Arcades: Investigating a Phenomena of an Urban Form

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Abstract

Urban arcades are glass-covered passageways that connect two or more city streets, lined on both sides by shops. Arcades host a multitude of activities such as retail establishments, serve as passageways for pedestrians between streets, and provide protection from inclement weather. This paper presents the background research and preliminary findings of a study into urban arcades.

This paper is divided into three sections:

1. A historical outline of the arcade, with examples of three existing arcades;
2. A presentation of recent research on the physical environment (sun, wind, light, temperature) in arcades;
3. A discussion of thermal comfort (ASHRAE Standard 55-1992) and its applicability to arcades.

The objective of this project is to show that arcades promote a "thermal diversity" in the city, allow for easier incorporation of mixed-use functions under a single roof, and function as common, public space on private property.

Introduction

As a building type and place of commerce, the arcade was a new, dominant form of the 19th century. Introduced in 1791 in Paris, the arcade sought to cover small shops with a modest skylight. (Geist, 1983) This changed mid-19th century with improvements in steel and glass technologies. These two materials became the basis for a new architecture, an unprecedented display of technology.

Under a clear, glass roof, both pedestrian and weather elements (sun, air) could penetrate the center of the densest city block. This eliminated the problem associated with a high concentration of people: dank, dark alleys. Arcades, as an urban form, were poised to reorganize the urban block and the modern city. However, before this potential was realized, the arcade disappeared.

There are many explanations for the fall of the arcade. Mumford finds fault with the arcade's "functional exactitude", citing that the arcade served only shopping, and was from the outset, unconvertible. (Mumford, 1961) The failure of downtown retail lowered the potential success rate of the arcade; businesses moved to suburban shopping centers.

Blake blames the fall on the ego of architects and developers, who are unwilling to share and develop common land in cities. Blake cites an unbuilt project by Philip Johnson for the Lincoln Center, an arcade idea was eliminated by other architects because they thought Johnson would be allowed to design all of the facades. (Blake, 2000)

MacKeith's explanation is that arcades fell out of favor as they lost their novelty, as covered shopping streets became commonplace. (MacKeith, 1986) To her, the availability of air conditioning and the increased number of arcades caused the arcade to lose its role as a unique space in a diverse city.

To these three authors, these problems killed a unique urban type. A new interest in arcades, and the renovation of historical arcades, has brought about a revival of the type. Several contemporary projects have proposed urban arcades, and a handful of new arcades have been built in the last ten years.

This frames two questions: *Is the arcade an appropriate form for rebuilding and enlarging city centers? If the arcade is appropriate, how does it deal with its past problems: mixed uses, public land on private property, and thermal diversity?*

A Historical Outline

An "arcade" is the translation of the German noun, *Passage*. Passage is borrowed directly from the French noun/verb, *passage*, and was in use as early as 1800 to describe the arcade type.

The root of passage is *passus,* the Latin for "step", conveying an element of movement and rhythm. All of the terms with a Romanic base, Geist states, have a common characteristic: "they express transition, threshold, passing, measured distance, or disappearance." (Geist, 1983) Geist defines the arcade as a "glass-covered passageway that connects two or more city streets, lined on both sides by shops." This definition represents the common use of the 19th century arcade, a center for shopping.

Arcade, thus synonymous with passage, describes a space with a beginning and an end, a thoroughfare linking streets.

In this sense, arcades are a "transitional" space, an internal artery connecting two or more external streets. Transitions through and over various types of thresholds are common as pedestrians move from street to street, or from sidewalk to interior shop. An arcade is a small, enclosed city, connecting shops together with a unique climate and street life.

This unique street life dates back nearly 2000 years, to Trajan's Markets, a center of commerce in ancient Rome. Under Trajan, in 100 A.D., the building was constructed next to the Forum, and housed shops under one roof. The central space, a basilica, was vaulted with large clerestory openings to admit light. This roof effectively covered pedestrians, protecting them from inclement weather. (Kostof, 1995)

This market hall was the predecessor for the arcade and the cathedral, linking in form commerce and religious activity. By the 11th century, European crusaders had carried this form to Jerusalem, where they constructed "souks". The souks were stone vaulted streets, adapted later into the Islamic bazaar and chan. (MacKeith, 1986)

In the Islamic city, the bazaar and chan were the city center. Along with the mosque, they functioned as the only public gathering spaces. The chan was the point where the trading caravan arrived, the warehouse and exchange center for bulk goods. The bazaar was generally located next to the chan, and was the center of day to day trading and retail. Widespread trade brought the arcade back to Europe in the Middle Ages, and market halls gradually increased in stature to accommodate the expanded production of guilds. The true arcade, however, would not appear until the 19th century in France, as architects adapted the bazaar form to the Parisian streets. (Geist, 1983)

The 19th century arcade was the result of the mass production of steel and glass, and a reflection of a shift in society. In the wake of the Crystal Palace, 19th century architects sought to use the language of glass and steel in their architecture. Mass production made luxury goods widely available and created a new middle class. The arcade served both, a symbol of its time.

The following three arcades are potential candidates for future study, a cross-section of 19th century arcades in size, function, and form. The issues inherent to these projects, effective mixed-use development, light and air to the middle of city blocks, and the anchoring of urban centers, are relevant concerns in designing the city of tomorrow.

The Galleria Vittorio Emanuele II, Milan, Italy

The Galleria in Milan was constructed between 1863 and 1867, the result of an open architectural

competition. The Galleria is cruciform in plan, covering the center with a glass dome equal in diameter to that of St. Peter's in Rome. The building connects Milan's cathedral with a large piazza, and is the civic center of Milan.

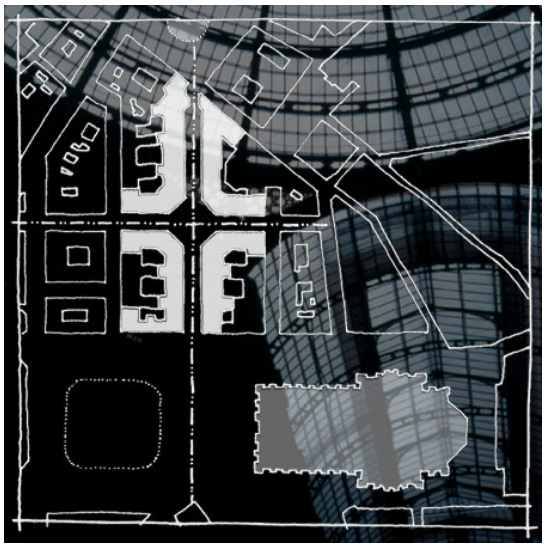

Figure 1: Plan and photograph of the Galleria Vittorio Emanuele II, Milan, Italy.

The Galleria consists of four main floors. The ground floor caters to the pedestrian, containing shops, showrooms, and cafes. Private offices are found on the second two floors, and residential apartments occupy the top floor.

The height from floor to top of vault is 110 feet, and the total length is over 600 feet. The only enclosure is the glass roof, and the ends of the arcade are open to the air. (Geist, 1983)

The Milan Galleria is the center of the city, the pedestrian arteries of Milan. With diverse functions, it is an effective, mixed-use facility. Owned privately, it acts as a public space, and amenity. The glass roof protects walkers in inclement weather, creating a novel indoor piazza. Through addressing these issues, the building stands as a success, an example for future designs.

Colonial & Cleveland Arcades, Cleveland, Ohio

The Colonial Arcade is a two-story passage connecting two 5-story office structures. The arcade is a straight corridor 400 feet long, but only 20 feet wide. The arcade was completed in 1898, and features a glass gambrel roof along its full length.

Figure 2: Plan and photgraph of the Colonial Arcade, Cleveland, Ohio, 1935. (Cleveland Public Library Photograph Collection)

The Cleveland Arcade is a three building complex that joins two 9-story office buildings with a 5-story arcade. The arcade was completed in 1891, the collaboration of an architect and structural engineer. At the time of construction, the roof trusses were revolutionary for their thinness; the arcade was featured in engineering journals around the world. (Schofield, 1966)

The Cleveland Arcade accommodates a 23-degree shift in axis, handled in a circular entry space. The arcade is the same length as the Colonial Arcade, but opens up to over 80 feet in width and 100 feet in height.

An elevation difference along the length of the arcade enables two ground floors of shops. The

Figure 3: Plan and photograph of the Cleveland Arcade. (Cleveland Public Library.)

upper three floors of the arcade originally housed

offices, galleries, and private studios, falling vacant in the 1970s. Both arcades are enclosed, glass doors at each end.

Within the last year, a private development corporation has purchased the two arcades, investing over 50 million dollars to restore their interiors. Upper floor offices have been converted into hotel rooms, and ground floor shops have been enlarged and updated.

The Colonial and Cleveland Arcades have the potential to anchor Cleveland's city center. The arcades can incorporate several mixed uses under one roof, bringing life to downtown. Owned by a private corporation, the arcades will again be part of a free, public pedestrian route. As enclosed walkways, the spaces will shelter during the winter, a thermal break from cold and winds.

Arcade and Transitional Space Research

Potvin makes a case for a greater diversity of thermal environments within the modern city, by the use of arcades through city blocks. He identified and evaluated the microclimate of 14 arcades in London and Cardiff using a head-mounted portable sensor array that measured wind speed, humidity, ambient and radiant temperature. Using the Penwarden thermal comfort equation based on wind speed, Potvin assessed thermal comfort of urban environments. (Potvin, 1999)

$$T_b - T_a = (M/A_{DU})R_b + k(M/A_{DU})R_c + (k(M/A_{DU}) + S)(4.2 + 13u^{0.5})^{-1}$$

T_b = Body core temperature = 37ºC
T_a = Air Temperature in ºC
M/A_{DU} = Metabolic rate of heat production per square meter of body surface W/m^2
k = Proportion of metabolic heat dissipated by means other than evaporation = 0.8
R_b = Thermal resistance of body tissues, m^2 deg C/W
R_c = Thermal resistance of clothing, m^2 deg C/W (1 clo = 0.155 m^2 deg C/W)
S = Solar heat input per square meter of body surface, W/ m^2
u = Wind Speed, m/ sec
$(4.2 + 13u^{0.5})^{-1}$ = Thermal resistance between clothing and surroundings, m^2 deg C/W

Penwarden's equations assume a body tissue resistance, R_b, between 0.04 m^2 deg C/W (onset of sweating) and 0.09 m^2 deg C/W (onset of shivering), and a metabolic rate of approximately 1.6 met, a subject walking at a moderate pace. (100 W/ m^2) (Penwarden, 1973)

In assessing thermal comfort of urban environments, Potvin quantifies the arcade as a hybrid form, categorized as between a building and a street. By serving as an intermediary, the arcade contributes to the overall thermal diversity of the city, allowing for greater variability between interior and exterior. Not limited to perform as a building, the arcade subsequently conserves energy.

The relevance of this research to future studies is in the application of a thermal comfort model as control. The Penwarden model, designed for exterior environments, is a standard applicable to all outdoor spaces. By assessing an arcade against this model, its role is defined in the context of the urban environment.

A variation on Potvin's method presents an opportunity for research. One approach would be to assess an arcade against a series of comfort models as a technique to determine an "appropriate" or relevant comfort model for arcades. Another method would be to compare historical concepts of comfort against seasonal data from arcades. This historical study would classify the role of the arcade in the evolution of comfort, expanding the written history of this building type.

A separate study could be to assess the arcade climatically, investigating only the arcades of a region. This type of study would shape the role of physical form and orientation in an arcade's performance, benefiting and enriching the design of future arcades.

Two questions posed by Potvin's research are especially relevant, and will frame this project:

- The application of Penwarden's model of thermal comfort is relevant for open-ended and free running arcades. *Would the same comfort model apply to conditioned and closed arcades,*

those typically found in the United States?

- The arcade is key to enabling thermal diversity and urban permeability in London and Cardiff. *Is there thermal diversity and urban permeability in the arcades in Northern America?*

Several studies in transitional space research have a relevance to arcades, summarized as follows:

Field measurements of thermal comfort were conducted at an airport and office building in Tokyo, Japan. The purpose was to create a model to predict the skin temperatures of both sedentary and transient subjects, in order to tailor spaces to their needs.

To accomplish this, measurements of ambient and radiant temperature, humidity, radiation, illuminance, and air velocity were assessed using a portable instrument cart. Data from the cart was used to create a simulation to demonstrate the thermal states of subjects within the spaces.

Each of the spaces was considered "transitional" because of large amount of people moving from outside to inside, and because each space acted as a thermal buffer for pedestrians. (Hayashi et al, 1986)

This experiment led to the conclusion that it is possible to create a numerical simulation to determine the thermal state of both a sedentary and walking person within a transitional space, and therefore to design a space to meet their needs. This model would be applicable to arcades, spaces that contain sedentary and transient subjects.

The value of this research is in the method of evaluating and measuring spaces.

- *What type of thermal comfort assessment device could be developed for an arcade?*
- *Would other measurements, such as thermal asymmetry and thermal stratification, make for a more complete analysis?*
- *Would a survey of pedestrian responses yield a greater accuracy?*

Another study, that of the half-opened space, or "hybrid" space, presents a method pertinent to investigate arcades. In this study, students walked along a set route through three spaces with set clothing values, casting votes on a thermal sensation scale. The experiment was repeated seasonally, with similar routes at the same time of day.

The experiment demonstrated how subjects are sensitive to an increase in temperature, and insensitive to a decrease in temperature. As seasons varied, there was a corresponding shift on a thermal sensation vote chart. (Chun & Tamura, 1996)

This project's relevance is in its documentation and presentation of the "human factor" of an arcade, the personal variables that affect thermal comfort. By surveying students along a set path, it is possible to get an objective analysis of thermal comfort, and votes on a sensation scale are tailored to specific points on a route.

- *How could a thermal sensation vote apply in researching arcades?*
- *What are common spaces and forms to all arcades, and do different thermal comfort zones apply to each individual and space?*

Thermal Comfort and Arcades

Designers often use ASHRAE 55-1992, *Thermal Environmental Conditions for Human Occupancy* (hereafter Standard 55) to design systems to provide an environment appropriate for thermal comfort. *Standard 55* defines a thermal comfort level deemed appropriate for all occupied indoor spaces.

Thermal comfort is expressed as the interaction of four environmental factors: air temperature, thermal radiation, air speed, and humidity; and two personal factors: activity (met) and clothing (clo). Standard 55 is based on the assumption that all occupants will be engaged in light, primarily sedentary activity in "typical" indoor clothing.

The only adaptation to seasonal variation is in a shift in the thermal comfort zone between winter and summer. This shift is an acceptance of individuals adapting their personal clothing values from season to season.

To account for activities outside primary, light sedentary activity, Standard 55 provides an equation to shift the thermal comfort zone. This equation would be applicable to arcades and transitional spaces, as pedestrians move at an elevated metabolic level (1.6 – 2 met) and varying levels of clothing depending on season.

T_o active = T_o sedentary – 3(1 + clo)(met – 1.2) (ºC)

T_o active = Active operative temperature
T_o sedentary = Sedentary operative temperature
clo = clothing insulative value (1 clo = 0.155 m^2 deg C/W)
met = metabolic rate (1 met = 58.2 W/ m^2)

This equation is appropriate between a metabolic rate of 1.2 and 3 met, and the minimum allowable operative temperature for all activities is 15ºC. (ASHRAE, 1992)

Potvin's method in investigating arcades was based upon the comparison of an arcade to exterior spaces, using an outdoor model of thermal comfort as control. The proposal of this project, in a similar vein, would be to utilize Standard 55 as a comparison tool to categorize arcades with interior environments. This approach would either evaluate an arcade against two other shopping types, such as an enclosed suburban mall and traditional shop, or weigh an arcades against similar interior forms: light wells and atria. This investigation would be limited by climactic region, as another control, investigating only the arcades of the Northwest United States.

To measure spaces, and compare thermal properties to Standard 55, a thermal assessment tool similar to those used in Hayashi et al. and Potvin's investigations would need to be assembled. At a minimum, the tool would need to quantify air temperature, radiation, air speed, and humidity, expanding to possibly include thermal asymmetry and stratification. The device would need to be portable, perhaps a "thermal backpack", powered from batteries, and constructed from available equipment to limit cost.

A final part to the investigation would follow the method of Chun and Tamura, using a thermal sensation vote to assess an arcade's performance. Student volunteers could visit the spaces seasonally, to get a variety of results, and this information could be compared to the data from field measurements.

Summary

To be a viable solution for the future city, the arcade must address the criticisms of its past. To research the arcade, there are several potential methods for evaluating these spaces, building from previous research methods. By better understanding arcades and transitional spaces, the designer can utilize accurate and appropriate solutions that conform to human needs and potentially save energy.

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