for the rest of the data is proportionately assigned. In the case of the variables "Retail at skywalk level" the raw data is either " No" or "Yes". Thus, the scores assigned are 0 and 10 respectively. For some of the variables raw data was not available for certain bridge ends. These have been marked "NA" in the weighted score table for the variables. The score assigned here is the "mean value" of scores for all the bridge ends for that variable. The raw data not available are "Daily pedestrian count across the bridge ends" for the bridge 5F-5E, "Hourly traffic count under the bridge ends" for bridge 7D-7C and "Wayfinding hurdles" for the bridge 8D-7D. The mean score assigned to these bridge are 3.17, 5.81 and 5.00 respectively. The scores are then multiplied by the weight of the variable to get a weighted score.

The sum of all the weighted score is the total weighted score. The bridge end with the highest total weighted score is the most important one, and the one with the lowest is the least important one for design retrofit. The weighted score for all the variables are given in Table C.1 through Table C.10. Table 3.4 gives a final ranking for all the bridge ends.

Conclusion

All the forty two bridge ends in the study area are now ranked for designing retrofits. Five bridge ends ranked 1st, 3rd, 4th, 5th and 6th are selected.

For the bridge end ranked 2nd, 5D(5E-5D), there is not enough space on the sidewalk for a vertical connection and designing a vertical connection inside the building drastically alters the functions of the First Interstate Bank and the First Interstate parking garage. Therefore, the other end of the bridge, that is, 5E(5E-5D), Parking ramp, which is ranked 6th is selected. The selected bridge ends are:

1. 5D(5D-4D), Kaleidoscope at the Hub

2. 5E(5E-5D), Parking ramp

3. 5E(5F-5E), Parking ramp

4. 7D(7D-7C), Younkers store

5. 7D(7D-6D), Younkers store

The existing conditions of these bridge ends have been described in Chapter 4. Figure 3.6 shows the selected bridge ends in the study area.

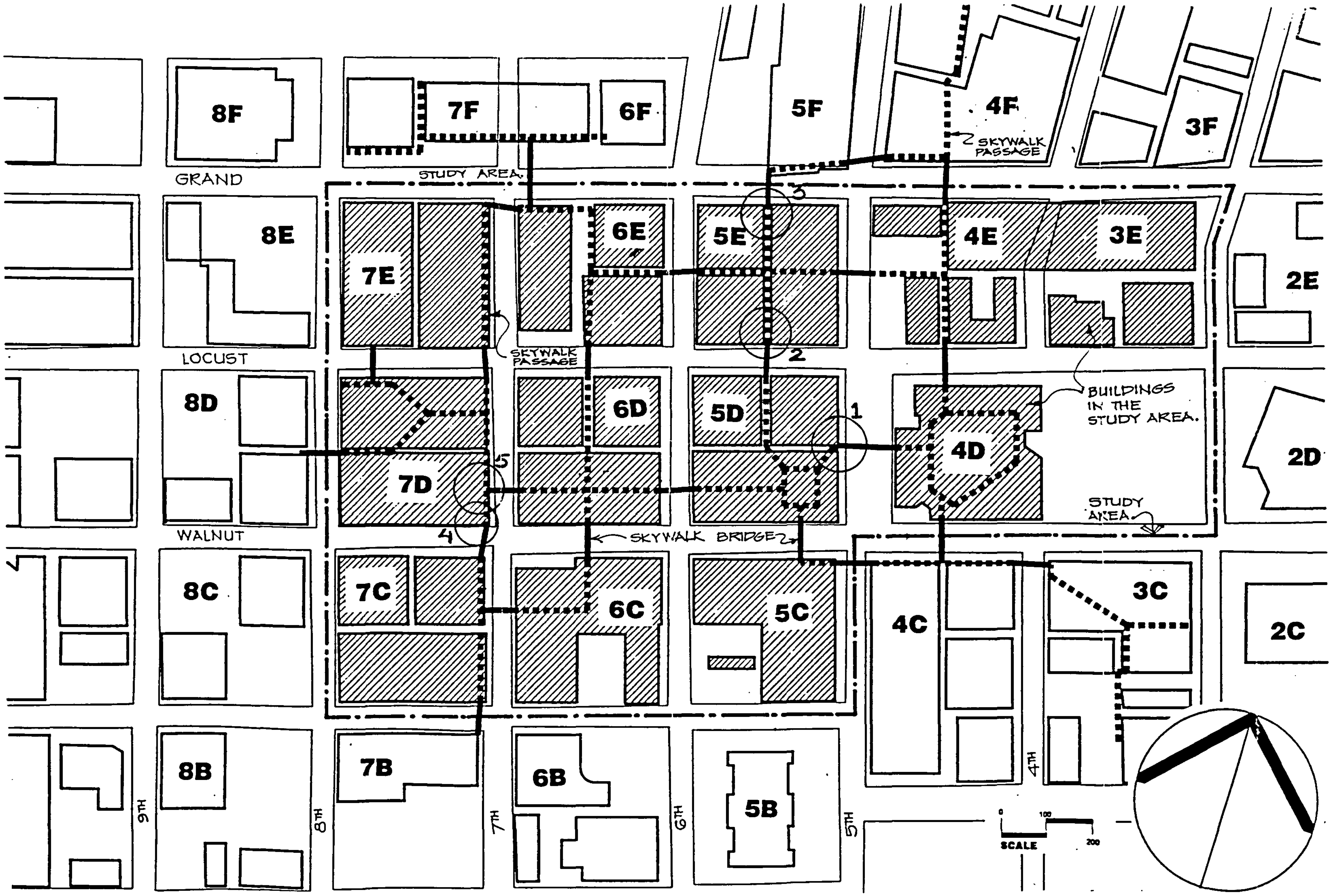


Figure 3.6: Study area showing the five selected bridge ends

Table 3.4: Final ranking with bridge name

Rank	Bridge name
1st	5D(5D-4D)
2nd	5D(5E-5D)
3rd	5E(5F-5E)
4th	7D(7D-7C)
5th	7D(7D-6D)
6th	5E(5E-5D)
7th	5D(6D-5D)
8th	4F(4F-4E)
9th	5E(6E-5E)
10th	6D(6E-6D)
11th	4D(5D-4D)
12th	6C(7C-6C)
13th	5C(5D-5C)
14th	4C(4D-4C)
15th	5C(5C-4C)
16th	7D(8D-7D)
17th	5D(5D-5C)
18th	6C(6D-6C)
19th	6D(6D-5D)
20th	6D(6D-6C)
21st	7D(7E-7D)E
22nd	6E(6E-6D)
23rd	6D(7D-6D)
24th	4E(4E-4D)
25th	5E(5E-4E)
26th	4D(4D-4C)
27th	7C(7C-6C)
28th	6E(6E-5E)
29th	7E(7E-7D)E
30th	8D(8D-7D)
31st	4E(5E-4E)
32nd	6E(6F-6E)
33rd	7C(7C-7B)
34th	7C(7D-7C)
35th	6F(6F-6E)
36th	7E(7E-7D)W
37th	7C(7C-7B)
38th	7D(7E-7D)W
39th	4D(4E-4D)
40th	5F(5F-5E)
41st	4E(4F-4E)
42nd	4C(5C-4C)

CHAPTER 4. DESIGN PROPOSALS

This chapter states the Skywalk guidelines for vertical connections for the bridges and the fire exit design requirements from the Uniform Building Code. A retrofit typology is formulated. Design recommendations based on the typology are proposed for each of the bridge ends in the study area. It describes the existing bridge ends selected for design retrofitting, and then proposes design solutions.

Skywalk Guidelines

Several studies in the past have been conducted on the skywalk systems. As a result guidelines have been formulated for the vertical connections. The proposed designs for the vertical connection are going to be within the framework of these guidelines. The primary source of these guidelines are the studies by Sunil Parab, "Wayfinding analysis of the skyalk system in Des Moines, IA," 1991, and by Byung Soo Lee, "Privatization of Urban public space: A case study of Des Moines skywalk system," 1989. The guidelines are as follows:

1. A minimum of one connection should be provided per bridge end.
2. The vertical connection should be located very close to the bridge end. The connection should be either a self standing structure or integrated with the facade of the building. It should be visible from the sidewalks.

3. The three possible modes of vertical connection are a staircase, an escalator and an elevator. Each mode has its advantages and disadvantages. Depending on the situation, a particular mode should be selected. Staircases should be provided as a basic mode and elevators can be added as needed for the physically handicapped people. Escalators should be used where there is enough space.

4. The vertical connection should be a conspicuous element. Although the skywalk system is more than the bridges, skywalk bridges are the only exposed part of the system. One locates the skywalk system at the first sight of a bridge. The vertical connection should be in the form of a vertical tower, visible from a distance. Even if the vertical connection is integrated with the building, the design should be such that it is a conspicuous element.

5. The entrance to a skywalk system should offer transparency so that a visitor is assured that it would lead to some kind of a lobby with a view of elevators or a staircase inside. This would assure a user that it would lead to the skywalk system. Even at the skywalk level, the lobby should offer transparency for the users to be able to reach the street level from the skywalk level.

6. A good signage system should be incorporated. A good signage system complements spatial information and provides information where the setting has failed to do so and thus reduces wayfinding difficulties.

Fire Exit Design Requirements

These requirements have been laid down in the Uniform Building Code, Stairway, Ramps and Escalator Enclosures, Section 3309 (Bush, 1988).

1. All vertical openings for every interior stairway, ramp or escalator to be used as a fire exit must be enclosed within fire-resistive construction. Since vertical openings provide probably the most readily available paths for fire communicating from floor to floor upward through buildings, it is extremely important that such vertical openings be adequately protected. This enclosure is required in order to protect and separate the vertical exitway from potential fire and the product of combustion in other spaces of the building (Bush, 1988, Section 3309, a - General, p. 325).

2. Openings into exit enclosures other than permitted exterior openings shall be limited to those necessary for exiting from a normally occupied space into the enclosure and exiting from the enclosure. Other penetrations into and opening through exit enclosure are prohibited except for ductwork and equipment necessary for independent stair pressurization, sprinkler piping, standpipes and electrical conduit serving the stairway and terminating in a listed box not exceeding 16 square inches in area (Bush, 1988, Section 3309, c - Openings into enclosures, p. 326).

3. An enclosure is not required for a stairway, ramp or escalator that serves only two adjacent floors and does not connect with corridors or with stairways serving floors other than the two connected floors (Bush, 1988, Section 3309, a - General, p. 325).

4. Since the exterior walls of an enclosed vertical stairway are not protecting the stairway from other building spaces, openings through the exterior wall are permitted. In fact, in buildings which are so located on the property that there would be no requirement for the fire-resistive construction of the exterior wall or for the protection of the openings in such a wall, the exterior wall of a stair enclosure could be eliminated entirely (Bush, 1988, Section 3309, c - Openings into enclosures, p. 326).

5. When openings for exit doorways are provided in exit enclosures, it is necessary that they be protected with a fire-rated assembly with a one and one-half hour fire-protection rating. Such doors must be maintained either as self-closing doors or as automatic closing by activation of a smoke detector (Bush, 1988, Section 3309, c - Openings into enclosures, p. 326).

6. One of the basic concepts governing safe exit design is that once a building occupant is brought to a certain level of safety, that level of safety is not reduced as that occupant proceeds throughout the rest of the exit system. Therefore, once an enclosure is required for an exit component it is necessary that the enclosure be continuous and provide continuous protection throughout the remainder of the system until the building occupant reaches the exterior of the building. When the occupant reaches the floor level which provides access to the exterior of the building , any travel on that floor level must be similarly enclosed and the protection must be continuous to the exterior of the building (Bush, 1988, Section 3309, d - Extent of enclosures, p. 327).

Retrofit Typology

One locates the skywalk system at the first sight of a bridge. People would look for the vertical tower instead of looking for a stair or an elevator once they are exposed to the skywalk bridge. The connection could either be a self standing structure or integrated with the facade. In some buildings it is advisable to keep the vertical connection separate from the building. The city may have to buy spaces from the building owners or build separate structures for vertical connection. The designed vertical connection should be within the framework of skywalk guidelines. Verticality, perceptibilty and transparency are the three design elements of a successful vertical connection. The vertical connection needs to be made into a perceivable element. Design elements have to be introduced to associate the entrance with the skywalk bridge. Some of the bridge ends may require redesigning the existing vertical connection.

Various types of solutions can be offered for designing retrofits. A typology can be formulated and solutions for each of the bridge ends in the study area would fall within a type. The various retrofit typology are as follows:

Addition of an independent vertical connection

In this typology an isolated vertical connection can be built in front of the building connecting the sidewalk to the skywalk. The vertical form can be identified from a distance, which can help in the wayfinding process. If there is not enough space on the sidewalk for the vertical connection it can be obtained on encroaching on the parallel parking space. The design of the towers should be such that it should blend with the facade of the existing building (see Figure 4.1).

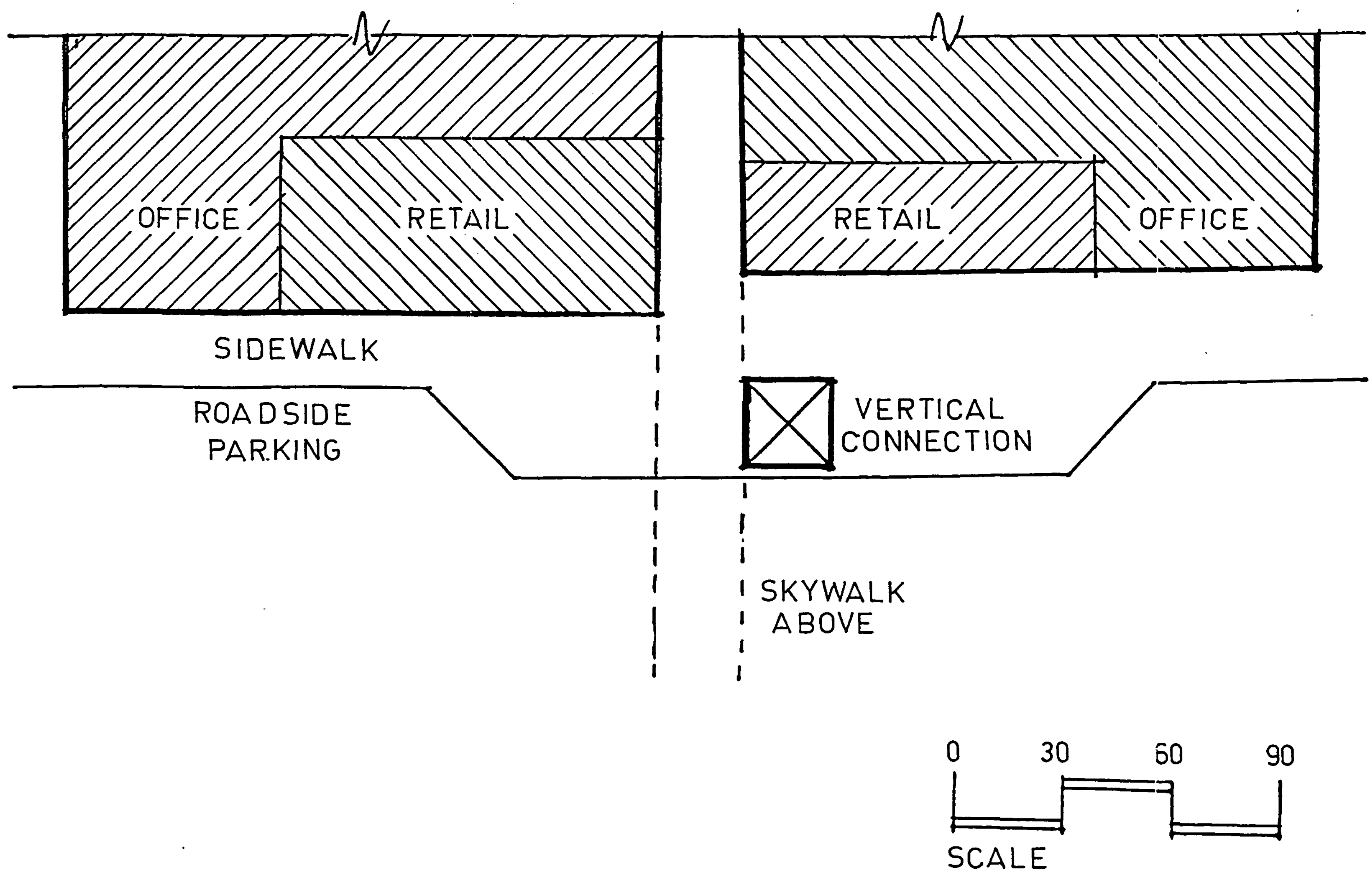


Figure 4.1: Addition of an independent vertical connection

Addition of a vertical connection integrated with the building

This typology requires designing a vertical connection integrated with the facade of the building. A skywalk lobby is created at the street level. The lobby should be designed such that it should not drastically alter the functions of the building and the architectural character of the facade. There should be enough space near the bridge for a vertical connection. The elements of the designed facade should associate with the elements of the skywalk bridge (see Figure 4.2).

Redesigning the existing vertical connection

In this type the existing vertical connection is redesigned within the framework of skywalk guidelines. The retrofit can be either making alterations to the existing skywalk lobby or just alterations in the facade of the entrance to the vertical connection.

Installing skywalk signs

In this typology the connection does exist from the sidewalk but the user is not sure whether the entrance leads to a vertical connection or not. A good signage system which provides information about the vertical connection from the sidewalk to the skywalk should be incorporated here.

Some of the solutions to the bridge ends may not fall in any of the categories. A combination of the above solutions could be required. For some bridge ends the retrofit could be very difficult to implement. In such cases, the opposite bridge end should be taken into consideration for designing as in the case of the bridge end 5D(5E-5D). In some cases one vertical connection can serve two bridge ends which

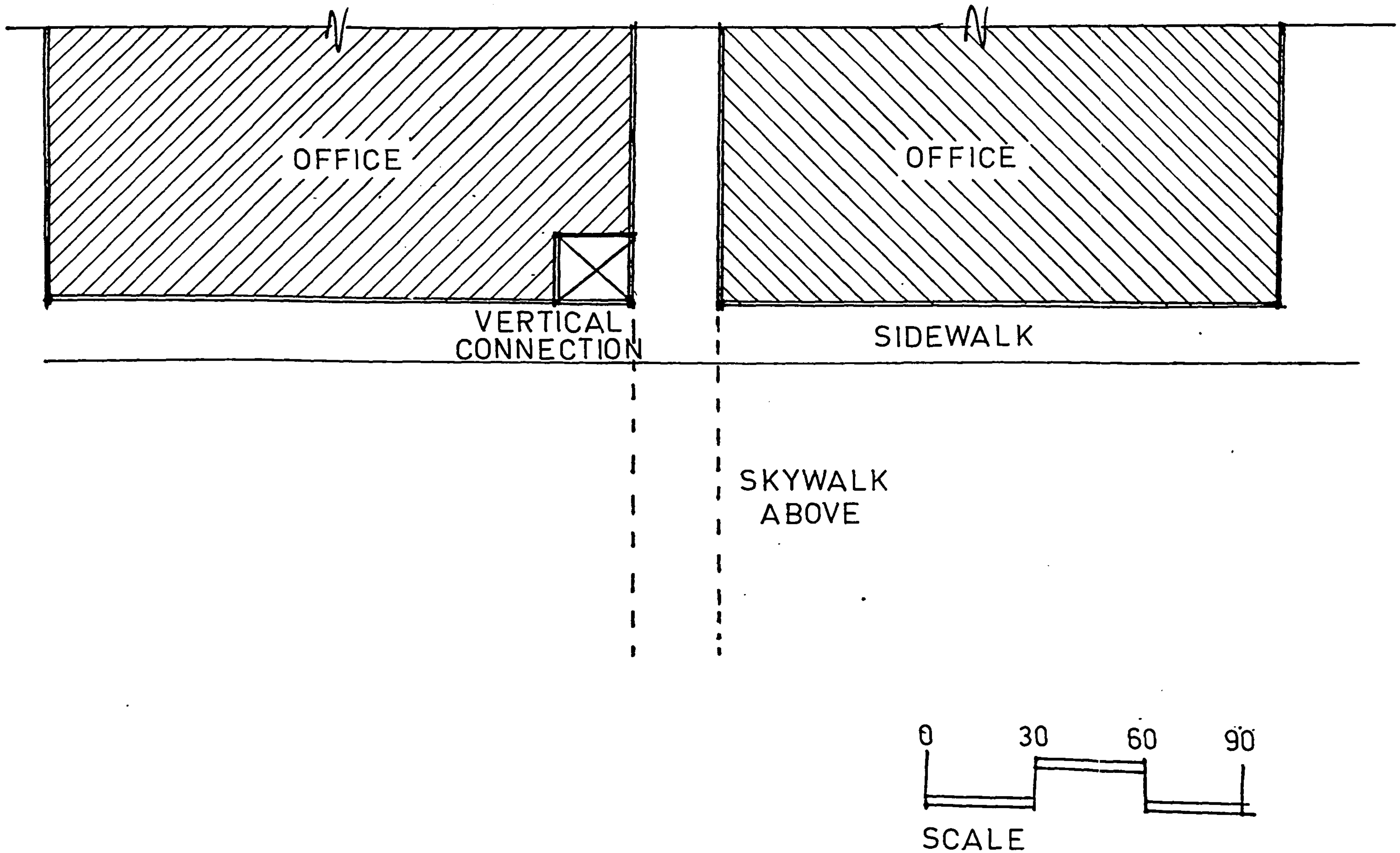


Figure 4.2: Addition of vertical connection integrated with the building

are in close proximity as in bridge ends 7D(7D-7C) and 7D(7D-7C).

The bridge ends that fall in the first category are:

Addition of an independent vertical connection

1. 4E(5E-4E)
2. 4D(4E-4D)
3. 4D(5D-4D)
4. 4D(4D-4C)
5. 4C(4D-4C)

The bridge ends in the second category are:

Addition of a vertical connection integrated with the building

1. 4F(4F-4E)
2. 6E(6E-5E)
3. 5E(6E-5E)
4. 7E(7E-7D)W
5. 7D(7E-7D)W
6. 7E(7E-7D)E
7. 6E(6E-6D)
8. 6D(6E-6D)
9. 5D(5E-5D)
10. 4E(4E-4D)

11 8D(8D-7D)

12 7D(8D-7D)

13 7D(7D-6D)

14 6D(7D-6D)

15 7D(7D-7C)

16 6D(6D-6C)

17 5D(5D-5C)

18 5C(5D-5C)

19 7C(7C-6C)

20 6C(7C-6C)

21 5C(5C-4C)

The bridge ends in the third category are:

Redesigning the existing vertical connection

1 5E(5F-5E)

2 7D(7E-7D)E

3 5E(5E-5D)

4 5D(5D-4D)

5 7C(7D-7C)

6 6C(6D-6C)

7 7C(7C-7B)

The bridge ends in the fourth category are:

	Installing skywalk signs
1	6E(6F-6E)
2	5F(5F-5E)
3	5E(5E-4E)
4	6D(6D-5D)
5	5D(6D-5D)
6	7B(7C-7B)

For some of the bridge ends no retrofit is required. These are 6F(6F-6E), Grand avenue Parking ramp, 4E(4F-4E), Parking ramp and 4C(5C-4C), Parking ramp. For some of the bridge ends one solution serves two bridge ends that are in close proximity as in the case with the bridge ends at the Younkers store, 7D(7D-6D) and 7C(7D-7C). The bridge ends 7C(7C-6C) and 7C(7D-7C) at the Walgreens store require redesigning of the vertical connection near the bridge end 7C(7D-7C). And the bridge ends 5C(5C-4C) and 5C(5D-5C) at the J.C. Penny store require addition of a vertical connection which will serve both the bridge ends. Figure 4.3 shows the typology reflected on all the bridge ends in the study area.

Existing Condition of the Selected Bridge Ends

The bridge end selected for design retrofit are 5D(5D-4D), 5E(5E-5D), 5E(5F-5E), 7D(7D-7C) and 7D(7D-6D).

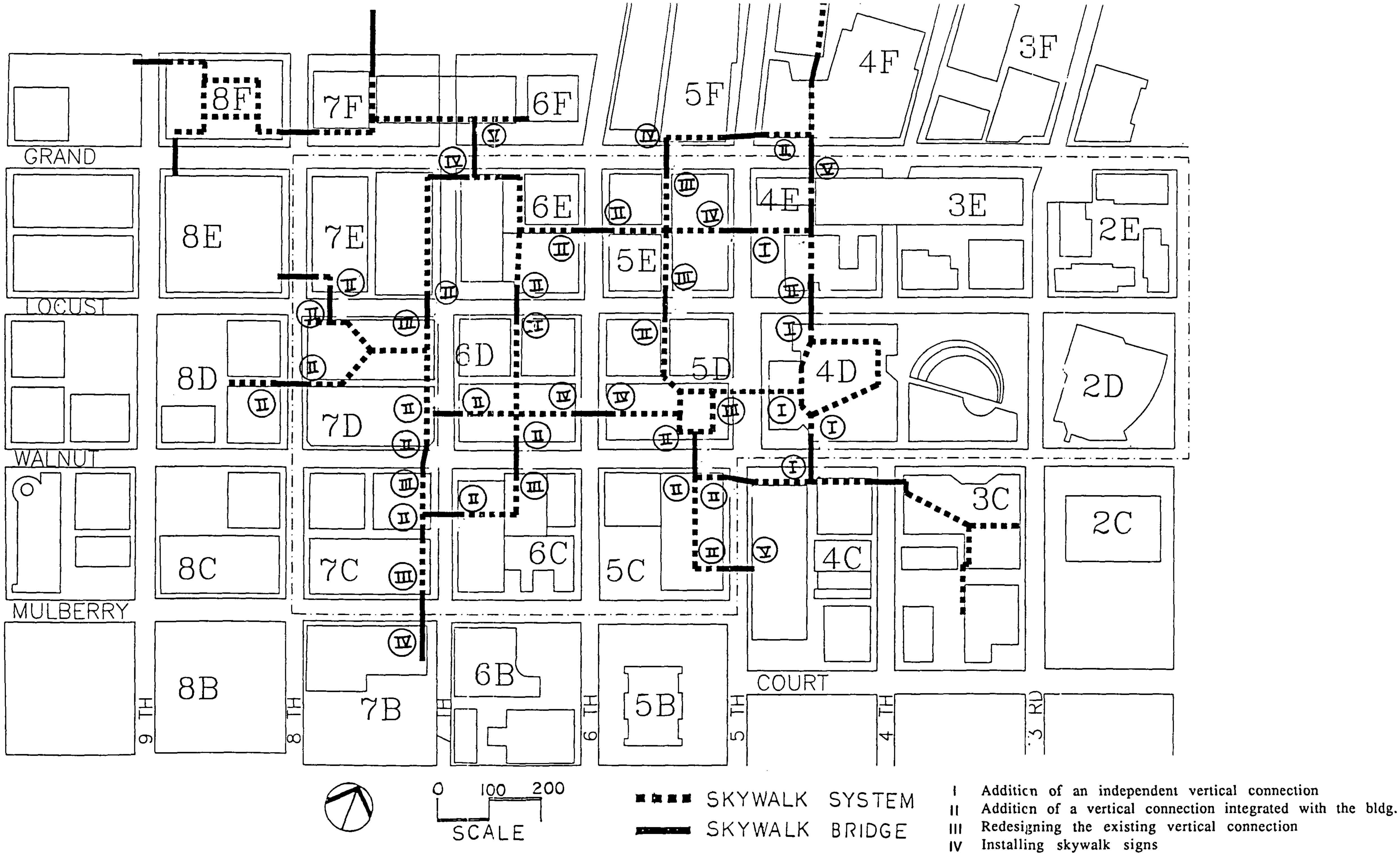


Figure 4.3: Proposed retrofit typology

Bridge end 5D(5D-4D), Kaleidoscope at the Hub

This bridge end at the Kaleidoscope at the Hub on the 5th street ranks first in the priority list. This bridge end has "N" number of hurdles according to the wayfinding analysis (see Figure 4.4 and Figure 4.5).

The vertical connection exists in the form a fire exit staircase. The exit at the street level opens into an alley between the Kaleidoscope at the Hub and the First Interstate Bank, which makes it very inconspicuous. Since no door is visible near the bridge end the visitor has to choose an alternative to reach the skywalk. The facade over the fire exit staircase is a blank wall which gives no indication of a vertical connection behind. From inside too there is no sign of a vertical connection leading to the street below.

Bridge end 5E(5E-5D), Parking Ramp

This bridge end is between the parking ramp and the Des Moines building on the Locust Street. The wayfinding hurdle for this bridge end is one (see Figure 4.6, Figure 4.7 and Figure 4.8).

The vertical connection exists in the form of a fire exit staircase from the parking ramp. This staircase is inside an alley and is not visible from the street until the user reaches right below the bridge. There is often a vehicle parked in front of the entrance to the staircase which makes it even less noticeable.

Bridge end 5E(5F-5E), Parking Ramp

This is the end of the bridge which connects the parking ramp with the Convention Center across the Grand Avenue. The bridge, which is an integral part

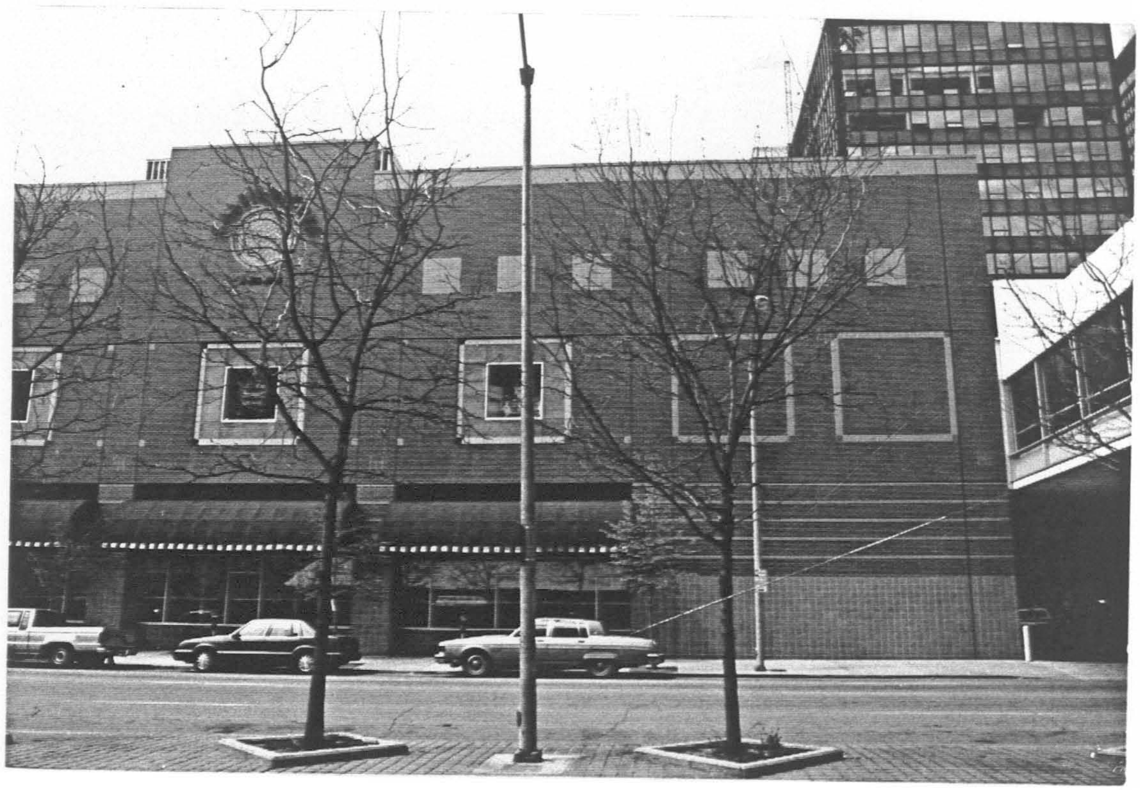


Figure 4.4: Bridge end 5D(5D-4D), Kaleidoscope at the Hub

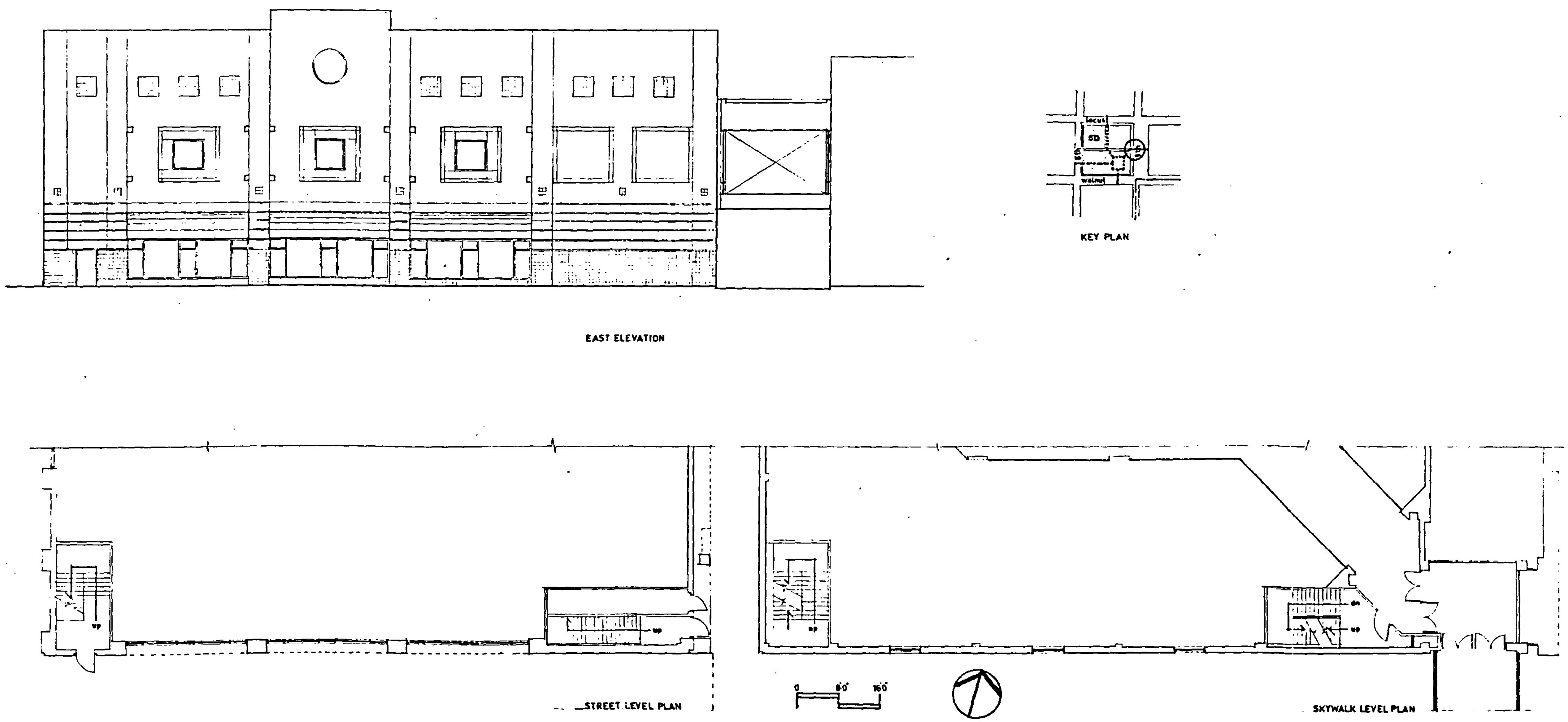


Figure 4.5: Existing condition: 5D(5D-4D), Kaleidoscope at the Hub

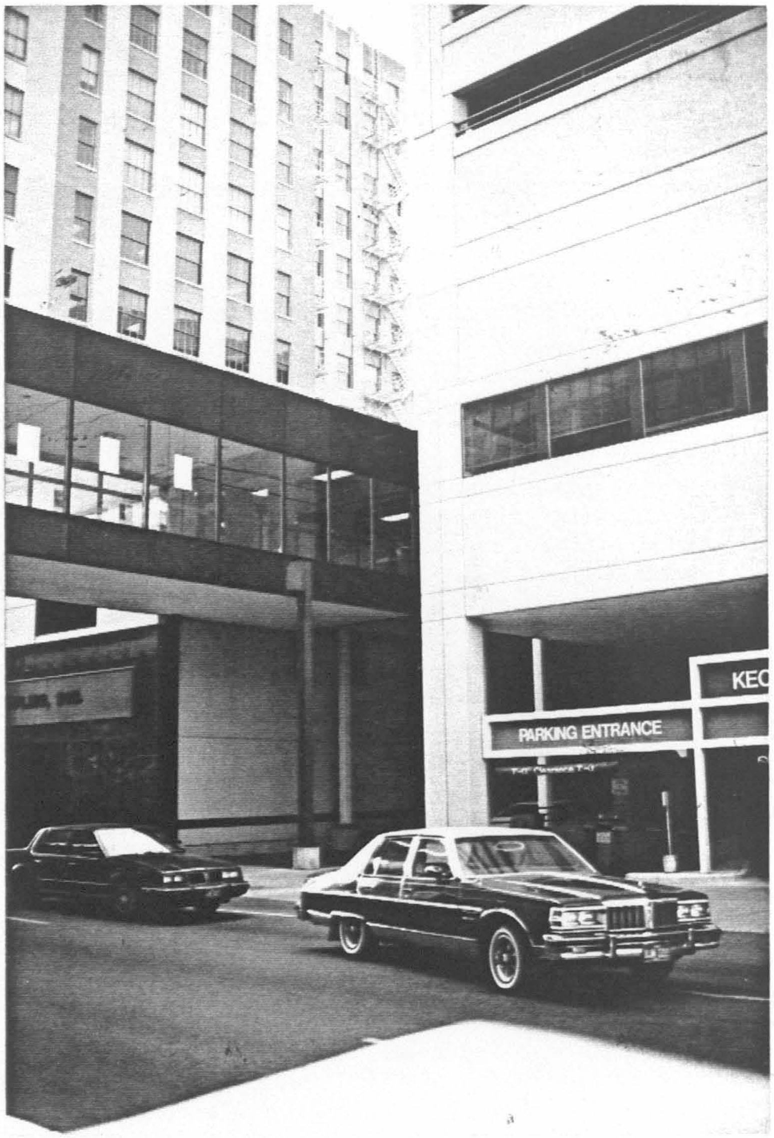


Figure 4.6: Bridge end 5E(5E-5D), Parking ramp

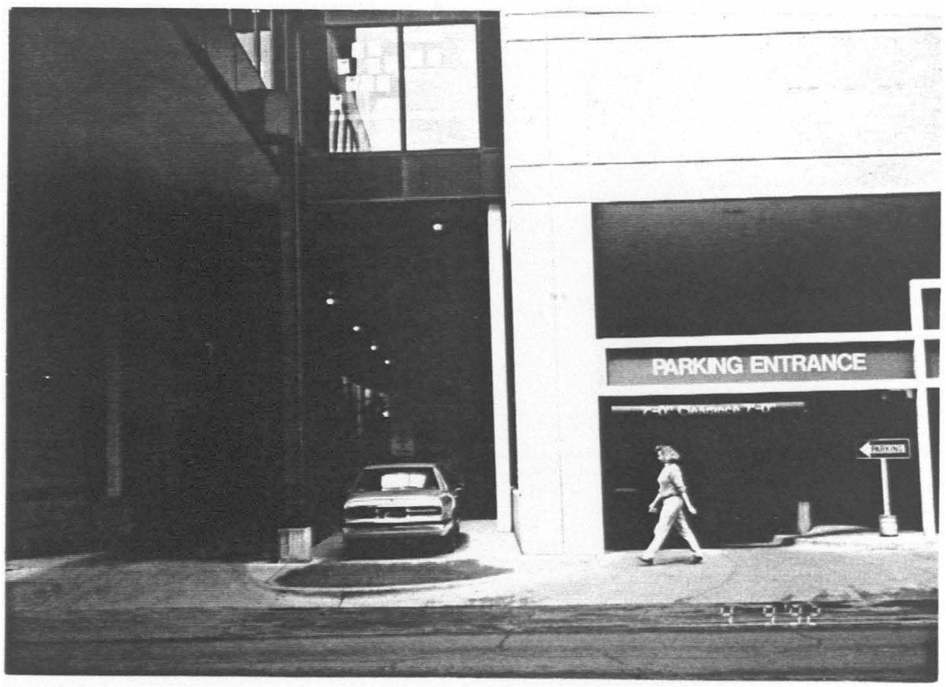


Figure 4.7: Bridge end 5E(5E-5D), Parking ramp

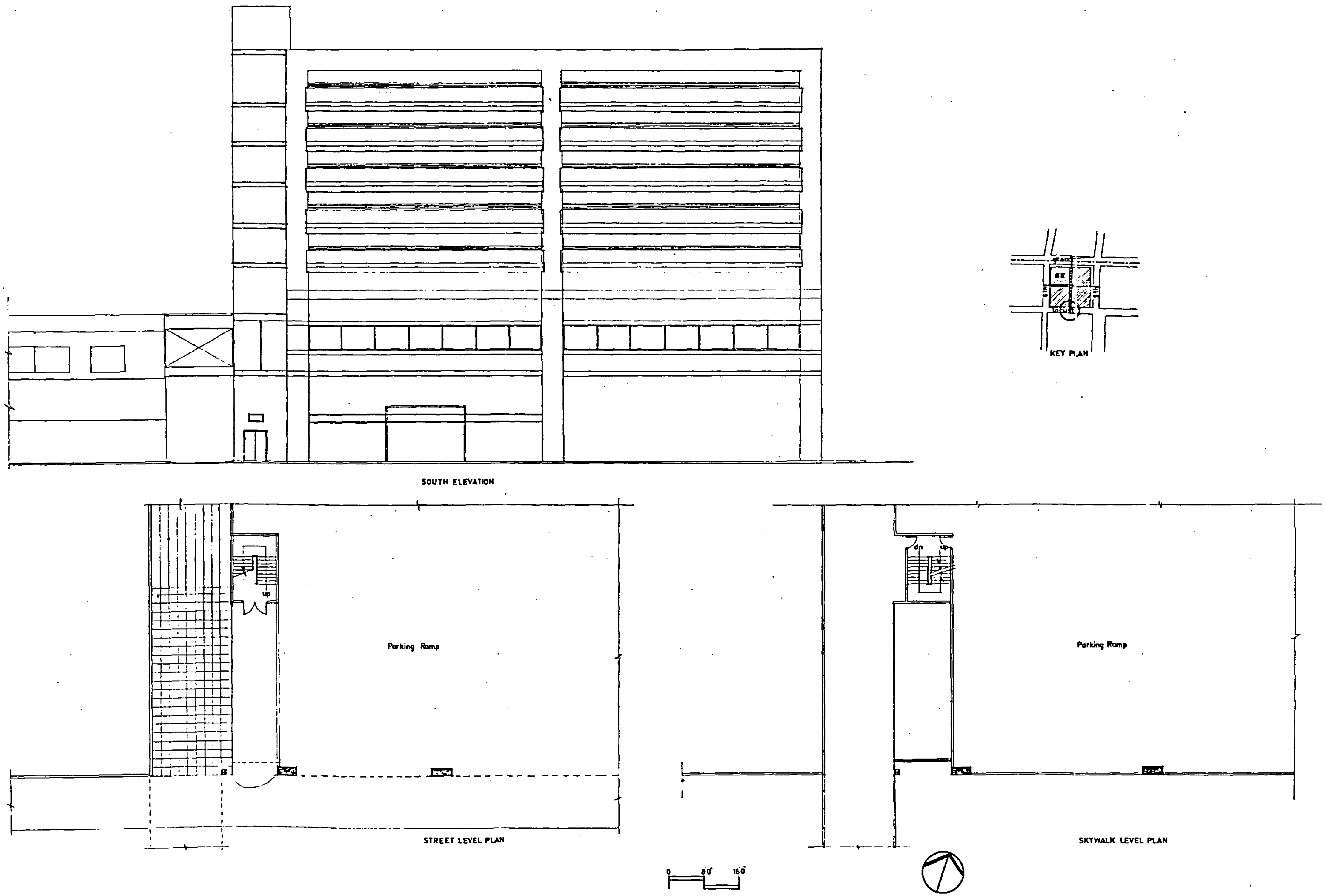


Figure 4.8: Existing condition: 5E(5E-5D), Parking ramp

of the Convention Center, meets the block 5E above the alley in between the parking ramp and a building next to it. The wayfinding hurdle for this bridge end is two (see Figure 4.9 and Figure 4.10).

The vertical connection is a fire exit staircase and an elevator lobby containing two elevators. The elevator lobby and the staircase are located adjacent to each other. The entrance to the vertical connection is a door next to the alley. Although the door is located close to the bridge it does not appear as a public entrance. This is because the awning on it makes it appear more like a door of a private shop or a theatre, thereby, confusing the user as to whether to use it or not. This confusion arises basically due to the design of the entrance.

Bridge end 7D(7D-6D), Younkers store

This bridge end at the Younkers store is on the 7th street and has "N" number of hurdles (see Figure 4.11, Figure 4.13 and Figure 4.14).

The vertical connection is in the form of escalators and elevators located inside the Younkers store. There is absolutely no sign of any access from the sidewalk. The visitor has to enter a private space in order to locate the escalator or the elevators. Though the escalator is visible once inside the store, the user is not sure whether it will lead to the skywalk. Wayfinding inside the store is difficult even for regular users as the interior changes frequently. The skywalk becomes inaccessible after 6 p.m. and on the weekends when the store remains closed.

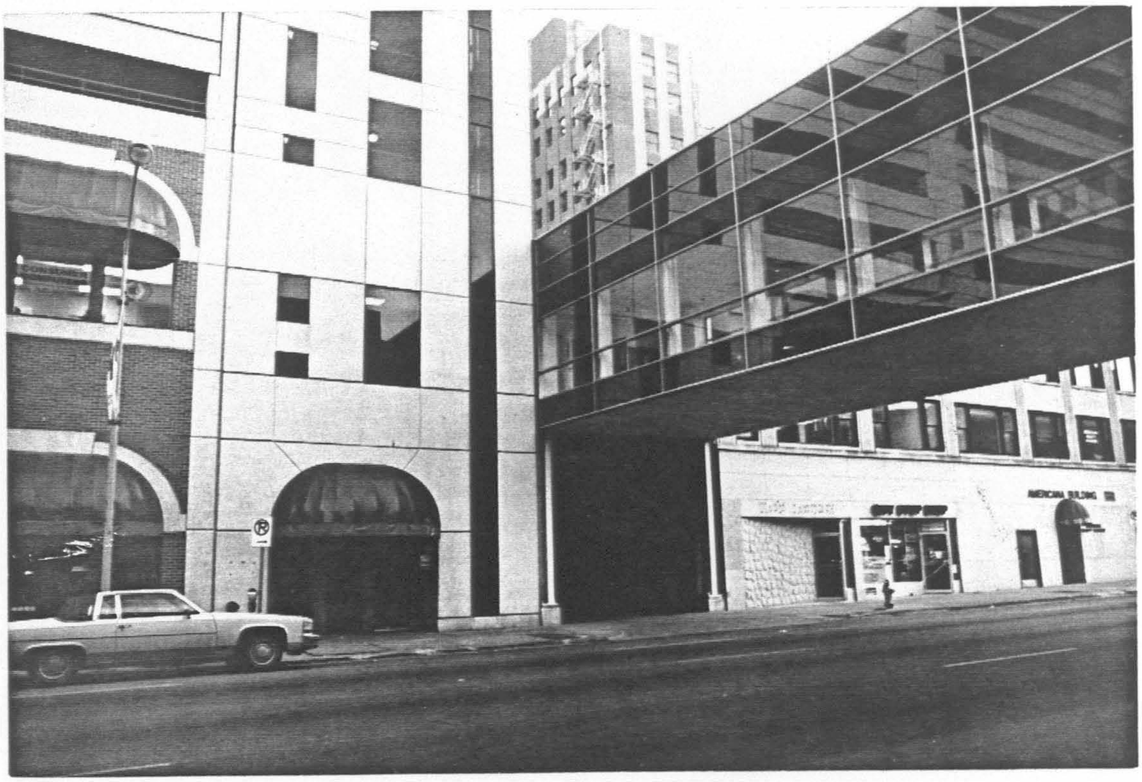


Figure 4.9: Bridge end 5E(5F-5E), Parking ramp

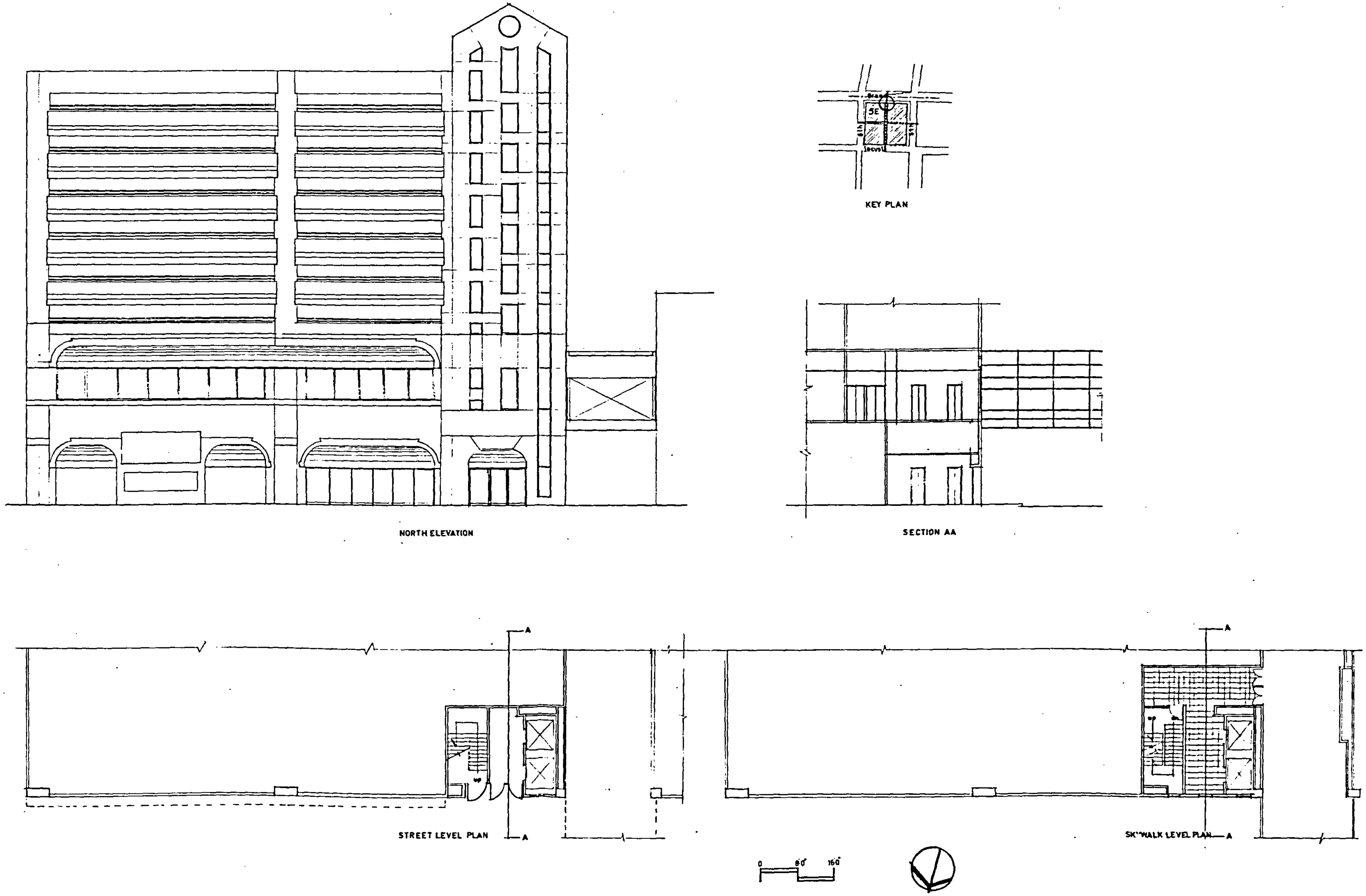


Figure 4.10: Existing condition: 5E(5F-5E), Parking ramp

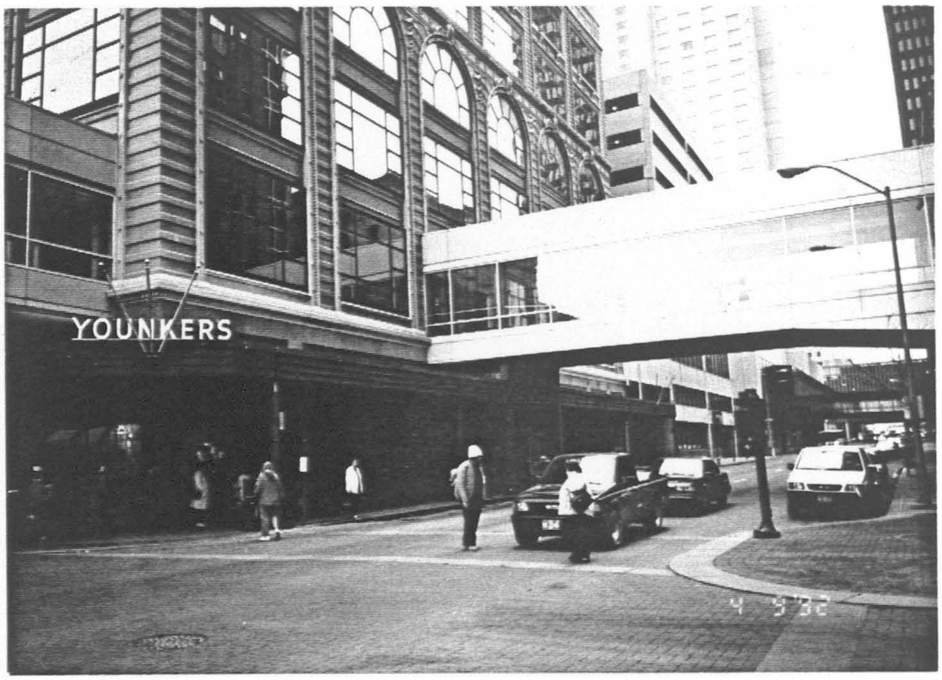


Figure 4.11: Bridge end 7D(7D-6D), Younkers store

Bridge end 7D(7C-7D), Younkers store

This bridge end is on the Younkers store side and joins the Walgreens store across the Mulberry Street. This bridge end is in close proximity to the bridge end 7D(7D-6D). The wayfinding hurdle is "N" (see Figure 4.12, Figure 4.13, Figure 4.14 and Figure 4.15).

There is no indication of a vertical connection from the street. The vertical connection is from inside the Younkers store. The two entrances to the store are a little away from the bridge. One is a little further to the left of the bridge on the Mulberry Street and the other below the bridge end 7D(7D-6D) on the 7th street. Wayfinding inside the store is difficult as the interior changes frequently. The access to the skywalk is dictated by the opening hours of the store.

Proposed Design

Bridge end 5D(5D-4D), Kaleidoscope at the Hub

This bridge end falls in the third category: redesigning the existing vertical connection. The proposed retrofit aims at converting the existing fire exit staircase into a conspicuous element visible from the sidewalk (see Figure 4.16 and Figure 4.17).

The old entrance in the alley is closed and a new entrance is designed on the 5th street facade just next to the skywalk. Transparency has been brought about by the use of glazing at street level as well as at the skywalk level. The door which leads to the staircase now opens on to the street. The wall is fully glazed to make the staircase visible from the sidewalk. The horizontal bands of the skywalk bridge

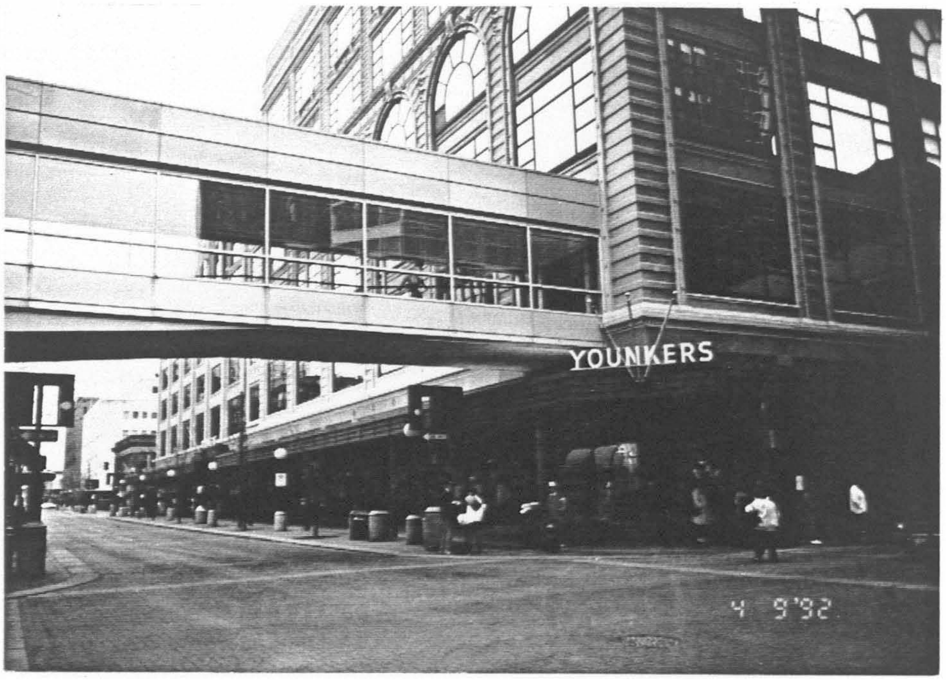


Figure 4.12: Bridge end 7D(7C-7D), Younkers store

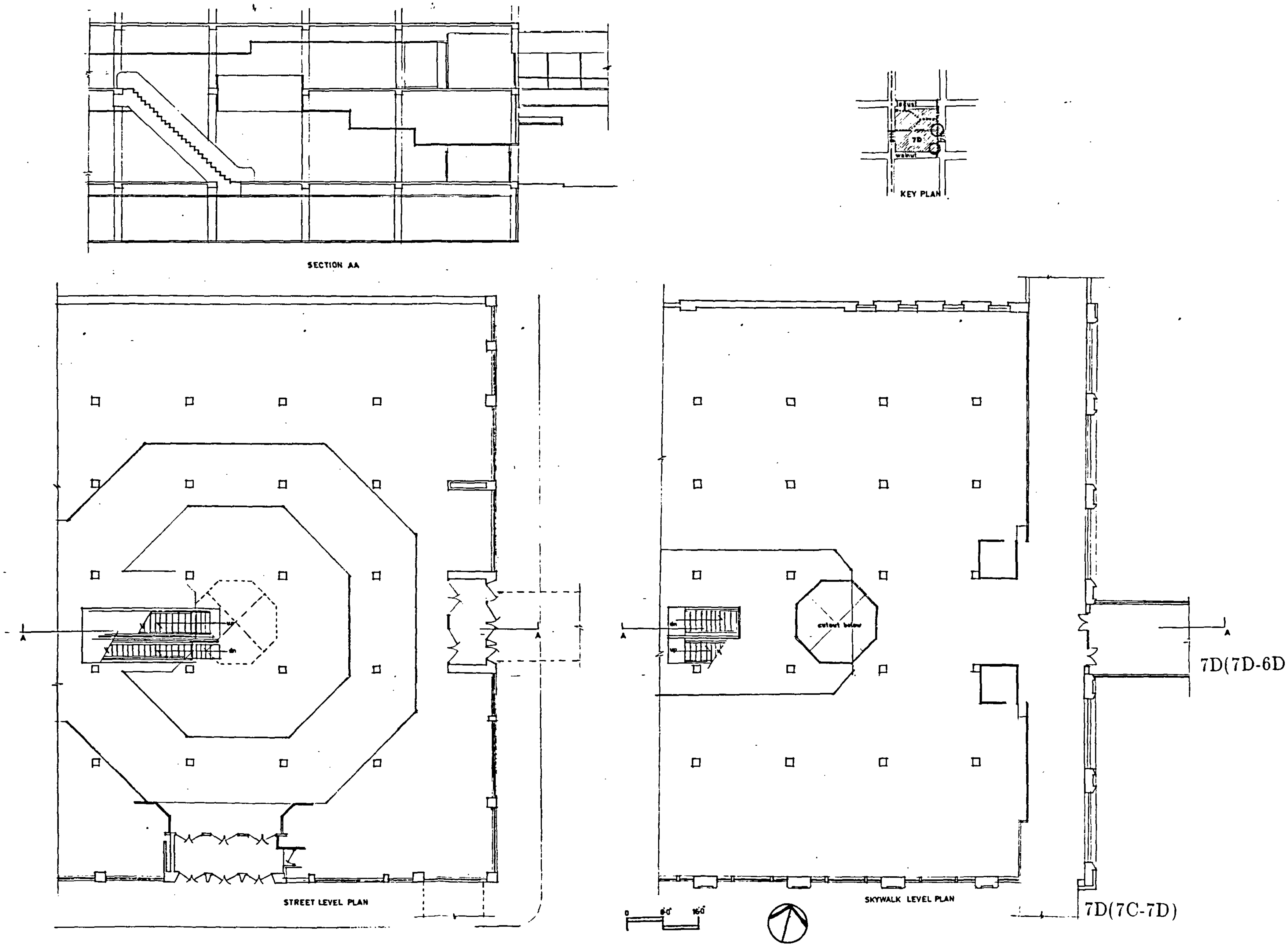


Figure 4.13: Existing condition: 7D(7D-6D) and 7D(7C-7D), Younkers store

Figure 4.14: Existing condition: 7D(7D-6D) and 7D(7C-7D), Younkers store

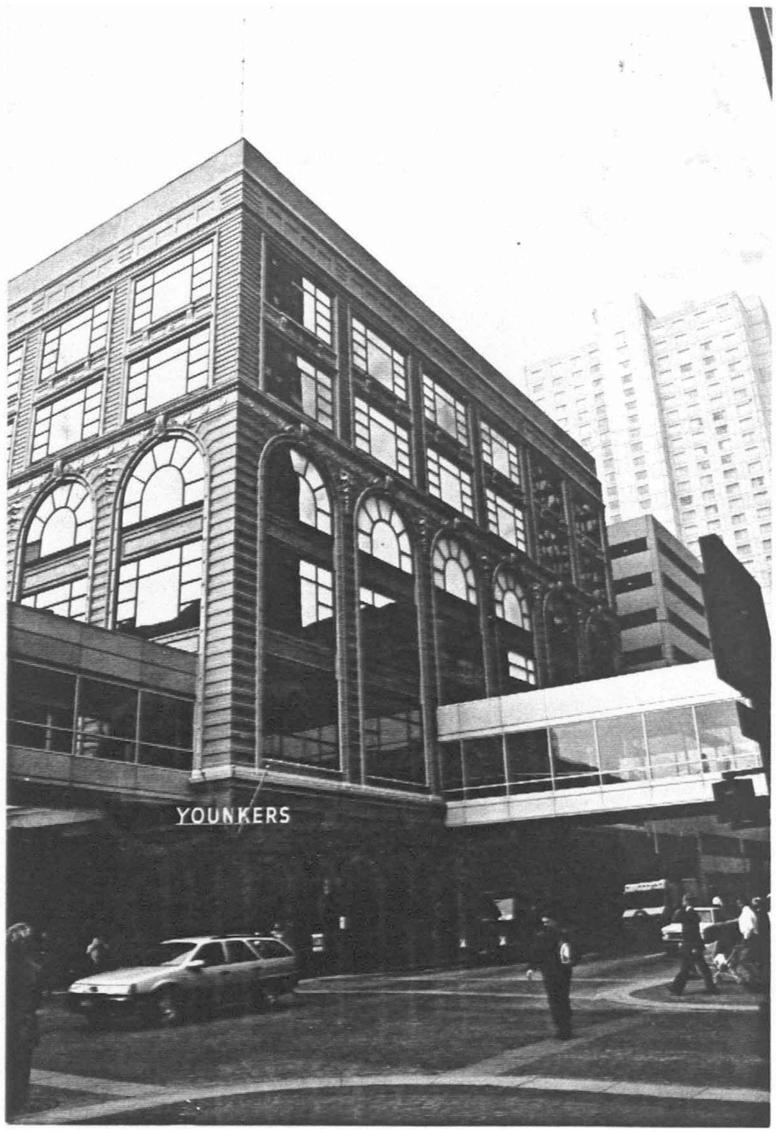


Figure 4.15: Bridge ends 7D(7C-7D) and 7D(7D-6D), Younkers store

have been carried over to the new entrance so that it seems a part of the skywalk and suggests a vertical connection leading to the skywalk.

Bridge end 5E(5E-5D), Parking ramp

This bridge end also falls in the third category: redesigning the existing vertical connection. The existing vertical connection is a fire exit staircase inside an alley. The entrance of the staircase is setback by about forty feet from the street-front. The entrance is not visible until one is directly under the bridge (see Figure 4.18, Figure 4.19 and Figure 4.20).

The design aims at bringing about the entrance to the skywalk right at the street-front. The existing staircase is maintained and an enclosed path is designed from the street to the existing staircase. This tube-like space which is well illuminated seems like an extension to the fire exit path. The walls are recessed in places to serve as a space for advertisements and skywalk directory. The ceiling, curved panels, is made of laminates mounted on plywood. The side walls are washed by lighting fixtures mounted above these curved panels.

On the exterior, the entrance has been recessed from the face of the upper storey. The horizontal bands of the skywalk have been carried over the entrance. The path leading from the sidewalk to the entrance is treated differently from that of the sidewalk to make it look attractive.

Bridge end 5E(5F-5E), Parking ramp

This bridge end requires redesigning the existing vertical connection. The existing vertical connection here is a fire exit staircase and two elevators leading to

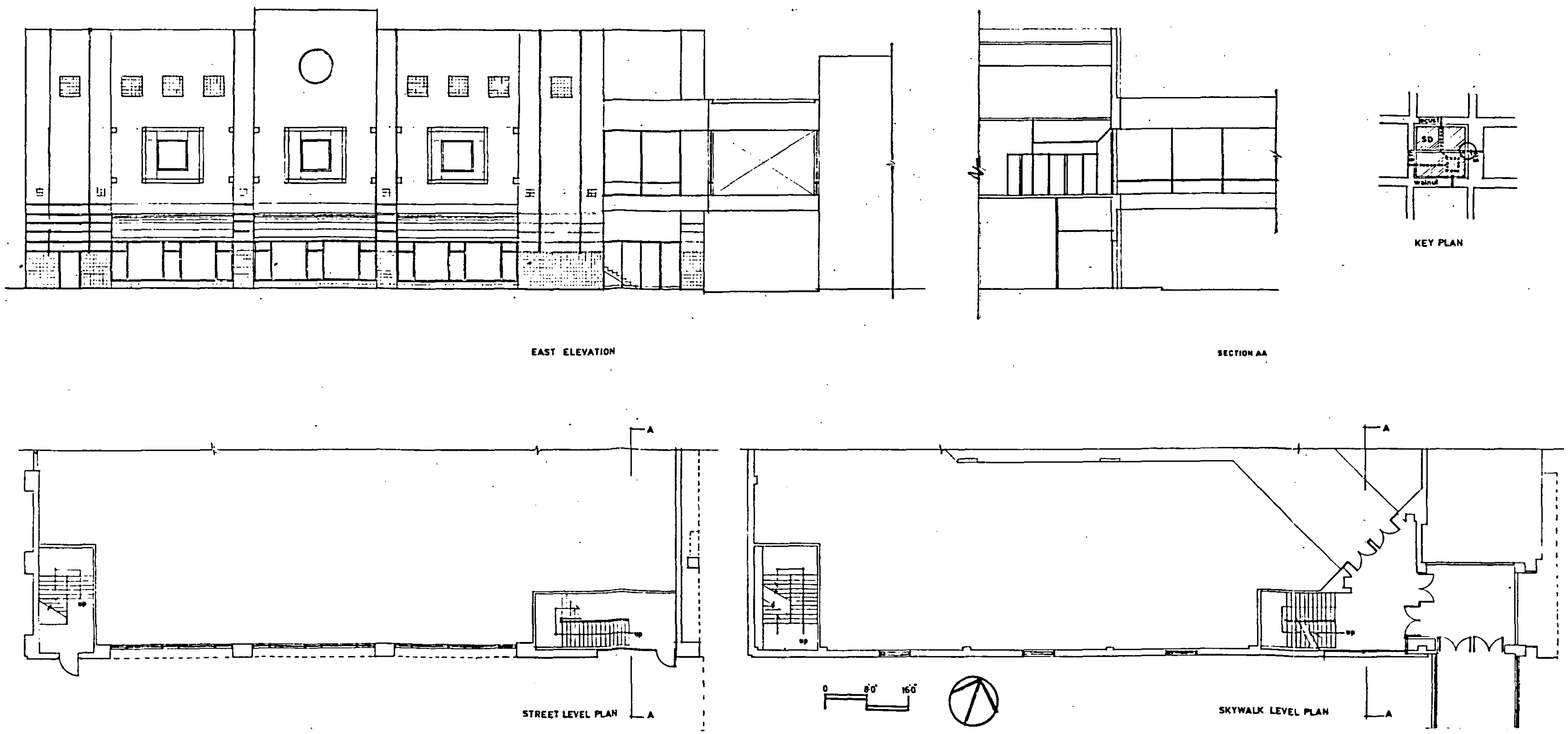


Figure 4.16: Proposed design: 5D(5D-4D), Kaleidoscope at the Hub

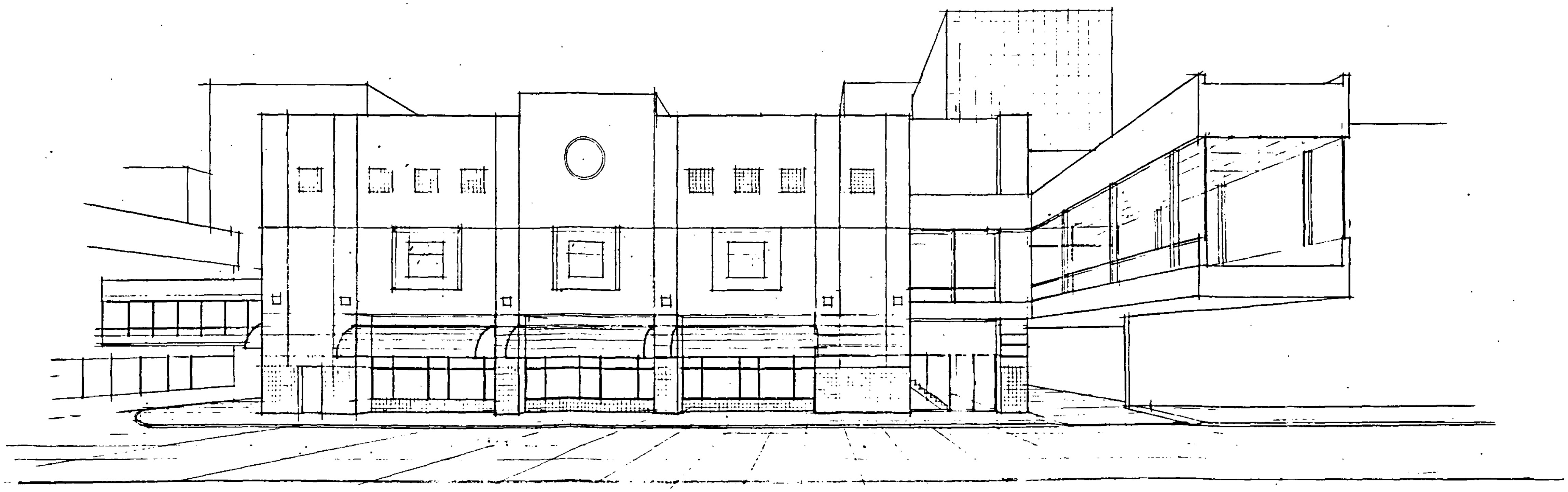


Figure 4.17: Proposed view: 5D(5D-4D), Kaleidoscope at the Hub

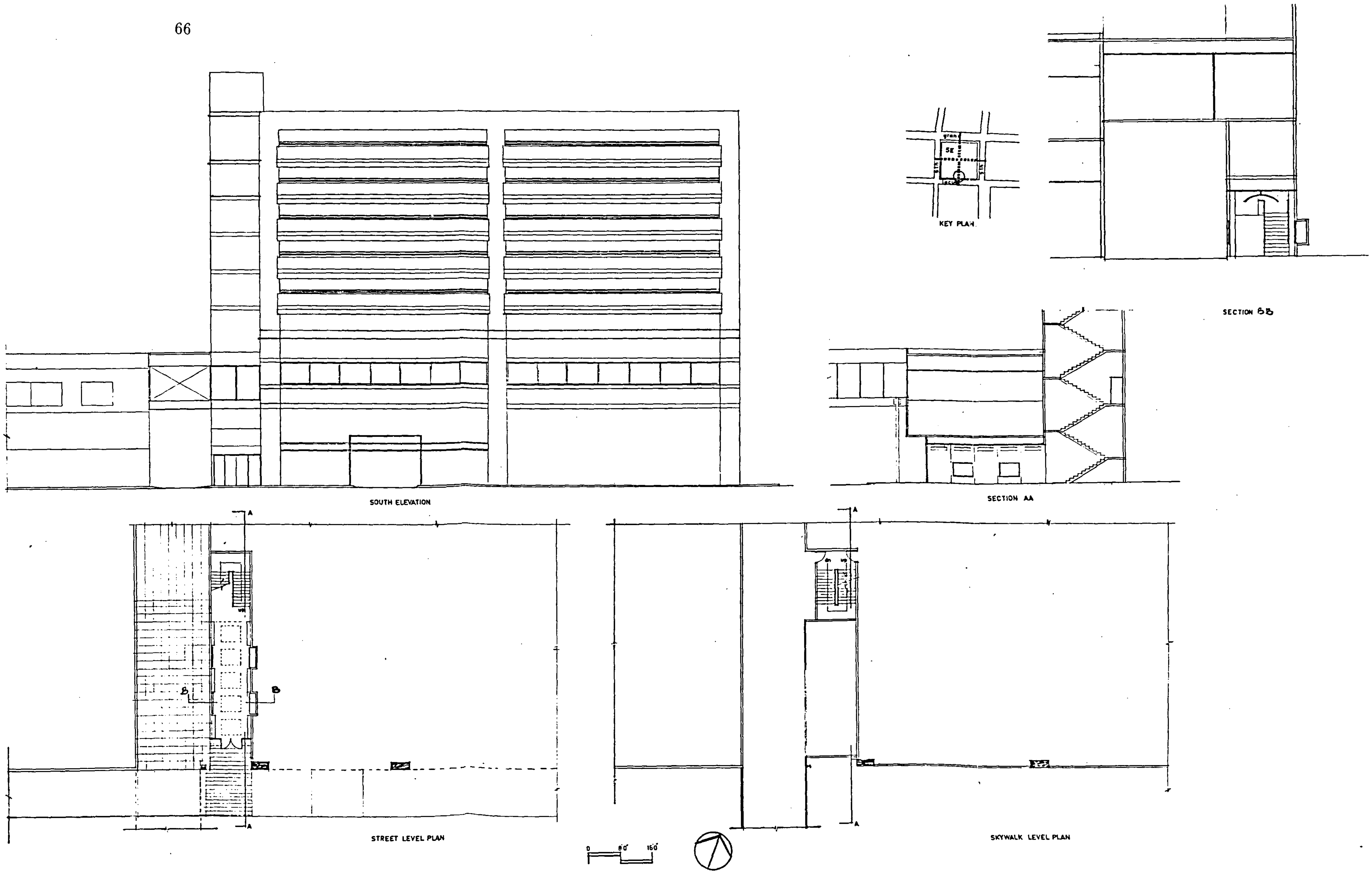


Figure 4.18: Proposed design: 5E(5E-5D), Parking ramp

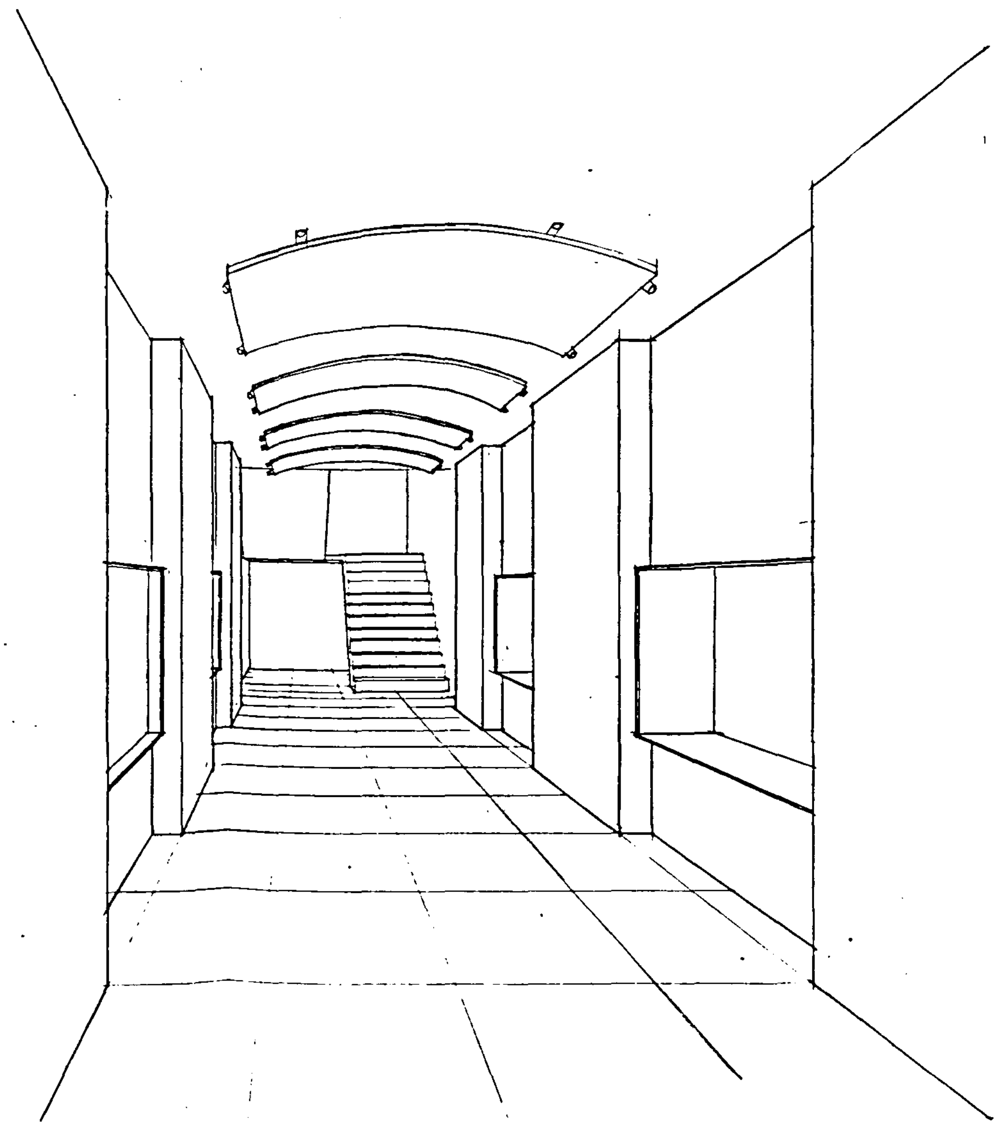


Figure 4.19: Proposed interior view: 5E(5E-5D), Parking ramp

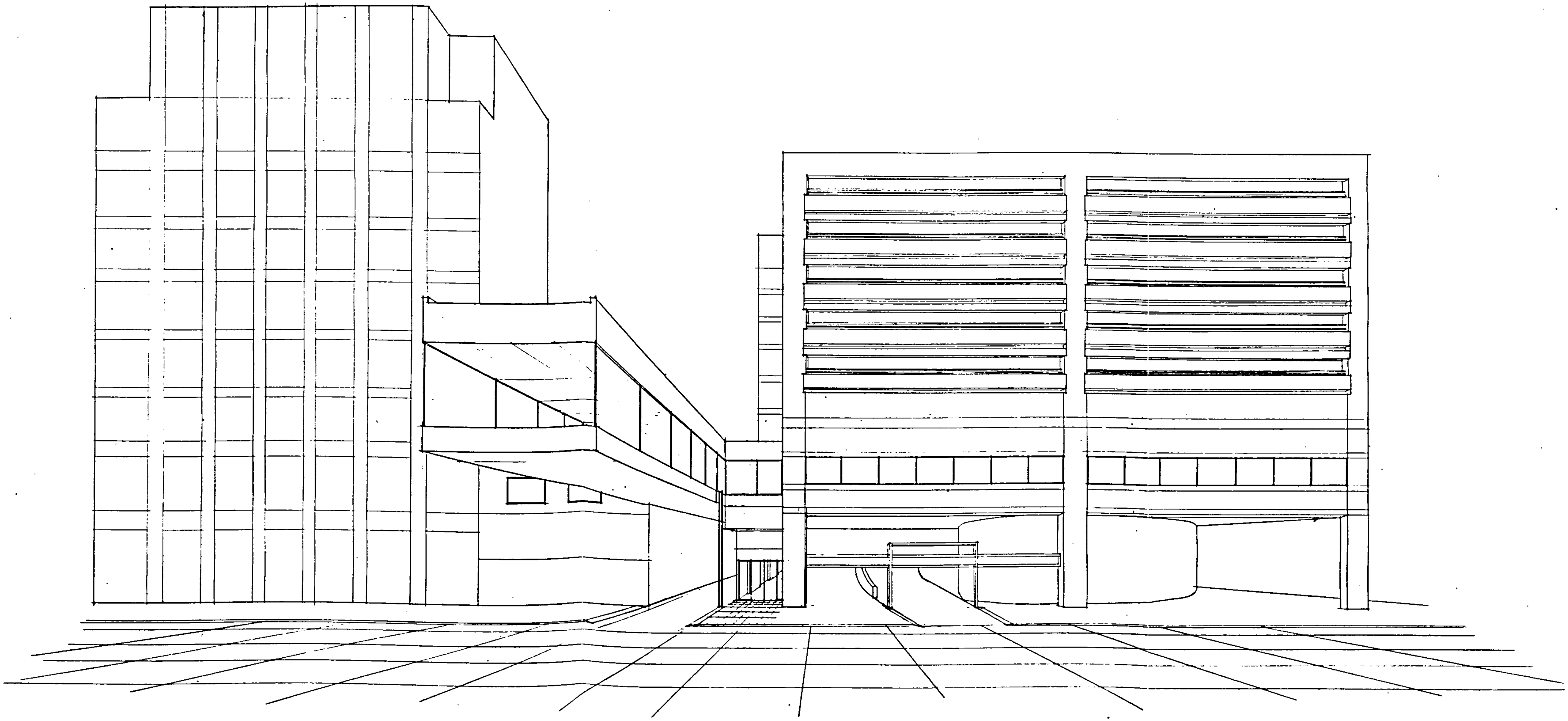


Figure 4.20: Proposed exterior view: 5E(5E-5D), Parking ramp

an entrance door with an awning (see Figure 4.21 and Figure 4.22).

Though the entrance is near the skywalk and the facade of this portion of the building does offer verticality, the awning on it gives an impression of a private space behind it. The proposed design integrates the architectural elements above the entrance with that of the skywalk, at the sametime maintaining the architectural character of the building. The awning has been removed in order to enhance a public image of the building. Glazing is incorporated at the skywalk level and horizontal elements blending with the skywalk bridge are introduced. The new entrance now has a vertical character and echoes the horizontal elements of the skywalk bridge.

Bridge ends 7D(7D-6D) and 7D(7C-7D), Younkers store

These bridges fall under the second category of retrofit typology and require addition of a skywalk lobby integrated with the building. These two bridge ends are at the Younkers store, one on the 7th street and the other on the Mulberry Street. The main entrance to the Younkers store is directly under the bridge 7D-6D. The existing vertical connection is deep inside the Younkers store (see Figure 4.23, Figure 4.24 and Figure 4.25).

The retrofit demands a separate vertical connection near the skywalk bridges. Since the existence of two entrances to the vertical connection and to the Younkers store in such close proximity would be very confusing for the users, only one vertical connection is proposed which would serve both the bridge ends. The entrance to this skywalk lobby is combined with that of the Younkers store. This way people using the skywalk get a glimpse of the Younkers store inside, which improves on the

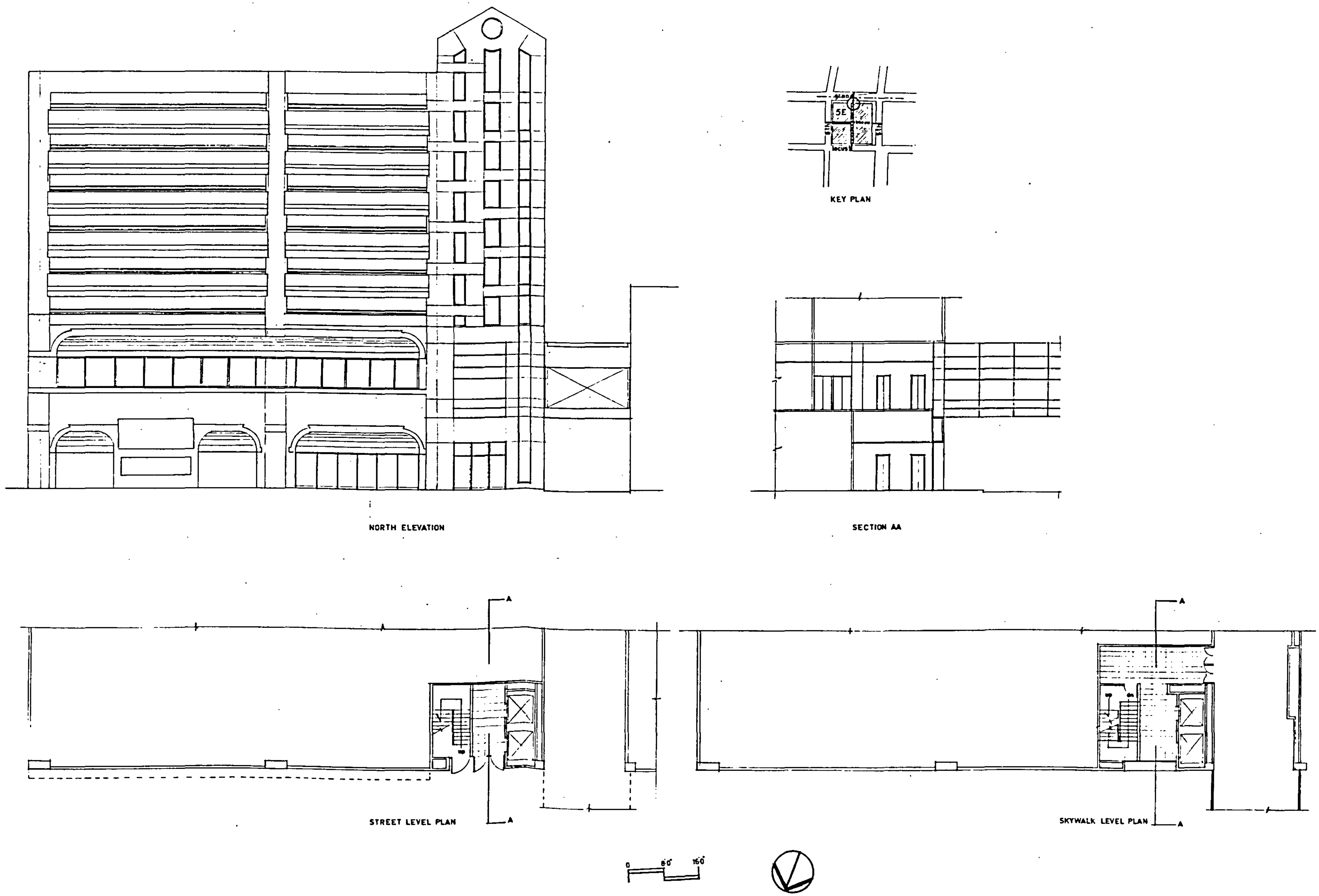


Figure 4.21: Proposed design: 5E(5F-5E), Parking ramp

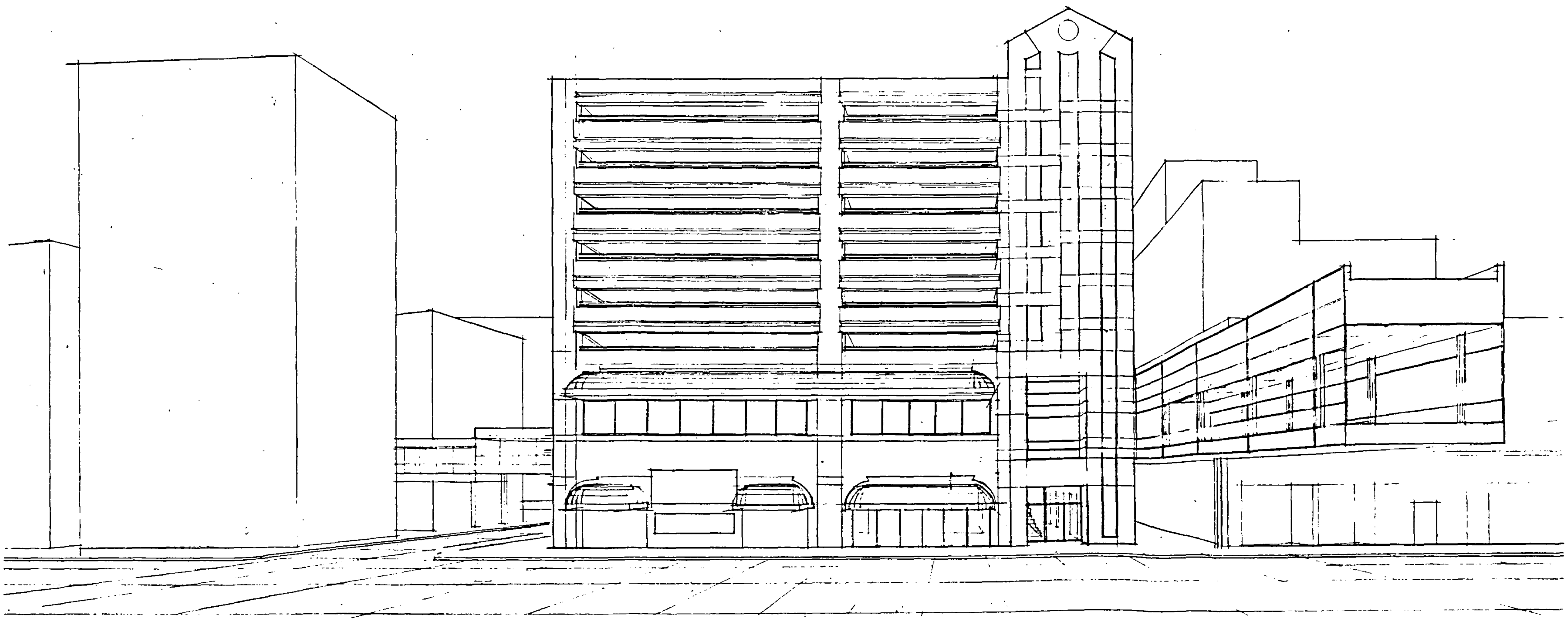


Figure 4.22: Proposed view: 5E(5F-5E), Parking ramp

retail activity of the Younkers. The proposed entrance is directly below the bridge end 7D(7D-6D). The entrance has show windows on either side. The path leading from the sidewalk to the entrance doors is wider near the sidewalk and narrower near the entrance door, an inviting gesture. The glazing is suspended from the ceiling. The structure can be seen behind the glass. A set of doors lead to a skywalk lobby with a staircase to the left and an elevator to the right. The staircase has glass all around it. The elevator car too has clear glass as its walls. The user has a view of the merchandise inside while using either the staircase or the elevator. Further down is the entrance to the Younkers store. Ample use has been made of glass to bring about transparency.

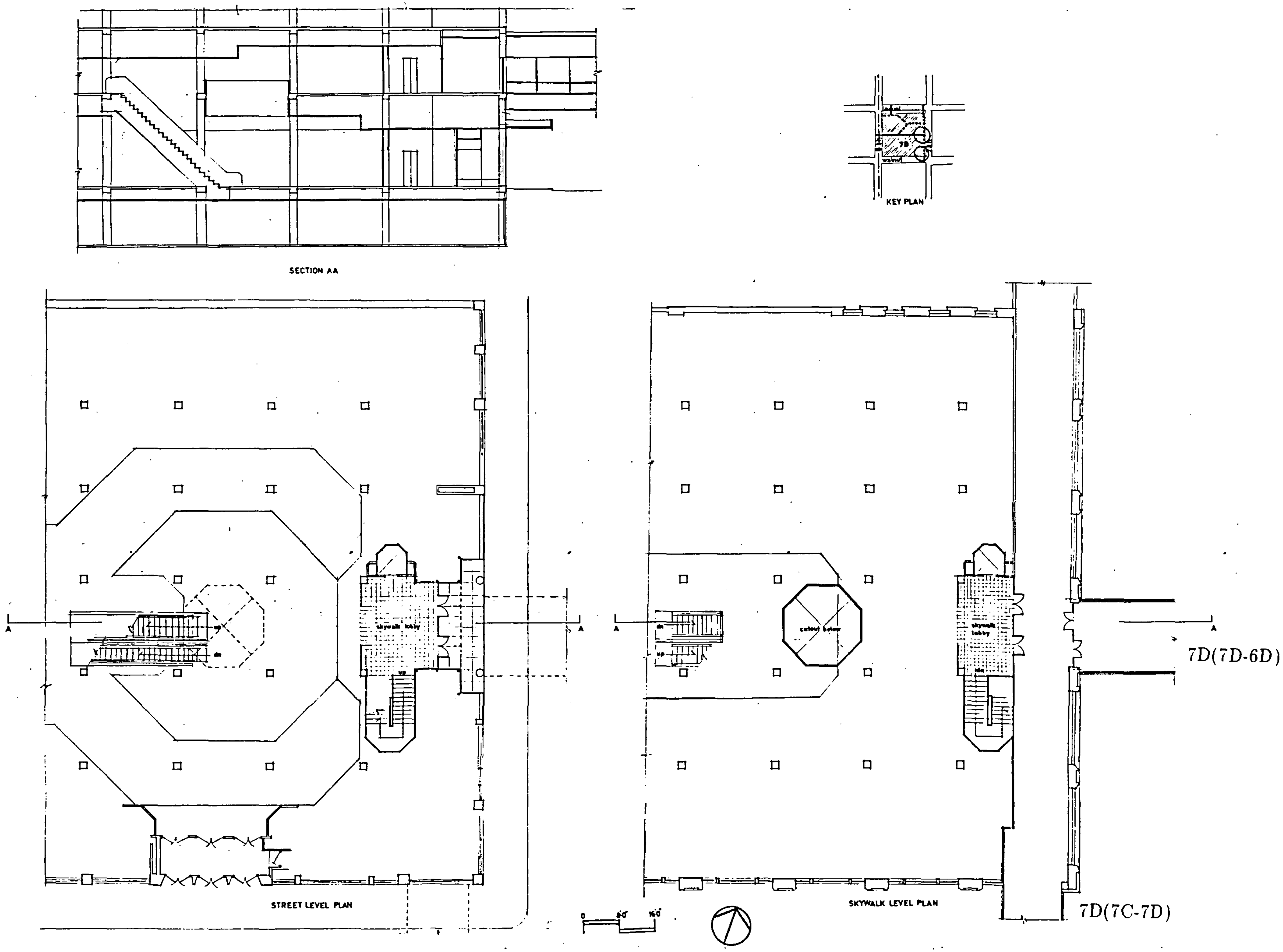


Figure 4.23: Proposed design: 7D(7D-6D) and 7D(7C-7D), Younkers store

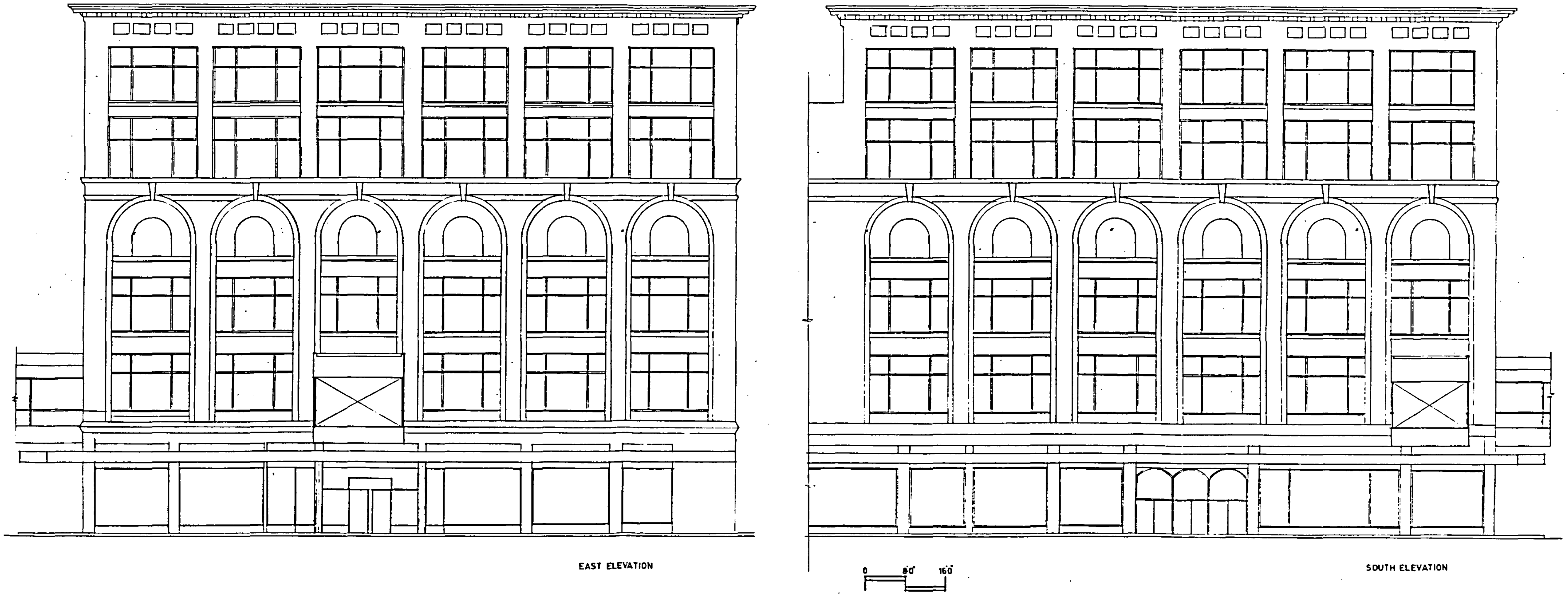


Figure 4.24: Proposed design: 7D(7D-6D) and 7D(7C-7D), Younkers store

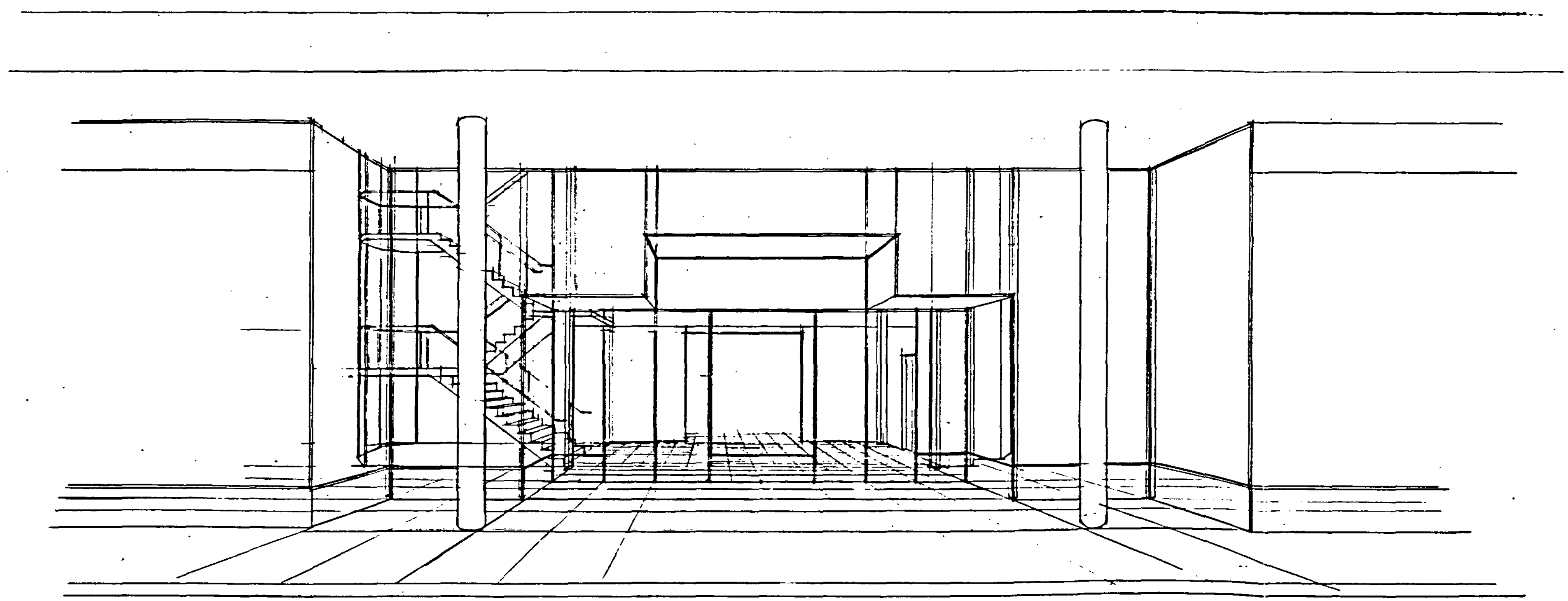


Figure 4.25: Proposed view: 7D(7D-6D) and 7D(7C-7D), Younkers store

Conclusion

This thesis analyzed all the forty two skywalk bridge ends in the study area and prioritized the bridge ends for design retrofitting. A retrofit typology was formulated and design recommendations based on the typology was proposed for each of the bridge ends in the study area. Proposing design solutions for all the forty two bridge ends was beyond the scope of this thesis. Therefore, five bridge ends were selected from the priority list for designing retrofits. The retrofit typology gives a guideline to work within.

Further study is recommended to propose design solutions for the rest of the bridge ends. The typology gives the type of solution needed to be applied. The skywalk guidelines should be used as criteria for designing retrofits as well as for future development. The designed retrofit can be implemented in phases in order of the priority ranking. The "Wayfinding hurdle index" of the bridge ends used in the complete worth method for priority ranking reflect on the degree of accessibility from the street level to the skywalk level. The "Wayfinding hurdle index" would certainly be different for accessibility from the skywalk to the street level. Further research is recommended to measure the wayfinding hurdles for accessibility from the skywalk to the street level. Based on this new index a new priority ranking can be made of the bridge ends for proposing design solutions for accessibility from the skywalk to the street level.

Any new building which will be connected with the skywalk system should integrate both pedestrian system and take into consideration the guidelines for vertical connection. Skywalk systems should be developed as part of an overall city land-use and transportation strategy. The development plan should call for a central core which should include entertainment, retail office and residential zones. This central core can be surrounded by fringe parking structures to be served by a ring road. Buses and cabs can be linked to the skywalk system. The goal should be an organized and compact downtown in which activities support each other and the interests of the pedestrian are paramount. In this type of plan, the skywalk system is viewed as one element of a comprehensive scheme. Without this comprehensive view a skywalk system becomes independent, self-serving and unrelated to the rest of the city.

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APPENDIX A. DATA MAPS

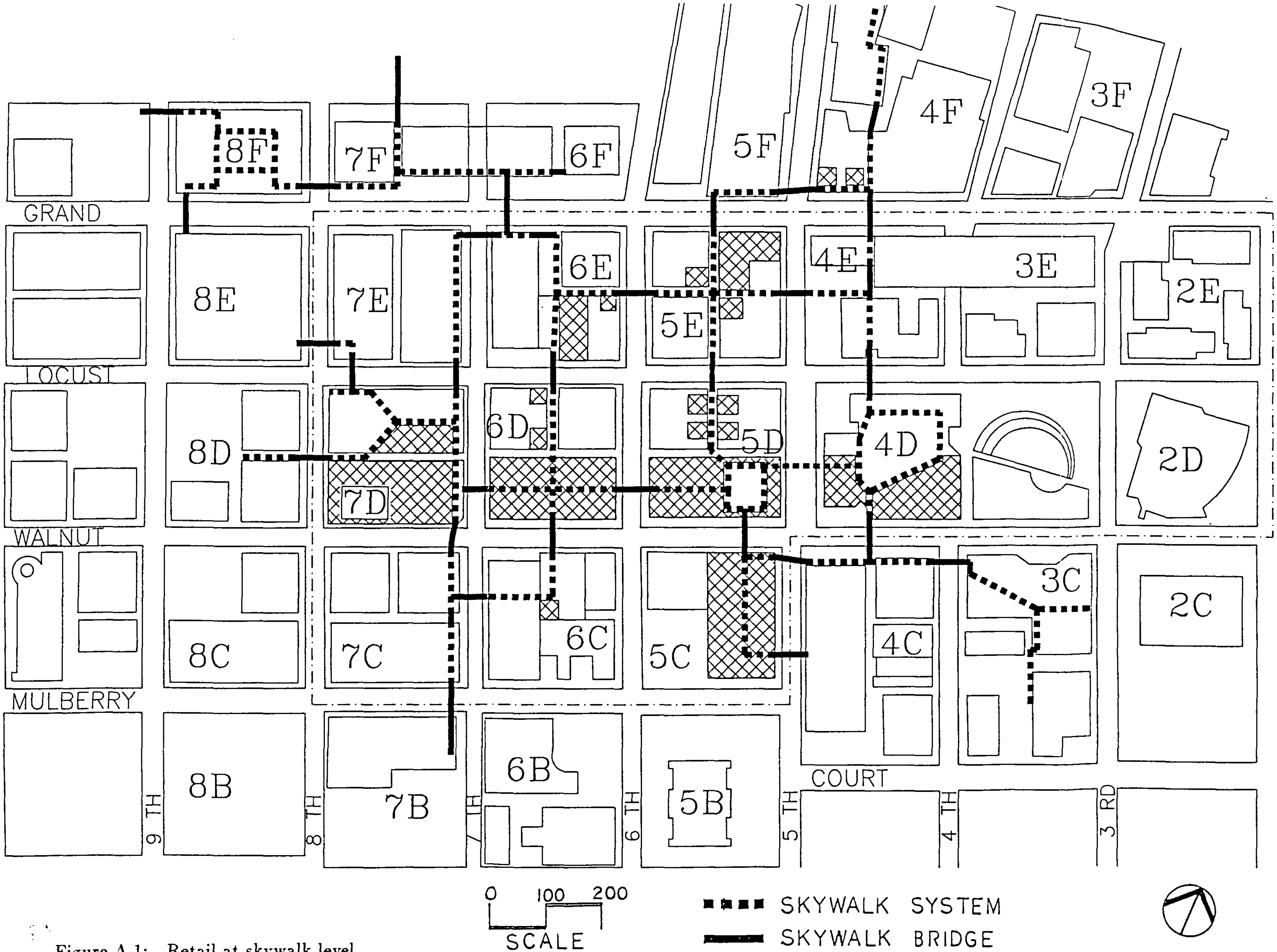

Figure A.1: Retail at skywalk level

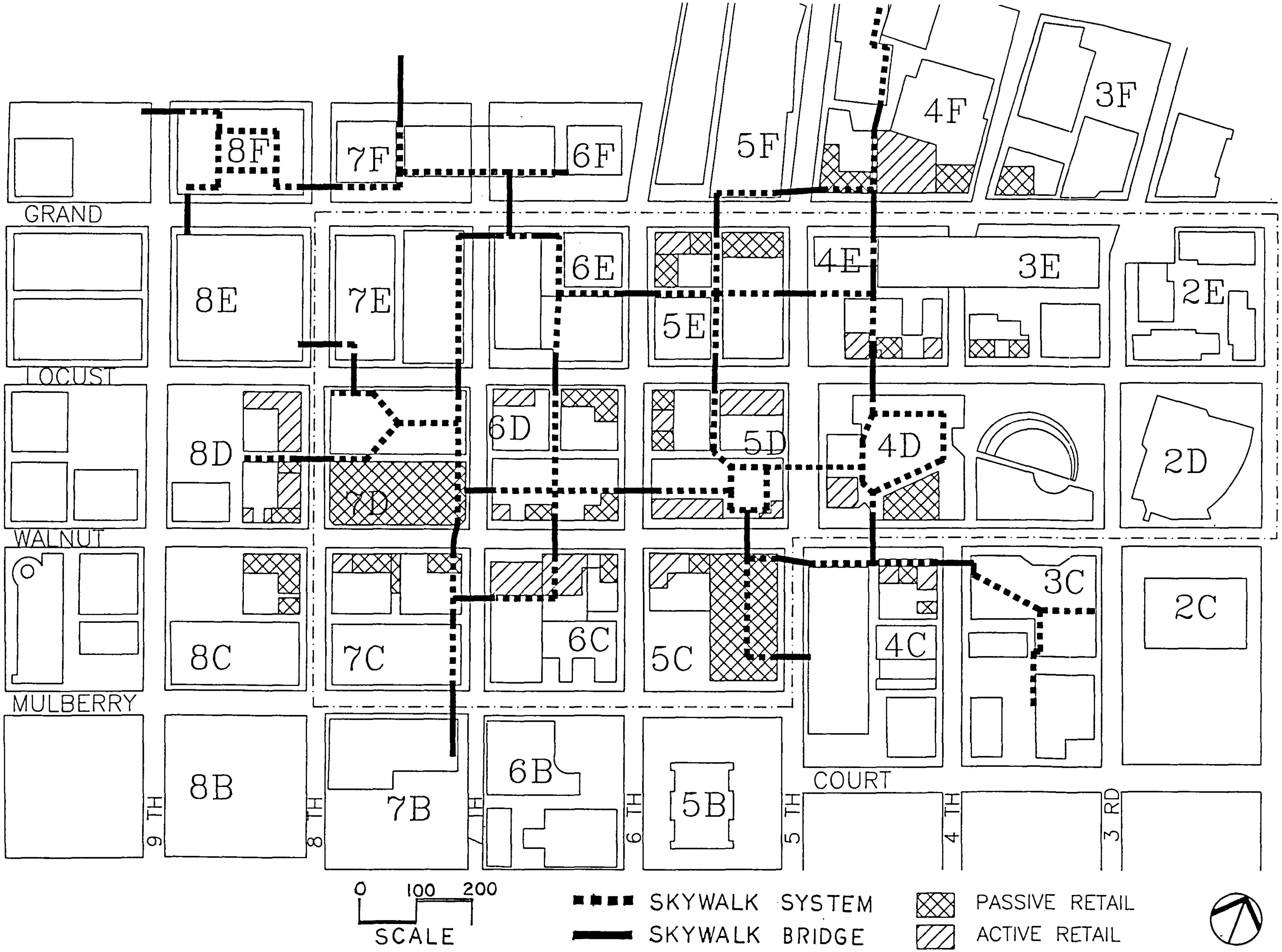

Figure A.2: Retail at street level

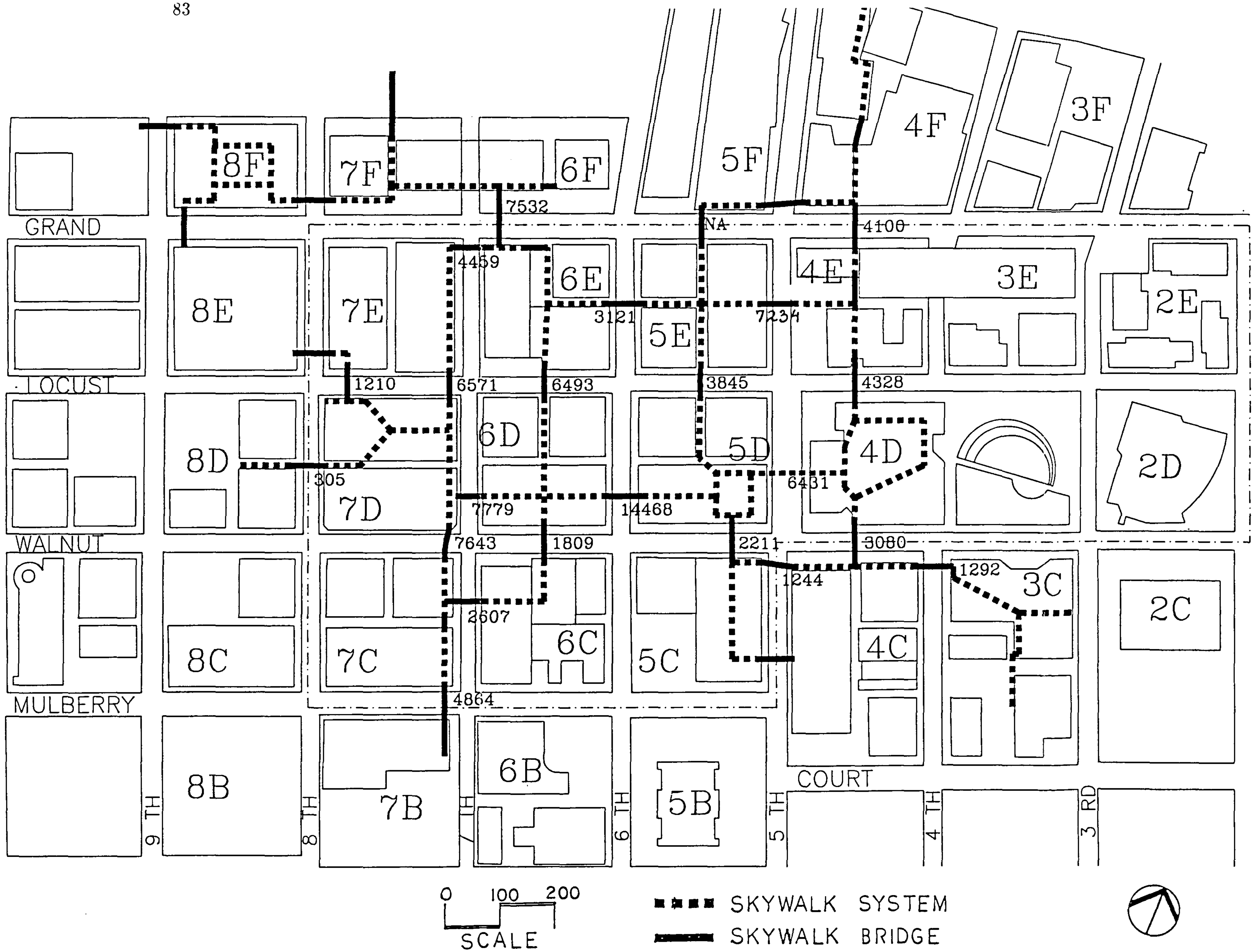

Figure A.3: Daily pedestrian volume on the skywalk bridges

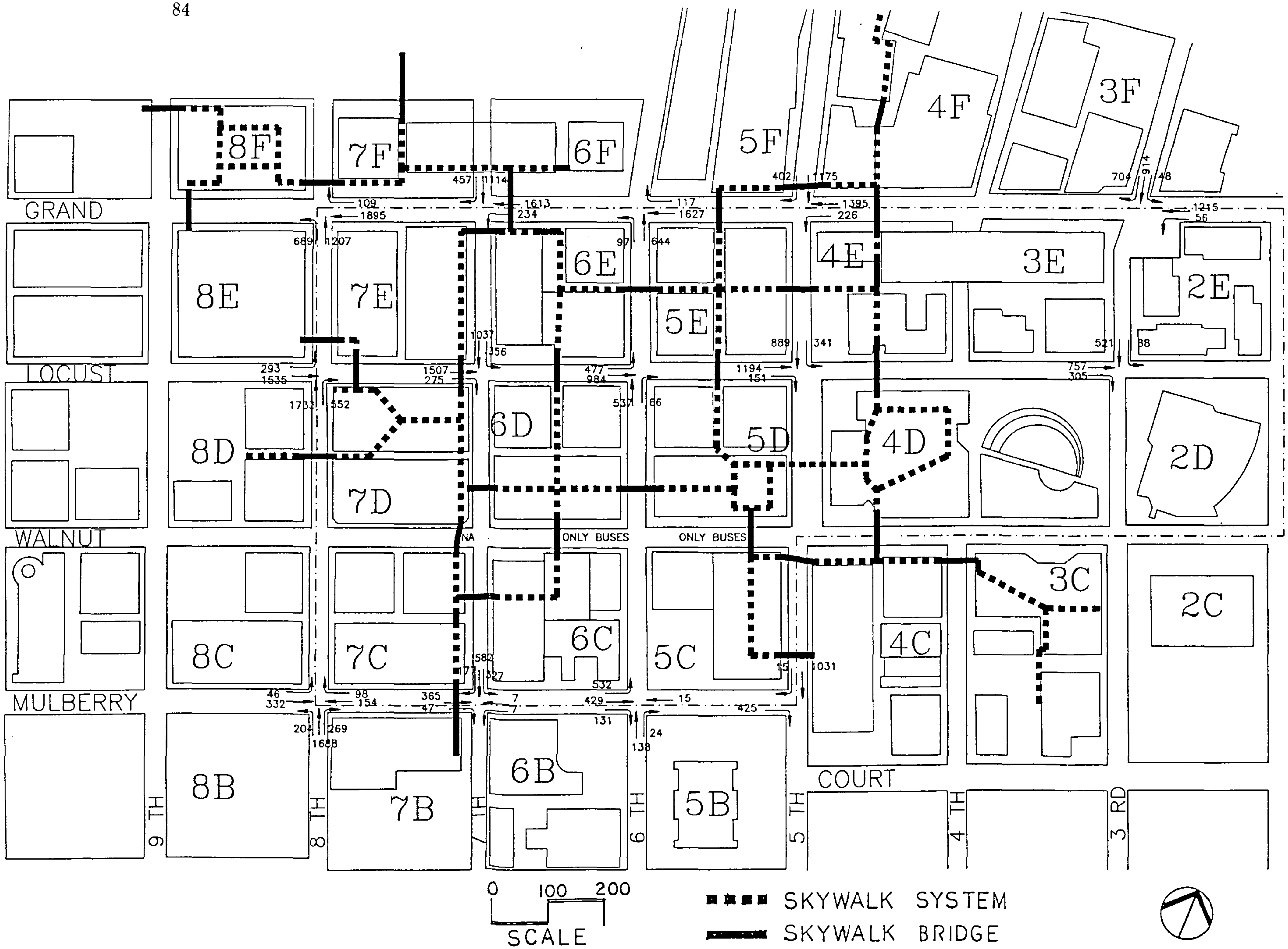

Figure A.4: Hourly traffic count

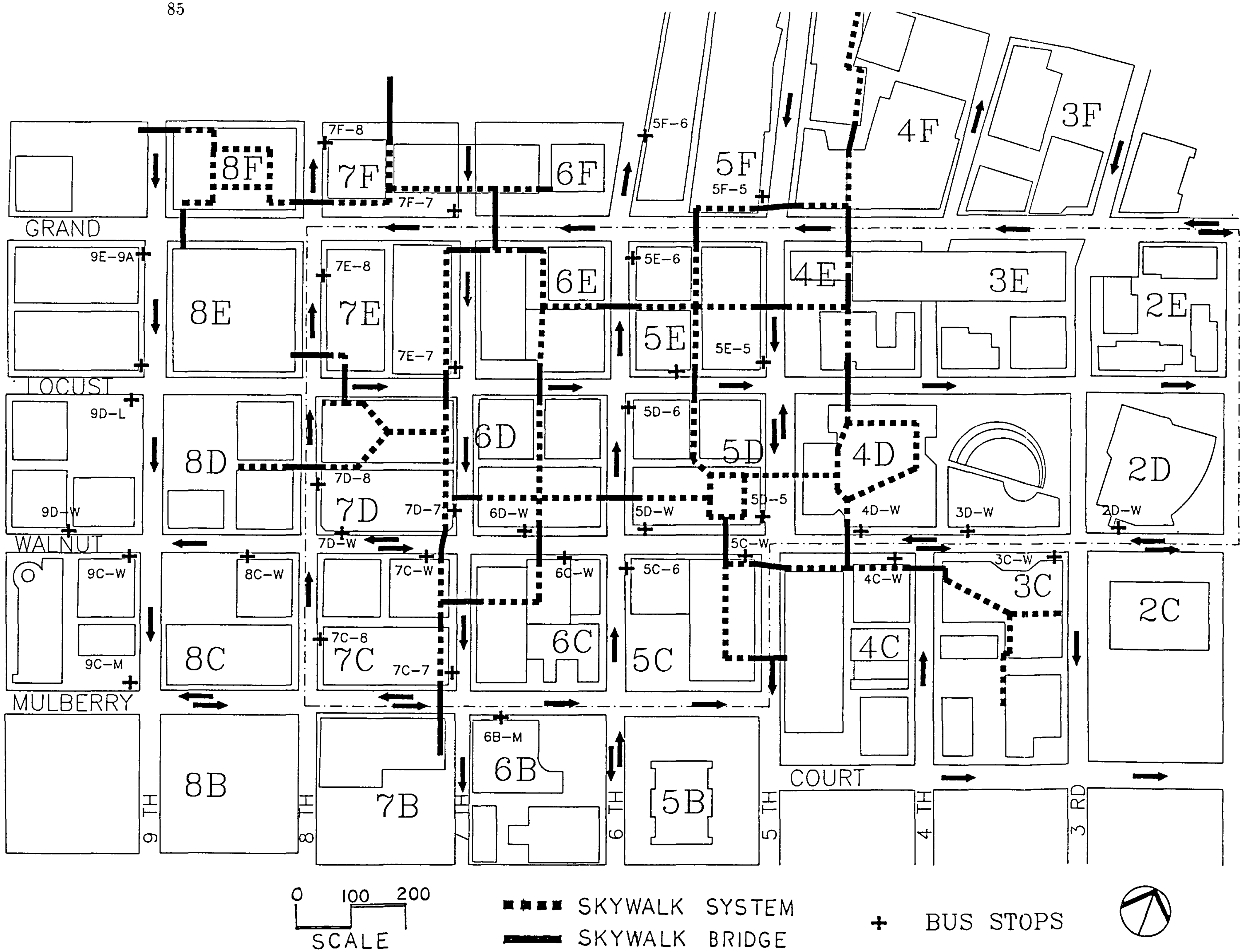

Figure A.5: Traffic direction and bus stops

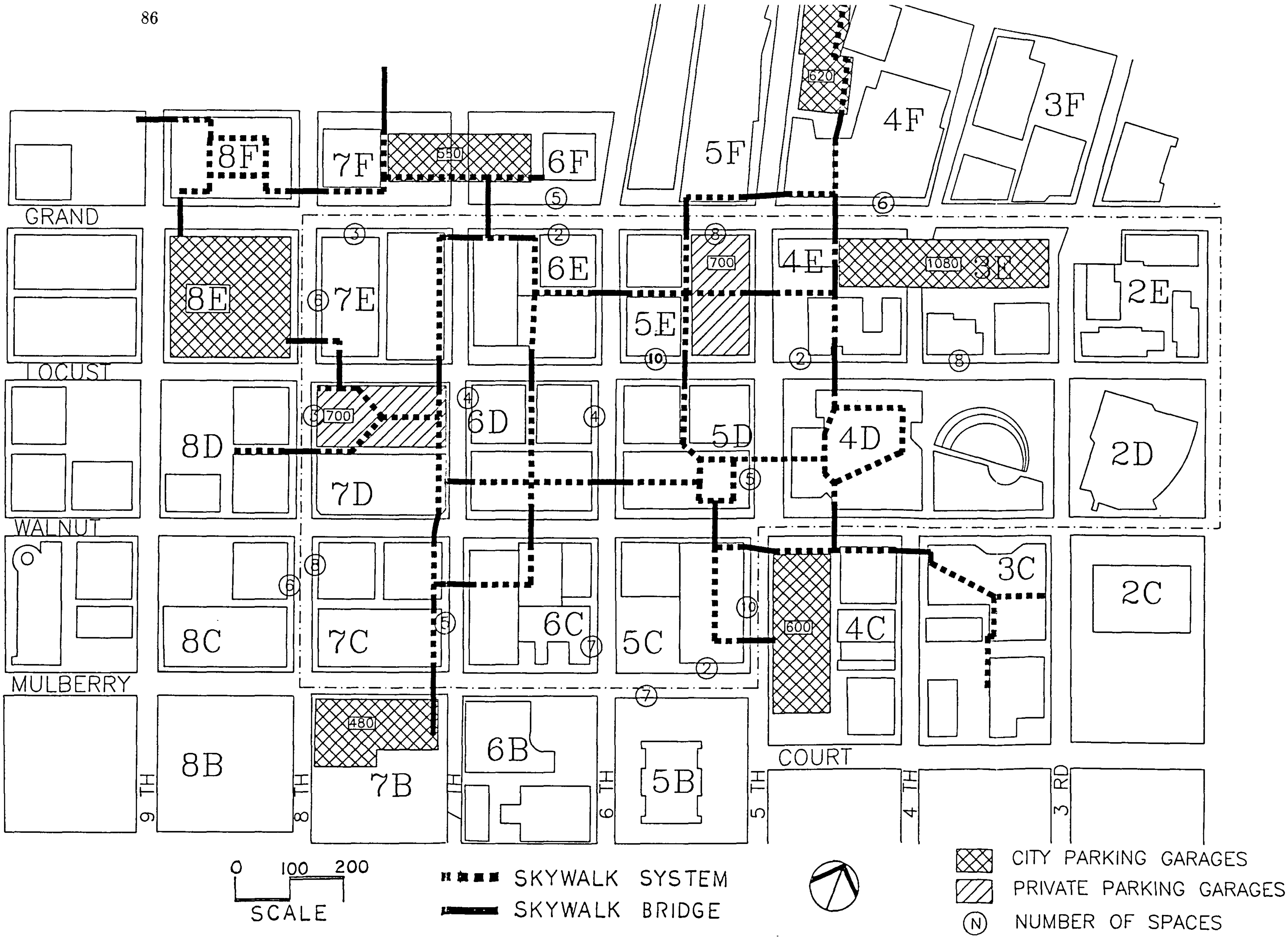

Figure A.6: Street parking and parking garages

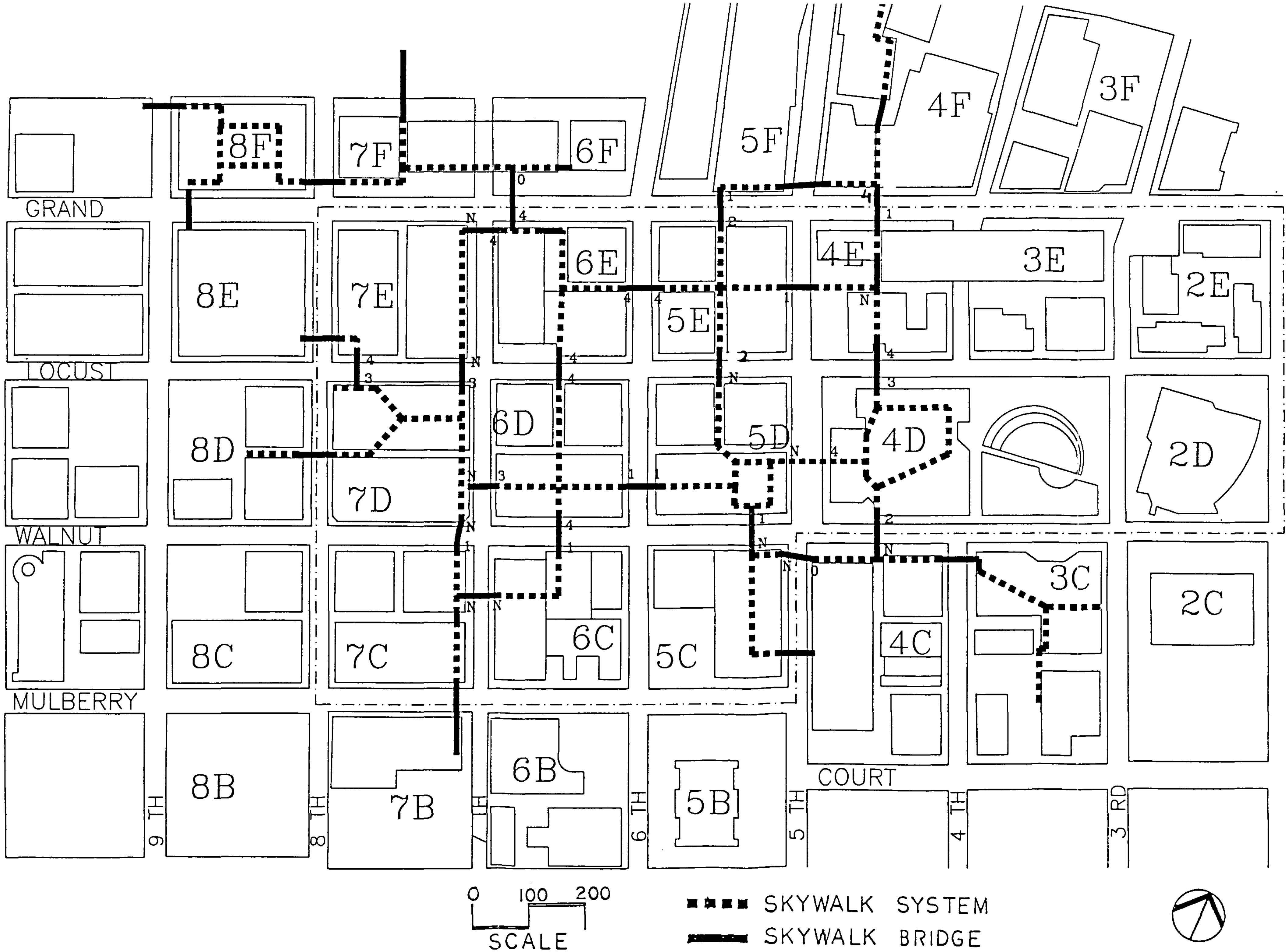

Figure A.7: Wayfinding hurdles

APPENDIX B. HALF-MATRIX METHOD EXAMPLE

The half-matrix method is a method used to prioritize among a set of tasks or variables. This example has been developed by Dr. R.D. Shinn (Shinn, 1988).

For instance, there is a student who has a number of tasks to do and has to decide which task to give priority to. The tasks are as follows:

- Prepare for finals.
- Participate in cultural parade.
- Job interview.
- Visit parents.
- Go for a picnic.
- Redecorate the apartment.

The next step is to list all the tasks and prepare a graph, a half-matrix.

		F	E	D	C	B	A
Finals	A						
Parade	B						
Interview	C						
Parents	D						
Picnic	E						
Redecorate	F						

Read across the rows and compare tasks in rows to that of in each column. Whichever of the pair is the more important one, enter it in the graph. For example, on comparing between task A (Finals) and F (Redecorate), task A is more important than F. Therefore, put down A in the half-matrix. Similarly, between B (Parade) and F (Redecorate), put down B, because B is more important than F. The completed half-matrix is:

		F	E	D	C	B	A
Finals	A	A	A	A	C	A	
Parade	B	B	B	B	C		
Interview	C	C	C	C			
Parents	D	F	D				
Picnic	E	F					
Redecorate	F						

Now count the occurences of each task in the graph. The higher the number of occurences for a task, the more important it is.

Tasks	No. of Occurences	Priority Order
A	4	2nd
B	3	3rd
C	5	1st
D	1	5th
E	0	6th
F	2	4th

Thus, we see that the task "Job interview" is the most important one and "Going for a picnic" the least important.

APPENDIX C. WEIGHTED SCORE TABLES

Table C.1: Weighted scores: Retail at Skywalk level

	Bridge ends	Raw data	Scores	Weighted score
1	6F(6F-6E)	NO	0.00	0.00
2	6E(6F-6E)	NO	0.00	0.00
3	5F(5F-5E)	NO	0.00	0.00
4	5E(5F-5E)	YES	10.00	7.50
5	4F(4F-4E)	YES	10.00	7.50
6	4E(4F-4E)	NO	0.00	0.00
7	6E(6E-5E)	YES	10.00	7.50
8	5E(6E-5E)	YES	10.00	7.50
9	5E(5E-4E)	YES	10.00	7.50
10	4E(5E-4E)	NO	0.00	0.00
11	7E(7E-7D)W	NO	0.00	0.00
12	7D(7E-7D)W	NO	0.00	0.00
13	7E(7E-7D)E	NO	0.00	0.00
14	7D(7E-7D)E	YES	10.00	7.50
15	6E(6E-6D)	YES	10.00	7.50
16	6D(6E-6D)	YES	10.00	7.50
17	5E(5E-5D)	YES	10.00	7.50
18	5D(5E-5D)	YES	10.00	7.50
19	4E(4E-4D)	NO	0.00	0.00
20	4D(4E-4D)	NO	0.00	0.00
21	8D(8D-7D)	NO	0.00	0.00
22	7D(8D-7D)	YES	10.00	7.50
23	7D(7D-6D)	YES	10.00	7.50
24	6D(7D-6D)	YES	10.00	7.50
25	6D(6D-5D)	YES	10.00	7.50
26	5D(6D-5D)	YES	10.00	7.50
27	5D(5D-4D)	YES	10.00	7.50
28	4D(5D-4D)	YES	10.00	7.50
29	7D(7D-7C)	YES	10.00	7.50
30	7C(7D-7C)	NO	0.00	0.00
31	6D(6D-6C)	YES	10.00	7.50
32	6C(6D-6C)	YES	10.00	7.50
33	5D(5D-5C)	YES	10.00	7.50
34	5C(5D-5C)	YES	10.00	7.50
35	4D(4D-4C)	YES	10.00	7.50
36	4C(4D-4C)	NO	0.00	0.00
37	7C(7C-6C)	NO	0.00	0.00
38	6C(7C-6C)	YES	10.00	7.50
39	5C(5C-4C)	YES	10.00	7.50
40	4C(5C-4C)	NO	0.00	0.00
41	7C(7C-7B)	NO	0.00	0.00
42	7B(7C-7B)	NO	0.00	0.00

Table C.2: Weighted scores: Active retail at street level

	Bridge ends	Raw data	Scores	Weighted score
1	6F(6F-6E)	NO	0.00	0.00
2	6E(6F-6E)	NO	0.00	0.00
3	5F(5F-5E)	NO	0.00	0.00
4	5E(5F-5E)	YES	10.00	5.90
5	4F(4F-4E)	YES	10.00	5.90
6	4E(4F-4E)	NO	0.00	0.00
7	6E(6E-5E)	NO	0.00	0.00
8	5E(6E-5E)	YES	10.00	5.90
9	5E(5E-4E)	NO	0.00	0.00
10	4E(5E-4E)	NO	0.00	0.00
11	7E(7E-7D)W	NO	0.00	0.00
12	7D(7E-7D)W	NO	0.00	0.00
13	7E(7E-7D)E	NO	0.00	0.00
14	7D(7E-7D)E	YES	10.00	5.90
15	6E(6E-6D)	NO	0.00	0.00
16	6D(6E-6D)	YES	10.00	5.90
17	5E(5E-5D)	NO	0.00	0.00
18	5D(5E-5D)	YES	10.00	5.90
19	4E(4E-4D)	YES	10.00	5.90
20	4D(4E-4D)	NO	0.00	0.00
21	8D(8D-7D)	YES	10.00	5.90
22	7D(8D-7D)	NO	0.00	0.00
23	7D(7D-6D)	NO	0.00	0.00
24	6D(7D-6D)	NO	0.00	0.00
25	6D(6D-5D)	NO	0.00	0.00
26	5D(6D-5D)	YES	10.00	5.90
27	5D(5D-4D)	YES	10.00	5.90
28	4D(5D-4D)	YES	10.00	5.90
29	7D(7D-7C)	NO	0.00	0.00
30	7C(7D-7C)	NO	0.00	0.00
31	6D(6D-6C)	NO	0.00	0.00
32	6C(6D-6C)	YES	10.00	5.90
33	5D(5D-5C)	YES	10.00	5.90
34	5C(5D-5C)	NO	0.00	0.00
35	4D(4D-4C)	NO	0.00	0.00
36	4C(4D-4C)	YES	10.00	5.90
37	7C(7C-6C)	NO	0.00	0.00
38	6C(7C-6C)	YES	10.00	5.90
39	5C(5C-4C)	NO	0.00	0.00
40	4C(5C-4C)	NO	0.00	0.00
41	7C(7C-7B)	NO	0.00	0.00
42	7B(7C-7B)	NO	0.00	0.00

Table C.3: Weighted scores: Passive retail at street level

	Bridge ends	Raw data	Scores	Weighted score
1	6F(6F-6E)	NO	0.00	0.00
2	6E(6F-6E)	NO	0.00	0.00
3	5F(5F-5E)	NO	0.00	0.00
4	5E(5F-5E)	YES	10.00	2.10
5	4F(4F-4E)	YES	10.00	2.10
6	4E(4F-4E)	NO	0.00	0.00
7	6E(6E-5E)	NO	0.00	0.00
8	5E(6E-5E)	YES	10.00	2.10
9	5E(5E-4E)	NO	0.00	0.00
10	4E(5E-4E)	NO	0.00	0.00
11	7E(7E-7D)W	NO	0.00	0.00
12	7D(7E-7D)W	NO	0.00	0.00
13	7E(7E-7D)E	NO	0.00	0.00
14	7D(7E-7D)E	NO	0.00	0.00
15	6E(6E-6D)	NO	0.00	0.00
16	6D(6E-6D)	YES	10.00	2.10
17	5E(5E-5D)	YES	10.00	2.10
18	5D(5E-5D)	YES	10.00	2.10
19	4E(4E-4D)	YES	10.00	2.10
20	4D(4E-4D)	NO	0.00	0.00
21	8D(8D-7D)	YES	10.00	2.10
22	7D(8D-7D)	YES	10.00	2.10
23	7D(7D-6D)	YES	10.00	2.10
24	6D(7D-6D)	NO	0.00	0.00
25	6D(6D-5D)	YES	10.00	2.10
26	5D(6D-5D)	NO	0.00	0.00
27	5D(5D-4D)	NO	0.00	0.00
28	4D(5D-4D)	NO	0.00	0.00
29	7D(7D-7C)	YES	10.00	2.10
30	7C(7D-7C)	YES	10.00	2.10
31	6D(6D-6C)	YES	10.00	2.10
32	6C(6D-6C)	NO	0.00	0.00
33	5D(5D-5C)	NO	0.00	0.00
34	5C(5D-5C)	YES	10.00	2.10
35	4D(4D-4C)	YES	10.00	2.10
36	4C(4D-4C)	YES	10.00	2.10
37	7C(7C-6C)	YES	10.00	2.10
38	6C(7C-6C)	NO	0.00	0.00
39	5C(5C-4C)	YES	10.00	2.10
40	4C(5C-4C)	NO	0.00	0.00
41	7C(7C-7B)	NO	0.00	0.00
42	7B(7C-7B)	NO	0.00	0.00

Table C.4: Weighted scores: Daily pedestrian count across the bridge ends

	Bridge ends	Raw data	Scores	Weighted score
1	6F(6F-6E)	7532	5.20	4.0560
2	6E(6F-6E)	7532	5.20	4.0560
3	5F(5F-5E)	NA	3.17	2.4726
4	5E(5F-5E)	NA	3.17	2.4726
5	4F(4F-4E)	4100	2.83	2.2047
6	4E(4F-4E)	4100	2.83	2.2047
7	6E(6E-5E)	3121	2.15	1.6770
8	5E(6E-5E)	3121	2.15	1.6770
9	5E(5E-4E)	7234	5.00	3.9000
10	4E(5E-4E)	7234	5.00	3.9000
11	7E(7E-7D)W	1210	0.083	0.0647
12	7D(7E-7D)W	1210	0.083	0.0647
13	7E(7E-7D)E	6571	4.54	3.5412
14	7D(7E-7D)E	6571	4.54	3.5412
15	6E(6E-6D)	6493	4.48	3.4944
16	6D(6E-6D)	6493	4.48	3.4944
17	5E(5E-5D)	3845	2.65	2.0670
18	5D(5E-5D)	3845	2.65	2.0670
19	4E(4E-4D)	4328	2.99	2.3322
20	4D(4E-4D)	4328	2.99	2.3322
21	8D(8D-7D)	305	0.021	0.0164
22	7D(8D-7D)	305	0.021	0.0164
23	7D(7D-6D)	7779	5.37	4.1886
24	6D(7D-6D)	7779	5.37	4.1886
25	6D(6D-5D)	14468	10.00	7.8000
26	5D(6D-5D)	14468	10.00	7.8000
27	5D(5D-4D)	6431	4.44	3.4632
28	4D(5D-4D)	6431	4.44	3.4632
29	7D(7D-7C)	7643	5.28	4.1184
30	7C(7D-7C)	7643	5.28	4.1184
31	6D(6D-6C)	1809	1.25	0.9750
32	6D(6D-6C)	1809	1.25	0.9750
33	5D(5D-5C)	2211	1.52	1.1856
34	5C(5D-5C)	2211	1.52	1.1856
35	4D(4D-4C)	3080	2.12	1.6356
36	4C(4D-4C)	3080	2.12	1.6356
37	7C(7C-6C)	2607	1.80	1.4040
38	6C(7C-6C)	2607	1.80	1.4040
39	5C(5C-4C)	1244	0.085	0.0663
40	4C(5C-4C)	1244	0.085	0.0663
41	7C(7C-7B)	4864	3.36	2.6208
42	7B(7C-7B)	4864	3.36	2.6208

Table C.5: Weighted scores: Hourly traffic count under the bridge ends

	Bridge ends	Raw data	Scores	Weighted score
1	6F(6F-6E)	1847	8.08	1.6968
2	6E(6F-6E)	1847	8.08	1.6968
3	5F(5F-5E)	1744	7.63	1.6023
4	5E(5F-5E)	1744	7.63	1.6023
5	4F(4F-4E)	1621	7.09	1.4889
6	4E(4F-4E)	1621	7.09	1.4889
7	6E(6E-5E)	741	3.24	0.6804
8	5E(6E-5E)	741	3.24	0.6804
9	5E(5E-4E)	1230	5.38	1.1298
10	4E(5E-4E)	1230	5.38	1.1298
11	7E(7E-7D)W	1782	7.79	1.6359
12	7D(7E-7D)W	1782	7.79	1.6359
13	7E(7E-7D)E	1782	7.79	1.6359
14	7D(7E-7D)E	1782	7.79	1.6359
15	6E(6E-6D)	1461	6.39	1.3419
16	6D(6E-6D)	1461	6.39	1.3419
17	5E(5E-5D)	1345	5.88	1.2348
18	5D(5E-5D)	1345	5.88	1.2348
19	4E(4E-4D)	1062	4.64	0.9744
20	4D(4E-4D)	1062	4.64	0.9744
21	8D(8D-7D)	2285	10.00	2.1000
22	7D(8D-7D)	2285	10.00	2.1000
23	7D(7D-6D)	1312	5.74	1.2054
24	6D(7D-6D)	1312	5.74	1.2054
25	6D(6D-5D)	603	2.63	0.5523
26	5D(6D-5D)	603	2.63	0.5523
27	5D(5D-4D)	1040	4.55	0.9555
28	4D(5D-4D)	1040	4.55	0.9555
29	7D(7D-7C)	NA	5.81	1.2210
30	7C(7D-7C)	NA	5.81	1.2210
31	6D(6D-6C)	00	0.00	0.0000
32	6C(6D-6C)	00	0.00	0.0000
33	5D(5D-5C)	00	0.00	0.0000
34	5C(5D-5C)	00	0.00	0.0000
35	4D(4D-4C)	1142	5.00	1.0500
36	4C(4D-4C)	1142	5.00	1.0500
37	7C(7C-6C)	1086	4.75	0.9975
38	6C(7C-6C)	1086	4.75	0.9975
39	5C(5C-4C)	1046	4.57	0.9597
40	4C(5C-4C)	1046	4.57	0.9597
41	7C(7C-7B)	596	2.60	0.5460
42	7C(7C-7B)	596	2.60	0.5460

Table C.6: Weighted scores: Bus stops near the bridge ends

	Bridge ends	Raw data	Scores	Weighted score
1	6F(6F-6E)	1	5.00	2.50
2	6E(6F-6E)	0	0.00	0.00
3	5F(5F-5E)	1	5.00	2.50
4	5E(5F-5E)	1	5.00	2.50
5	4F(4F-4E)	0	0.00	0.00
6	4E(4F-4E)	0	0.00	0.00
7	6E(6E-5E)	0	0.00	0.00
8	5E(6E-5E)	0	0.00	0.00
9	5E(5E-4E)	1	5.00	2.50
10	4E(5E-4E)	0	0.00	0.00
11	7E(7E-7D)W	0	0.00	0.00
12	7D(7E-7D)W	0	0.00	0.00
13	7E(7E-7D)E	1	5.00	2.50
14	7D(7E-7D)E	0	0.00	0.00
15	6E(6E-6D)	0	0.00	0.00
16	6D(6E-6D)	0	0.00	0.00
17	5E(5E-5D)	2	10.00	5.00
18	5D(5E-5D)	1	5.00	2.50
19	4E(4E-4D)	0	0.00	0.00
20	4D(4E-4D)	0	0.00	0.00
21	8D(8D-7D)	0	0.00	0.00
22	7D(8D-7D)	1	5.00	2.50
23	7D(7D-6D)	1	5.00	2.50
24	6D(7D-6D)	0	0.00	0.00
25	6D(6D-5D)	0	0.00	0.00
26	5D(6D-5D)	2	10.00	5.00
27	5D(5D-4D)	1	5.00	2.50
28	4D(5D-4D)	0	0.00	0.00
29	7D(7D-7C)	2	10.00	5.00
30	7C(7D-7C)	1	5.00	2.50
31	6D(6D-6C)	1	5.00	2.50
32	6C(6D-6C)	2	10.00	5.00
33	5D(5D-5C)	2	10.00	5.00
34	5C(5D-5C)	2	10.00	5.00
35	4D(4D-4C)	1	5.00	2.50
36	4C(4D-4C)	1	5.00	2.50
37	7C(7C-6C)	1	5.00	2.50
38	6C(7C-6C)	0	0.00	0.00
39	5C(5C-4C)	0	0.00	0.00
40	4C(5C-4C)	0	0.00	0.00
41	7C(7C-7B)	1	5.00	2.50
42	7C(7C-7B)	1	5.00	2.50

Table C.7: Weighted scores: Street parking near the bridge ends

	Bridge ends	Raw data	Scores	Weighted score
1	6F(6F-6E)	5	5.00	1.40
2	6E(6F-6E)	2	2.00	0.56
3	5F(5F-5E)	0	0.00	0.00
4	5E(5F-5E)	8	8.00	2.24
5	4F(4F-4E)	6	6.00	1.68
6	4E(4F-4E)	0	0.00	0.00
7	6E(6E-5E)	0	0.00	0.00
8	5E(6E-5E)	0	0.00	0.00
9	5E(5E-4E)	0	0.00	0.00
10	4E(5E-4E)	0	0.00	0.00
11	7E(7E-7D)W	0	0.00	0.00
12	7D(7E-7D)W	0	0.00	0.00
13	7E(7E-7D)E	0	0.00	0.00
14	7D(7E-7D)E	0	0.00	0.00
15	6E(6E-6D)	0	0.00	0.00
16	6D(6E-6D)	0	0.00	0.00
17	5E(5E-5D)	10	10.00	2.80
18	5D(5E-5D)	0	0.00	0.00
19	4E(4E-4D)	2	2.00	0.56
20	4D(4E-4D)	0	0.00	0.00
21	8D(8D-7D)	0	0.00	0.00
22	7D(8D-7D)	3	3.00	0.84
23	7D(7D-6D)	0	0.00	0.00
24	6D(7D-6D)	4	4.00	1.12
25	6D(6D-5D)	4	4.00	1.12
26	5D(6D-5D)	0	0.00	0.00
27	5D(5D-4D)	5	5.00	1.40
28	4D(5D-4D)	0	0.00	0.00
29	7D(7D-7C)	0	0.00	0.00
30	7C(7D-7C)	0	0.00	0.00
31	6D(6D-6C)	0	0.00	0.00
32	6C(6D-6C)	0	0.00	0.00
33	5D(5D-5C)	0	0.00	0.00
34	5C(5D-5C)	0	0.00	0.00
35	4D(4D-4C)	0	0.00	0.00
36	4C(4D-4C)	0	0.00	0.00
37	7C(7C-6C)	5	5.00	1.40
38	6C(7C-6C)	0	0.00	0.00
39	5C(5C-4C)	10	10.00	2.80
40	4C(5C-4C)	0	0.00	0.00
41	7C(7C-7B)	0	0.00	0.00
42	7C(7C-7B)	0	0.00	0.00

Table C.8: Weighted scores: Parking garages near the bridge ends

	Bridge ends	Raw data	Scores	Weighted score
1	6F(6F-6E)	YES	10.00	1.80
2	6E(6F-6E)	NO	0.00	0.00
3	5F(5F-5E)	NO	0.00	0.00
4	5E(5F-5E)	YES	10.00	1.80
5	4F(4F-4E)	NO	0.00	0.00
6	4E(4F-4E)	YES	10.00	1.80
7	6E(6E-5E)	NO	0.00	0.00
8	5E(6E-5E)	NO	0.00	0.00
9	5E(5E-4E)	YES	10.00	1.80
10	4E(5E-4E)	NO	0.00	0.00
11	7E(7E-7D)W	NO	0.00	0.00
12	7D(7E-7D)W	YES	10.00	1.80
13	7E(7E-7D)E	NO	0.00	0.00
14	7D(7E-7D)E	YES	10.00	1.80
15	6E(6E-6D)	NO	0.00	0.00
16	6D(6E-6D)	NO	0.00	0.00
17	5E(5E-5D)	YES	10.00	1.80
18	5D(5E-5D)	NO	0.00	0.00
19	4E(4E-4D)	NO	0.00	0.00
20	4D(4E-4D)	NO	0.00	0.00
21	8D(8D-7D)	NO	0.00	0.00
22	7D(8D-7D)	YES	10.00	1.80
23	7D(7D-6D)	YES	10.00	1.80
24	6D(7D-6D)	NO	0.00	0.00
25	6D(6D-5D)	NO	0.00	0.00
26	5D(6D-5D)	NO	0.00	0.00
27	5D(5D-4D)	NO	0.00	0.00
28	4D(5D-4D)	NO	0.00	0.00
29	7D(7D-7C)	NO	0.00	0.00
30	7C(7D-7C)	NO	0.00	0.00
31	6D(6D-6C)	NO	0.00	0.00
32	6C(6D-6C)	NO	0.00	0.00
33	5D(5D-5C)	NO	0.00	0.00
34	5C(5D-5C)	NO	0.00	0.00
35	4D(4D-4C)	NO	0.00	0.00
36	4C(4D-4C)	NO	0.00	1.80
37	7C(7C-6C)	NO	0.00	0.00
38	6C(7C-6C)	NO	0.00	0.00
39	5C(5C-4C)	NO	0.00	0.00
40	4C(5C-4C)	YES	10.00	1.80
41	7C(7C-7B)	NO	0.00	0.00
42	7C(7C-7B)	YES	10.00	1.80

Table C.9: Weighted scores: Wayfinding hurdles of the bridge ends

	Bridge ends	Raw data	Scores	Weighted score
1	6F(6F-6E)	0	0.00	0.00
2	6E(6F-6E)	4	8.00	7.68
3	5F(5F-5E)	1	2.00	1.92
4	5E(5F-5E)	2	4.00	3.84
5	4F(4F-4E)	4	8.00	7.68
6	4E(4F-4E)	1	2.00	1.92
7	6E(6E-5E)	4	8.00	7.68
8	5E(6E-5E)	4	8.00	7.68
9	5E(5E-4E)	1	2.00	1.92
10	4E(5E-4E)	N	10.00	9.60
11	7E(7E-7D)W	4	8.00	7.68
12	7D(7E-7D)W	3	6.00	5.76
13	7E(7E-7D)E	N	10.00	9.60
14	7D(7E-7D)E	3	6.00	5.67
15	6E(6E-6D)	4	8.00	7.68
16	6D(6E-6D)	4	8.00	7.68
17	5E(5E-5D)	2	2.00	3.84
18	5D(5E-5D)	N	10.00	9.60
19	4E(4E-4D)	4	8.00	7.68
20	4D(4E-4D)	3	6.00	5.76
21	8D(8D-7D)	NA	5.00	4.80
22	7D(8D-7D)	NA	5.00	4.80
23	7D(7D-6D)	N	10.00	9.60
24	6D(7D-6D)	3	6.00	5.76
25	6D(6D-5D)	1	2.00	1.92
26	5D(6D-5D)	1	2.00	1.92
27	5D(5D-4D)	N	10.00	9.60
28	4D(5D-4D)	4	8.00	7.68
29	7D(7D-7C)	N	10.00	9.60
30	7C(7D-7C)	1	2.00	1.92
31	6D(6D-6C)	4	8.00	7.68
32	6C(6D-6C)	1	2.00	1.92
33	5D(5D-5C)	1	2.00	1.92
34	5C(5D-5C)	N	10.00	9.60
35	4D(4D-4C)	2	4.00	3.84
36	4C(4D-4C)	N	10.00	9.60
37	7C(7C-6C)	N	10.00	9.60
38	6C(7C-6C)	N	10.00	9.60
39	5C(5C-4C)	N	10.00	9.60
40	4C(5C-4C)	0	0.00	0.00
41	7C(7C-7B)	NA	5.00	4.80
42	7C(7C-7B)	NA	5.00	4.80

Table C.10: Total weighted score and final ranking

	Bridge ends	Total weighted score	Ranking
1	6F(6F-6E)	11.4528	35
2	6E(6F-6E)	13.9928	32
3	5F(5F-5E)	8.4949	40
4	5E(5F-5E)	29.9549	3
5	4F(4F-4E)	28.5563	8
6	4E(4F-4E)	7.4163	41
7	6E(6E-5E)	17.5374	28
8	5E(6E-5E)	28.0374	9
9	5E(5E-4E)	18.7498	25
10	4E(5E-4E)	14.6298	31
11	7E(7E-7D)W	11.0606	36
12	7D(7E-7D)W	9.2606	38
13	7E(7E-7D)E	17.2771	29
14	7D(7E-7D)E	20.2371	21
15	6E(6E-6D)	20.0163	22
16	6D(6E-6D)	28.0163	10
17	5E(5E-5D)	28.7418	6
18	5D(5E-5D)	30.9018	2
19	4E(4E-4D)	19.5466	24
20	4D(4E-4D)	9.0666	39
21	8D(8D-7D)	14.9164	30
22	7D(8D-7D)	21.6564	16
23	7D(7D-6D)	28.8940	6
24	6D(7D-6D)	19.7740	23
25	6D(6D-5D)	20.9923	19
26	5D(6D-5D)	28.6723	7
27	5D(5D-4D)	31.3187	1
28	4D(5D-4D)	25.4987	11
29	7D(7D-7C)	29.5385	4
30	7C(7D-7C)	11.8585	34
31	6D(6D-6C)	20.7550	20
32	6C(6D-6C)	21.2950	18
33	5D(5D-5C)	21.5056	17
34	5C(5D-5C)	25.3856	13
35	4D(4D-4C)	18.6436	26
36	4C(4D-4C)	24.6036	14
37	7C(7C-6C)	18.0015	27
38	6C(7C-6C)	25.4015	12
39	5C(5C-4C)	23.0260	15
40	4C(5C-4C)	2.8260	42
41	7C(7C-7B)	10.4668	37
42	7C(7C-7B)	12.2668	33