GLOBAL DIFFERENCES IN BUILDING ENCLOSURES

A Thesis in
Architectural Engineering
by
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Successful design and construction of building enclosures on foreign projects presents a challenge for those who are new to international business. In addition to basic building enclosure functional requirements (i.e., structural, acoustics, heat control, air control, moisture control, etc.), professionals must accommodate local considerations of a building project’s site, which vary globally from market to market and are not always clearly understood in the early stages of a project. This study consists of twenty-nine interviews conducted with building enclosure professionals who have significant experience working in the following five global markets: Europe, Far East, Latin America, Middle East, and North America. The interviewees expressed that there are significant global differences that affected how they perform services in relation to the design and construction of building enclosures on mainstream, modern, low-to-mid-rise commercial buildings across each market. Thirteen factors were found to account for global differences in building enclosures, although not all thirteen factors were deemed important in a given global market. This study summarizes market-specific design and construction considerations as expressed by interviewees for building enclosures in the five distinct global markets.

Keywords: Building enclosures, Globalization, International construction
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PREFACE

This thesis consists of a paper submitted for peer review in a refereed journal, along with seven appendices that accompany the paper. The paper (Pages 1 through 40) was authored by David Tran, Dr. Richard Behr, and M. Kevin Parfitt, and was submitted to the ASCE Journal of Architectural Engineering for peer review and possible publication. The format of the paper was changed for inclusion in this thesis to accommodate The Pennsylvania State University thesis guidelines. The seven appendices appear in this thesis only and did not accompany the manuscript submission to the Journal of Architectural Engineering.

The five appendices detailing a representative case study building in each of the five global markets are presented to illustrate salient attributes derived from the interviews that comprised much of this study’s research methodology. Information contained within each building enclosure case study helps to illustrate significant global differences in building enclosures.
ACKNOWLEDGEMENTS

The author would like to thank the many people who made this thesis possible. First of all, sincere gratitude is given to The Leonhard Center for Enhancement of Engineering Education for providing portions of funding to support this thesis work. In particular, the author would like to thank Dr. Thomas Litzinger, who served on the author’s committee, Mary Lynn Brannon, and Sarah Zappe of the Leonhard Center for guidance and assistance throughout the development of the research portion of this thesis. Without their support, none of this would have been possible.

Special thanks are extended to Dr. Richard Behr, who acted as advisor and guide. He provided the author with an opportunity to enhance his education and worked with him in growing as a student, as well as an individual. Appreciation is also extended to Professor M. Kevin Parfitt, who served on the author’s committee and acted as his counsel when Dr. Behr accepted a dean position at Florida Gulf Coast University. His input helped guide the direction of the work presented.

The work contained within was made possible through the assistance of many individuals, who kindly participated in the interviews and helped in the development of the case studies. Their time and effort are greatly appreciated by the author.

Finally, the author would like to thank his family and friends for their unyielding support, and also for tolerating him during his twenty-five years of existence.
1. INTRODUCTION

The building enclosure, known interchangeably as the building envelope, is defined as the part of a building that separates the interior environment from the exterior environment (Straube and Burnett 2005). It is a critical component of any building, and can comprise upwards of twenty percent of the total initial building cost (Arnold 2009). With projections of the earth’s population to increase from the current 7 billion to 9 billion inhabitants by the year 2050 (U.N. 2004), countries around the world are investing in the construction of new infrastructure, including buildings. This global trend of increased building construction creates an opportunity for building enclosure professionals in Architecture, Engineering, and Construction (AEC) firms to expand their international scope of practice.

Although companies in the AEC industry have been practicing internationally since the late 1970’s (Ramcharran 1998), global variations still exist and account for differences seen in construction techniques and processes used on projects around the world (Yates 2007). This is especially true for building enclosures, which are heavily influenced by construction developments and progress in each global region, resulting in multiple solutions around the world based upon local characteristics (Santos 2007). For building enclosure professionals, a “one size fits all” approach towards building enclosure design and construction on international projects is inappropriate (Kragh 2008).

It is important that professionals in firms venturing into international work understand local considerations, i.e., location specific design and construction influences that may have a significant effect on the building enclosure. Limited publications available in the open literature (e.g., Ledbetter et al. 1992, Santos 2007, and Bilow 2012) address the
building enclosure in the context of global markets. Individuals or firms wishing to learn about local conditions in a new international market must normally conduct their own independent research, which requires significant time and effort. Open literature dedicated to distinguishing local considerations in different global markets could reduce the chance of learning international nuances “the hard way.”
2. OBJECTIVE AND SCOPE

This study addresses global differences in local considerations for the design and construction of building enclosures and their prominent underlying factors on mainstream, modern, low-to-mid-rise commercial buildings. The five global markets selected for this study are Europe, Far East, Latin America, Middle East, and North America. Global differences are derived from twenty-nine interviews with building enclosure professionals who have experience working in one or more of the global markets of interest.

It was important to identify a specific type of building for analysis in order to reasonably compare the building enclosure across different global markets. The global building enclosures and factors contributing to their differences discussed are limited in this study to buildings with the following characteristics:

*Mainstream* – Here defined as a building whose architectural style is common to that particular global market. Buildings that are considered landmark, avant-garde, or unique are not considered in this study because they could make market-to-market comparisons less meaningful.

*Modern* – The term “modern building” is somewhat subjective. Here, a “modern building” is one that has been constructed within the last twenty years.

*Low-to-Mid-Rise* – The term “low-to-mid-rise building” is also somewhat subjective. In certain regions, a particular building could be viewed as a high-rise, while in other regions the same building could be classified as mid-rise. Here, “low-to-mid-rise” refers to a building that has a maximum of ten stories above grade.

*Commercial* – The building functions as offices, retail stores, or entertainment spaces.
The factors contributing to global differences in building enclosures are applicable to the project development stages of conceptual design through finished construction. Although these factors could impact long-term performance issues and/or the life span of the building enclosure, the factors included in this study do not explicitly address the building enclosure beyond finished construction.
3. BACKGROUND ON INTERNATIONAL BUILDING ENCLOSURE COMMERCE

Advances in transportation and telecommunication technologies have recently opened new markets within the building construction industry not previously seen (Ngowi et al. 2005). This is a manifestation of globalization, which Ngowi et al. define as “a situation where political borders become increasingly more irrelevant, economic interdependencies are heightened, and national differences are accentuated due to dissimilarities in societal cultures and central issues of business.” The advent of globalization within the AEC industry has brought foreign methods of building design and construction to new markets. Firms embarking on new international ventures often tend to retain their familiar ways of practice. However, these domestic means and methods may not be effective for use in new international markets.

In the AEC industry, international work can be unusual and challenging (Gunhan 2005). Although working on international projects has the potential for significant payoffs, there is a significant chance of failure (McConville 1996). Such failures can be attributed to risks not found on domestic projects. Yates (2007) defines such risks as coming in the form of potential outcomes or uncertainties that are unfavorable to a given condition or situation. A major source of increased risk faced by AEC firms is related to a lack of familiarity with conditions in a new project location. Firms who are unfamiliar with a new market in which they are working are labeled as suffering from “liability of foreignness” (Zaheer 1995). This situation makes such firms susceptible to risks that otherwise would not be present if they had appropriate experience in the target market.
Acquisition of local knowledge is imperative for AEC firms when entering new markets (Lord and Ranft 2000). Javernick-Will and Scott (2010) conducted a study comprised of fifteen international case study companies and they focused on identifying differences in rules, political systems, norms, customs, and values and beliefs on international projects referred to as “institutional knowledge.” Attaining institutional knowledge on international ventures would reduce knowledge gaps, which is defined as the difference between institutional knowledge that is needed on a given international project and the knowledge the firm actually possesses (Peterson et al. 2008). Javernick-Will and Scott determined three types of international institutional knowledge needed by AEC firms: (1)-regulative – rules of formal governance structures and legal processes in a given society; (2) normative – how things should be done; and (3) cognitive cultural – common beliefs and shared conceptions/meanings. Obtaining and understanding these types of institutional knowledge would reduce knowledge gaps for internationally entrant AEC firms and mitigate risks due to unfamiliarity with new markets.
4. RESEARCH METHODOLOGY AND ANALYSIS

The research methodology for this study consists of a qualitative information gathering approach using scripted interviews. The interview method was chosen because it is a popular means of data collection in built environment disciplines due to its flexibility (Knight and Ruddock 2008). The interviews followed a semi-structured format consisting of several key questions that help define areas of interest, but also allow the interviewees to explore other ideas or responses in greater detail (Gill et al. 2008). In this study, interviewees were provided with a brief introduction of the topics to be discussed, followed by a series of questions where they provided responses based upon their prior expertise and experience. Follow up questions were employed to expand discussion or clarify respondent comments. The scripted questions were designed to elicit clear, non-interviewer influenced responses from each interviewee.

The general structure of the interview began with the interviewee introducing himself/herself, a detailing of that person’s industry experience, followed by a review of the global markets in which that person had building enclosure knowledge. Following this, the interviewee was asked if there was a noticeable difference in the design and construction of building enclosures in different global markets. All twenty-nine interviewees expressed the belief that there are some significant differences in the design and construction of building enclosures based upon global market location. The interviewees then described those global differences and their beliefs as to why they exist. Much of this portion of the interview was more ‘conversational’, as opposed to rigid responses to questions. Throughout most of the interview, interviewees were free to express their thoughts and opinions without interruption.
from the interviewer. Intermittent questions were asked between topics and/or thoughts in order to clarify interviewee responses.

All interviews were conducted by telephone with the exception of four that utilized email. From July 2012 through March 2013 a total of twenty-nine interviews were conducted. Telephone interviews were recorded electronically with the consent of the interviewee. Handwritten notes were taken throughout the interviews. The duration of each phone interview ranged from approximately thirty minutes to two hours.

Using a transcription service, five interviews covering each of the five chosen global markets considered in this study were transcribed. These five interviews were selected because their responses were amongst the more thorough received in this study. These five transcriptions were then analyzed using the software QSR NVivo©. This software supports qualitative and mixed research, allowing for organization and analysis of content from interviews (NVivo 2012). NVivo was used to develop and group themes that were brought up during discussion by the interviewees.

With a baseline of topics and themes developed from the initial analysis using NVivo, a set of preliminary “codes” was developed to organize and analyze the rest of the interviews. From re-listening to the recordings of all interviews, looking at notes taken, and examining email responses, Microsoft Excel was used to track the frequency of a “code” being brought up by the interviewee without prompting from the interviewer. Excel was also used to organize similar topics discussed during each interview. When a new topic was brought up by an interviewee not covered in previous interviews, a new code was developed for analysis of subsequent interviews.
After all codes were created, comments categorized under each code were analyzed across all interviews. This method of triangulation allowed for the researcher to evaluate the consistency of observations made by the various interviewees. The information gathered and processed from these responses was used to help illustrate differences in typical building enclosures presented on mainstream, modern, low-to-mid-rise commercial buildings in the five global markets studied.
5. RESEARCH PARTICIPANT BACKGROUND

Multiple parties involved in a building project interact with the design and construction of the building enclosure in some demonstrable way. During recruitment of research participants, efforts were made to interview individuals who had broad knowledge of building enclosures. Five groups define the backgrounds of the research participants in this study: researcher, manufacturer, consultant, contractor, and real estate professional. Table 1 provides a breakdown of the number of research participants in each of these five groups including average years of experience related to building enclosure work. In the consultant group, four interviewees described their work as primarily related to architectural services, while the remaining eleven identified themselves as engineers. Fifteen of the interviewees currently reside in North America, nine in Europe, two in the Middle East, two in Latin America, and one in the Far East.

**Table 1:** Characteristics of Interviewees

<table>
<thead>
<tr>
<th></th>
<th>Researcher</th>
<th>Manufacturer</th>
<th>Consultant*</th>
<th>Contractor</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Interviewees</td>
<td>4</td>
<td>8</td>
<td>15</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Avg. Years of Experience</td>
<td>15.8</td>
<td>16.9</td>
<td>19.9</td>
<td>30.0</td>
<td>32.0</td>
</tr>
</tbody>
</table>

*Consultant occupations: Architects – 4; Engineers - 11

With the exception of Latin America, a minimum of ten interviewees expressed familiarity with each global market, as depicted in Table 2. Twenty-six participants had expertise in multiple global markets, providing a firsthand account of global differences in building enclosures. These personal narratives provided a rich and detailed perspective into building enclosures that is not always fully included in the open literature.
Table 2: Global Market Knowledge of Interviewees

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Europe</th>
<th>Far East</th>
<th>Middle East</th>
<th>North America</th>
<th>Latin America</th>
</tr>
</thead>
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<tr>
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<td>29</td>
<td>x</td>
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<td>x</td>
</tr>
</tbody>
</table>

Total 25 12 10 24 4
6. FACTORS CONTRIBUTING TO GLOBAL DIFFERENCES IN BUILDING ENCLOSURES

The interview results for factors contributing to global differences in building enclosures across all five global markets are presented in Table 3. The factors are divided into four categories as a function of the (1) environment, (2) regulative, (3) normative, and (4) cognitive cultural characteristics of each global region. The environment category is defined as “external surroundings or conditions around the building enclosure” while the latter three categories were devised by Javernick-Will and Scott (2010), whose definitions were presented earlier in this paper. Specific attributes related to each of the five global markets addressed in this study are described later. The frequencies in Table 3 represent the amount of times a specific factor was cited by interviewees without prompting from the interviewer.

Table 3: Factors That Contribute to Global Differences in Building Enclosures

<table>
<thead>
<tr>
<th>Factor</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate</td>
<td>13</td>
<td>45%</td>
</tr>
<tr>
<td><strong>Regulative</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Codes and Standards</td>
<td>18</td>
<td>62%</td>
</tr>
<tr>
<td>Degree of Litigation</td>
<td>5</td>
<td>17%</td>
</tr>
<tr>
<td><strong>Normative</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Role</td>
<td>10</td>
<td>34%</td>
</tr>
<tr>
<td>Construction Quality/Control</td>
<td>15</td>
<td>52%</td>
</tr>
<tr>
<td>Cost of Energy</td>
<td>11</td>
<td>38%</td>
</tr>
<tr>
<td>Availability of Materials and Products</td>
<td>13</td>
<td>45%</td>
</tr>
<tr>
<td><strong>Cognitive Cultural</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social and Regional Views</td>
<td>12</td>
<td>41%</td>
</tr>
<tr>
<td>Ventilation</td>
<td>7</td>
<td>24%</td>
</tr>
<tr>
<td>Thermal Performance</td>
<td>12</td>
<td>41%</td>
</tr>
<tr>
<td>Moisture Protection</td>
<td>9</td>
<td>31%</td>
</tr>
<tr>
<td>Long Term Performance</td>
<td>8</td>
<td>28%</td>
</tr>
<tr>
<td>Sustainability</td>
<td>8</td>
<td>28%</td>
</tr>
</tbody>
</table>

Note: A total of 29 interviews were conducted
Environment

Climate

The building enclosure should be designed and constructed to resist the climatic demands of each region, with climate being defined as weather patterns expected over a long period of time in a particular region. It was pointed out by interviewees that accommodating local climate is a main responsibility of the building enclosure. Because climate varies significantly with global location, building enclosures will vary in each market if designed in accordance with local climatic demands.

Regulative

Codes and Standards

When working internationally, the codes and standards used in each market was the most frequently mentioned factor as to why global differences in building enclosures exist. The degree of stringency in codes and standards associated with the building enclosure varies in each market. In turn, the building enclosure’s design and construction performance level will differ because code-dictated minimum provisions are not the same in all global markets.

Degree of Litigation

Certain global markets have more developed and more heavily utilized legal systems than others. Often, architects and engineers will write tighter building enclosure design and construction specifications when there is a greater risk of product liability litigation. Where litigation is not as prevalent, it was perceived by interviewees that
specifications may be viewed as more of a *guideline* to building enclosure design and construction, rather than a prescriptive *requirement*.

**Normative**

**Design Role**

Several interviewees expressed that the specific roles played by the various parties involved with the design of the building enclosure can vary depending on the market. In more developed markets, the roles of architects, engineers, and contractors tends to be more clearly defined. Specifically, architects in these markets will often provide input throughout the entire design process and make final decisions with regard to the building enclosure. The design role and final decision-making process is not as clear in less developed markets. Expertise for the building enclosure in these markets is often left to the general contractor on the project, which might not always be the most appropriate situation.

**Construction Quality/Control**

The types of skilled labor available and the ability to monitor construction in a given global market can greatly affect the final building enclosure product. From the design and performance perspectives, over half of the interviewees pointed out that the availability of skilled local labor can influence significantly the final performance of the building enclosure. Designs that are overly complicated to fabricate or erect by the local labor force will often fail to perform as intended. The variability of construction supervision from market-to-market will also affect the final building enclosure product. Interviewees expressed frustration with the lack of supervision
present on building construction sites in less developed markets. The inability to enforce written specifications on site often results in a failed building enclosure installation.

**Cost of Energy**

The price of energy fluctuates depending on global market. In response, the building enclosure may be designed specifically to minimize operating costs. In such a case, the initial cost of the building enclosure will often be increased to enable reduction in the amount of energy consumed over the long term. This practice is especially prevalent for building owners who will occupy the building throughout the majority of its service life. Conversely, it may not be a priority to design a building enclosure with the intention of reducing energy consumption in markets where energy prices are low, or where operating costs are passed on to building tenants.

**Availability of Materials and Products**

Some materials and products are not readily available in each global market. For example, interviewees noted that in markets with tight financial resources, domestic materials and products were used heavily in building construction. In contrast, imported materials and products are frequently employed in building enclosures in less financially constrained environments.
Cognitive Cultural

Social and Regional Views

Prevailing social and regional views is a broad category entailing the values of each global market. Each market tends to have certain engrained views that can influence the building enclosure. For example, certain markets tend to be hesitant to incorporate new forms of technology due to lack of confidence in their ability to implement such technology effectively. Another example is the amount of social prestige a market places on the building as expressed in the building enclosure. Several interviewees noted that architectural styles that are prevalent in building enclosures in the Middle East and the Far East are associated with exhibiting a social status similar to that existing in Europe and North America.

Ventilation

The way in which a building is ventilated can differ depending on climate type and prevailing views held in that region. Some interviewees expressed that it might be acceptable in some parts of the world to rely exclusively on mechanical systems to provide ventilation. In other regions, the use of natural ventilation by means of operable windows is preferred. This preference for operable windows can be so strong that it eventually becomes part of model building code provisions for that region. Such instances where operable are normal in building enclosure constructions are cases found in Europe and the Far East.
Thermal Performance

Expectations regarding thermal performance of the building enclosure vary based on global market. Almost half of the interviewees stated that the level of detailing to avoid thermal bridges, as well as the amount of insulation used in a building enclosure, are results of how each market prioritizes thermal performance. If thermal performance has a high priority, attention to detailing and make-up of the building enclosure will reflect it. Similarly, a low priority on thermal performance often results in a building enclosure that is not well designed to reduce heat transmission.

Moisture Protection

Similar to thermal performance, the design of a building enclosure to resist moisture intrusion was often attributed to each individual global market’s performance expectation. Some markets tend to view preventing water penetration into the building as a crucial functional requirement of the building enclosure. Means of achieving this could involve ensuring that water barriers are continuous or providing flashing and weep holes throughout the enclosure to provide effective water drainage.

Long Term Performance

Eight of the interviewees pointed out that emphasis on long term performance (i.e. life-cycle) of the building enclosure will vary from market to market. Some markets tend to focus on the initial cost of the building enclosure, paying less attention to the need of maintenance and repair and the ability to reduce operating costs over the life of the building. In other regions, the long term performance of the building enclosure is given a higher priority. This results in higher initial costs to provide a building
enclosure that requires reduced maintenance/operating costs throughout the life of the building.

**Sustainability**

The idea of sustainability in the built environment has become ingrained in building design in some global markets. This approach to design has influenced building enclosure design and construction significantly. Markets where sustainability is a common goal for building practice often produce building enclosures that emphasize green principles, such as reducing the dependency on non-renewable natural resources to construct and operate the building.

The following sections summarize how these factors were found to apply in the five global markets included in this study.
7. DESCRIPTION OF BUILDING ENCLOSURES IN FIVE GLOBAL MARKETS

The following sections contain a description of aspects of the design, construction and physical characteristics of building enclosures that are vernacular to each global market included in this study. Each global market contains several sub-states and countries, each possessing their own individualized design and construction characteristics. Thus, the interviewees stressed that providing a single description of each market’s natural environment, codes and regulations, normative practices, and cultural views would be an unrealistic endeavor. However, the general market descriptions below capture some common perceptions that were gleaned from the interview process.

Europe

In Europe, a building is not typically viewed as an individual entity by the public, but rather a part of the broader community. Each building has an impact on its surrounding environment. Europeans are often environmentally conscious (Yudelson 2008), seeking to reduce human impact on the natural environment. This environmentally conscious view manifests itself in the form of overall higher expectations for building performance. The building enclosure is a portion of the building that carries a heavy responsibility for meeting generally high European demands for energy performance and sustainability.

Building enclosures in Europe generally embody a high degree of technical sophistication as compared to other global regions, according to 23 of the 25 interviewees who were familiar Europe. As one interviewee remarked about past experience working with building enclosures in Germany as compared to North America:
“Generally, the expectations in the quality of the envelope are much, much higher. What we refer to as a ‘high performance’ building is what they consider standard.”

This was a common sentiment shared throughout many of the interviews relating their experience working in Europe to other global markets.

A major difficulty identified by nine of the interviewees while working on European building enclosure projects (from an outsider’s perspective) is the stringent codes, standards and regulations. The most prominent of these mentioned is maximum allowable thermal conductance of wall assemblies, which is far more stringent than those in the rest of the world. This often results in designers resorting to solutions that would not be common in a different global market. For example, outside of Europe, the highly conductive metal frame of a window is typically given only minimal consideration in terms of eliminating thermal bridging because the surface area of the metal frame is small compared with the area of the framed window panel. However, European designs of these metal window frames are often intricate to reduce thermal bridging. This requires skilled craftsmanship as well as specialized machinery to create appropriate details for actual construction. In glazing assemblies, double and triple glazing is standard in commercial buildings throughout Europe as a means to control thermal flux across the building enclosure. These additional expenses are not commonly allowable in other parts of the world, but in Europe they are not only expected, but they are virtually mandated by European building codes. Another instance of stringent European regulations is the more limited use of structural silicone in glazing systems. In North America, particularly the United States, structural silicone glazing systems are commonly employed for curtain wall construction. Many of these systems are permitted to be designed structurally as non-redundant, relying solely on the structural silicone to
provide a means securing glazing panels to the underlying building enclosure frame. In Europe, structural silicone glazing systems for curtain walls must be designed as a redundant system, incorporating the use of mechanical capturing devices as backups to the structural silicone for fire safety purposes.

In terms of design roles, European architects are heavily involved throughout the entire building enclosure design process. Often, they provide expertise in determining the performance level of the building enclosure. Façade consultants and building physicists are also employed commonly in Europe in the design of the building enclosure. In addition to well defined roles in the design process, the workmanship levels in Europe to manufacture and construct the building enclosure are high. This can be attributed to highly organized apprenticeship programs in Europe. Availability of such formalized training has allowed for more sophisticated building enclosure designs to be delivered successfully in the European market.

All 25 of the interviewees familiar with the European market were in agreement that the building enclosure is often designed to reduce energy usage and great consideration is given to its long term performance due to sustainability goals. A majority of commercial buildings in Europe use natural ventilation in conjunction with mechanical systems. As an example, operable windows are standard components of office spaces. They provide building occupants with the ability to control the amount of fresh air available to them without having to spend energy on regulating air flow.

In Europe, due to high energy taxes (Reed 2012), building occupants view the reduction of energy usage through the life of a building as a critical matter. Even in
speculative building projects, where a developer owns a building for only a few years, it is still important in Europe to consider long term costs because building occupants/tenants expect high energy performance over the service life of the building. This long term perspective towards the building enclosure often leads to larger initial construction budgets compared with other global markets. It is normal to spend more on initial construction because the costs will be paid back through life-cycle cost savings. An example of this is the more prevalent use of double-skinned facades in Europe, despite their higher initial costs compared with single-skin wall systems.

Another common design feature of European building enclosures that helps to reduce energy usage is passive solar design. Nine of the interviewees who have worked in Europe expressed that incorporating natural sunlight into a building space was more prominently considered in this region than others. Although not explicitly related to building enclosures, these interviewees cited narrow European floor plans that allow for natural light to penetrate interior spaces. This reduces the need to use artificial lighting to illuminate interior spaces. For controlling direct solar gain, external lighting louvers are often incorporated into the building enclosure. The interviewees stated that the use of external lighting louvers is not as prevalent elsewhere in the world.

**Far East**

Economic developments within the Far East over the past two decades, particularly in countries in the southeast Pacific (e.g., China, Vietnam, Indonesia) have accelerated construction activity in the market greatly. This has given rise for the need/opportunity of
AEC firms from around the world to conduct an increasing amount of business in the Far East.

According to ten out of the twelve interviewees familiar with the Far East, client and building owner expectations are high in this market, similar to levels found in North America, and possibly on par with those in Europe. Clients in the Far East expect building enclosures that are aesthetically pleasing, watertight, thermally efficient, acoustically effective and, more recently, that reduce long term energy consumption of the building. From a design standpoint, eight out of the twelve interviewees who have worked in the Far East stated that an appropriate level of understanding on “proper” building enclosure design principles was prevalent in the market.

Although the technical sophistication of building enclosure design is increasing in the Far East and regulations are in place that addresses the building enclosure, all interviewees familiar with the Far East expressed that the actual fabrication and construction of building enclosures is often weak in comparison with comparable projects in other global markets. A reason cited for the disparity between what is designed and what is actually fabricated and constructed is the difficulty in being able to enforce building enclosure specifications. Unlike other parts of the world where specifications are a binding agreement, in the Far East specifications have a tendency to be viewed only as suggestions. Thus, specification writing has less ability to control the influence the as-built building enclosure product.

The labor employed on many building enclosure projects in the Far East is often found locally due to cost constraints. Eleven of the twelve interviewees expressed that labor is relatively inexpensive in the Far East, but the labor force is substantially unskilled. Many
workers used to construct the building enclosure come from backgrounds not associated with construction. The following quote from an interviewee summarizes this situation:

“The labor is not high paid. The people are from the farms...they are not very informed of building technologies so the quality is compromised.”

Only a limited amount of supervision is typically found on site. This compromises quality control. However, because it is unusual to address construction issues in the Far East through litigation, there is very little motivation to increase the amount of site supervision to enhance quality control in building enclosure projects.

Similar to the wide use of local labor on projects, seven interviewees stated that many systems and materials used for building enclosures in the Far East are manufactured and available regionally. China, in particular, was pointed out as a mass producer of building enclosure systems that are used on commercial buildings worldwide. Four interviewees stated that it is difficult to determine whether many building enclosure products used in the Far East are certified to perform as intended. These four interviewees shared experiences on projects where substituted products were used from local contractors instead of ones that were specified. This is commonly done to reduce costs; however, they noted it poses a serious risk because these products are untested and may not perform to meet client expectations.

The opportunity to work on building enclosures in the Far East is promising, but the twelve interviewees familiar with this market expressed apprehension about the market with regard to the quality of building enclosures that are actually being delivered. Increased concerns for energy costs and sustainability have started to become more prevalent in many
building designs in the Far East. However, since the demand for buildings far exceeds the ability to train construction personnel appropriately, it will continue to be difficult to execute these building enclosure projects successfully.

**Latin America**

Recent foreign investments in segments of the Latin American market, particularly in South America, have created a growing potential for international work for AEC firms to address the market’s need for new infrastructure. Currently, most commercial building enclosures in Latin America are heavily influenced by a culture that stresses providing only what is essential for building occupants. In comparison with other global markets, building enclosures as a whole, from design concepts to construction capabilities, are comparatively less developed in Latin America. Most of the improvements in building enclosures, including technology developments and increased regulations, are centered in Brazil, Argentina and Chile, although these countries were viewed as still lagging behind most other global markets in terms of building enclosure performance.

Until recently, most Latin American standards and building codes did not provide specific details regarding performance of the building enclosure. Within the past decade, it was pointed out by two interviewees that more codes and standards have been written in the region, most notably in Chile, Brazil, Argentina, and Colombia. Many North American standards, such as those published by the American Architectural Manufacturers Association (AAMA), provide specific performance levels for the building enclosure. AAMA standards have been accepted relatively widely in Latin America because they are perceived to be reasonable and achievable. Energy codes have also been adapted in Latin America to address
some long-term performance issues. Brazil, for example, has created the first energy code in
the region that contains provisions for the building enclosure (Goncalvese and Umakoshi
2010). This new Brazilian energy code explicitly addresses only commercial buildings,
which are responsible for a significant portion of the country’s electricity consumption from
the use of air conditioning and artificial lights.

Most end users in Latin American commercial buildings have lower expectations for
the performance of the building enclosure compared to those in other markets as observed by
the four interviewees who have familiarity with Latin America. One example is that most
building occupants are accustomed to the warm climate that dominates the region. One
interviewee stated the following with regard to user’s expectation on building enclosure
thermal performance:

“If you are living in South America, you can accept having 17°C [63°F] inside a building,
which is coldish in winter, and 29°C [84°F] in summer, which is fairly hot. Owners,
developers – either for them or for tenants – are not asking architects to improve
performance values.”

These low expectations drive how building enclosures are designed in the Latin
American market. Moisture protection, thermal performance, and air permeability are not
high priorities in Latin America, so designers are not likely to focus heavily on these
performance attributes in the design process. Instead, there tends to be a heavy focus on the
initial costs of the building enclosure. This focus on minimizing initial costs is reflected in
the work performed by architects, engineers and contractors. As a result of these modest
performance expectations, building enclosures in Latin America are sometimes of lower quality than those in other global markets.

All four interviewees familiar with Latin America felt that the roles for delivering the building enclosure in Latin America are often ill-defined and tend to vary from project to project. One of the interviewees stated the following with regard to how building enclosure projects in Brazil are delivered as compared to Europe:

“...in Brazil, there are many ways to deliver [a building enclosure]. None of them is as structured as in Europe.”

The lack of clear definition of responsibility for designing, producing, and constructing a building enclosure in Latin America affects how the resulting product will eventually perform. Apparently, many Latin American architects have not been exposed to rigorous building enclosure design, and will often rely heavily on the expertise of the façade contractor. Contractors will typically present simple solutions for the building enclosure because there is generally not a strong demand for high building enclosure performance.

Because initial cost budgets associated with building construction are generally lean, there tends to be a greater use of readily available materials in Latin America. Traditional materials such as precast concrete and masonry are still commonly utilized in commercial Latin American building enclosures. Within the past 15 years, more products from Europe and North America have been imported into Latin America because the architectural styles from abroad provide inspiration to local Latin American projects (Marshall 2009). These imported products and systems used for building enclosure projects are designed specifically for the North American and European markets. If used, they must be modified to
accommodate the local workforce who will be installing them on site. A major concern when working in Latin America is the shortage of skilled labor (Lora and Márquez 1998). Local labor is mostly unfamiliar with these imported building enclosure systems and lack knowledge of how to install them properly on site. There is often a need to simplify complicated details on these systems in order for them to be installed on site. In addition, the amount of trained supervision in Latin America is limited, with many site supervisors lacking comprehension on proper installation for these foreign systems, which leads to faulty performance.

According to two interviewees, many younger architects in Latin America are being exposed to more international ways of designing and constructing building enclosures. Building regulations in the region are also being developed further to address building enclosures in a more rigorous fashion. However, the demand for higher performing building enclosures in the market has not become as widespread in other markets and it is expected that most building enclosures will continue to be modest in comparison to other global markets.

**Middle East**

Historical vernacular building enclosures in the Middle East were characterized as having high thermal mass and natural ventilation with small openings in the façade to address the warm climate that prevails in the region (Bahaj et al. 2007). With the economic boom in the Middle East during the early 2000’s, a sharp change in architectural direction for the building enclosure occurred, most prevalently in those countries located in the oil-rich Arabian Gulf region. A primary reason for this change in architecture in these regions is the
more recent shift toward the building form expressing status and prestige rather than responding to the surrounding environment (Al-Asad 2012). This economic boom provided significant opportunities for international AEC firms to conduct vibrant business in the region.

A major concern pointed out by eight of the ten interviewees familiar with the Middle East is that heavily glazed building enclosures are not in harmony with the surrounding natural environment. In particular, the glazing that is used extensively to adorn the building exterior is not effective in terms of thermal control and reducing direct solar heat gain into the building. Often, this leads to overreliance on mechanical systems to create a thermally comfortable interior environment. This is often tolerated because there is great wealth in many areas of the Middle East and energy prices are still relatively cheap as compared to other global markets.

From three interviewees’ previous experience in the Middle East, waterproofing of building enclosures is not often emphasized because precipitation is an uncommon occurrence in much of the region surrounding the Arabian Gulf. However, when it does rain, these buildings can experience significant water penetration. Still, for the Middle East as a whole, the interviewees held the view that serious efforts at building enclosure moisture control were not currently a priority in that region. Three interviewees expressed an environmental concern that is common in some of the more highly developed areas in the Middle East: high salt content in the air. High salt content, which is attributed to the surrounding bodies of sea water, is detrimental to many finishes used on buildings, particularly in conjunction with the relatively high ambient temperatures in most of the
Middle East, which accelerates corrosive chemical reactions. One interviewee described his experience when surveying coastal Middle East buildings for environmental deterioration:

“I think that the proximity of the sea, while it moderates the temperatures and all that, does have an effect on buildings that are immediately adjacent within a few blocks. It’s very common to see deteriorated buildings that are older along the coast.”

Five interviewees who worked in the Middle East stated that most building enclosures on modern, Middle Eastern commercial buildings are designed to achieve performance levels found in North America and Europe. For mid-to-higher end commercial projects, international design teams are often employed for the building enclosure, while lower end projects tend to default to the project contractor to handle the building enclosure. Many building enclosure products used on the mid-to-higher end projects are designed using building codes and standards from either North America or Europe, and these products are often imported into the Middle East. Two main reasons exist for the use of foreign building codes and standards: (1) most existing building codes in the Middle East do not contain significant detail regarding the building enclosure; and (2) foreign designers often utilize codes and standards with which they are most familiar.

Most commercial building projects in the Middle East use local labor for construction due to project cost limitations. Unlike North America and Europe, which have long traditions in modern building construction, the Middle Eastern industry is relatively inexperienced with modern building enclosures. Six of the ten interviewees who had experience working in the Middle East expressed frustration due to poor construction quality in the region. Specifically, five of these interviewees felt there is often disconnect between those designing the building
enclosure and those constructing it. These interviewees felt that early in the building enclosure design process their expertise was relied upon heavily. However, as the project moved from design to construction, they were often omitted from the construction phase of the project.

Another issue mentioned by four interviewees is that most projects in the Middle East are run on compressed schedules. From their experience, Middle Eastern projects are often fast-tracked, so there is little time spent on design development before project construction actually begins. Problems are often identified and remedied during construction. As one of the interviewees remarked:

“The design programs are short – too short, basically, to deliver and to deliver consistently. And time frames are always very short, and there’s little time for the design development and coordination, which often happens after the delivery, unfortunately.”

Five of the interviewees familiar with the Middle East stated that building owners and occupants are beginning to place greater emphasis on building energy performance. Green policies such as LEED: Leadership in Energy and Environmental Design (USGBC 2012) and the BRE Environmental Assessment Method (BREEAM 2009) emerged as integral parts of building construction. There is now a greater emphasis in the Middle East on long term performance and increased investment in research dedicated to alternative energy and sustainable practices, as exemplified by futuristic initiatives such as Masdar City (Masdar 2013). It is expected that such developments will influence how future building enclosures are designed and constructed in the Middle East.
North America

North America has historically been a speculative market for commercial buildings, with many properties developed by owners with the intention of generating profit during resale of the building (Glaeser 2013). To maximize revenue from selling the property, minimizing initial costs associated with building construction is essential for owners ascribed to this business model. The emphasis on being able to recover initial costs from a project often dictates many aspects of design and construction, particularly in the building enclosure. The long term performance of the building enclosure in a speculative real estate environment is often overlooked in preliminary stages of design, and is usually relegated to a much lower priority.

All twenty interviewees who had familiarity with both North America and Europe acknowledged that priorities for building enclosures in Europe, such as sustainability and energy performance, have not historically been as prominent in North America. Compared to Europe, North American energy prices are significantly lower (Wiesmann 2012), which has inhibited demands in North America for building enclosures that reduce energy consumption, according to six interviewees. However, growing concerns for the environmental impact of buildings has fostered increased concerns for how building enclosures are designed. Leadership in Energy and Environmental Design (LEED), a green rating system developed by the United States Green Building Council in 2000, has become a major force in influencing the design of buildings in North America. LEED has provided designers with a starting point for the building enclosure to be more energy efficient. Example recommendations from LEED include designing the building enclosure to maximize energy performance and to meet ASHRAE provisions for human comfort (ASHRAE 90.1 2010).
Today, more than 40,000 building projects have been LEED certified or are in the process of LEED certification (Christ and Furness 2011).

Although North America still lags Europe in incorporating sustainable and energy efficient practices into mainstream building enclosures, a common perceived strength regarding North America from eight interviewees is its deep understanding of moisture and waterproofing. One interviewee remarked:

“I think that which distinguishes the U.S. and Canada [from the rest of the world] is the interest on water, mold, condensation and barrier issues, particularly in the north.”

From experience, North America tends to focus heavily on waterproofing the building enclosure. Several standards have been developed and implemented over the years to test building enclosure systems for water penetration (e.g. ASTM E783, AAMA 501.2, etc.). The tests used in these standards are often stringent as compared to international standards. For products and systems that are imported, it may be difficult to get these products to meet North American water control standards.

According to five interviewees, a plausible reason for North America’s emphasis on water protection can be attributed to instances of litigation resulting from building enclosure failures associated with excessive mold and condensation. North America possesses a highly litigious society in comparison to the rest of the world. From a designer’s standpoint, it is prudent to emphasize protecting the building enclosure from moisture intrusion, which is especially problematic in the northern parts of North America. A higher number of sealed building enclosure systems using silicone are employed in North America with the intention of fully preventing water infiltration. This method of moisture protection was noted as being
uncommon in other global markets. Instead, interviewees stated other markets employ “rainscreen” systems, where water is permitted to enter the exterior layer of the building enclosure, but is captured and shed through an interior drainage plane. In addition to designing for water issues, building construction sites are often heavily monitored for quality control. Due to the risk of litigation, there tends to be more careful construction oversight in North America.

Although the North American market is well developed in terms of understanding building enclosure performance and possesses the capabilities to construct a wide variety of commercial building enclosures, it still hesitates to adopt newer technologies, according to six interviewees familiar with the market. Building enclosures in North America tend to possess components that have been tried and tested for many years. Even with the emphasis on sustainable design and construction, North American building enclosures tend to embody less innovation than those in other, less litigious global regions.
8. CONCLUSIONS AND RECOMMENDATION FOR CONDUCTING INTERNATIONAL BUILDING ENCLOSURE WORK

With AEC firms rapidly expanding their international scope of work to remain competitive in the global building market, the need to be informed of international nuances is critical to enable success on international projects. This is especially true for those interested in practicing international building enclosure design and construction, which are heavily influenced by global location. Prior to the work presented in this study, only limited information was available in the open literature that address global differences in building enclosures.

Analyzing building enclosure design and construction in Europe, Far East, Latin America, Middle East, and North America, thirteen factors were found to contribute to global differences in building enclosures. Applications of these thirteen factors to each of the five studied global markets were presented, as derived from twenty-nine interviews conducted with building enclosure professionals who had international building enclosure knowledge and experience. Interviewees expressed that significant global differences do exist regarding the design and construction of the building enclosure. It was found through these dialogues that prevalent climate, rules and forms of governance, normative behavior, and acceptable societal views within each market greatly affected the final building enclosure product. Such information can inform new practitioners so that they might avoid some of the pitfalls associated with international work.

For individuals or firms considering a venture into international building enclosure work, the global market descriptions present relevant market-specific considerations for
building enclosure design and construction as gleaned from experienced practitioners. It was expressed by some interviewees that the best course of action to take when entering into a new global market is to deliver the building enclosure project with a local partner who has familiarity working in the specific market. This external party can help inform about global nuances that needs to be considered and understood in order to carry out work successfully.
9. ACKNOWLEDGEMENTS

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10. REFERENCES


PREFACE TO CASE STUDIES

Five representative case studies describing a building enclosure project for each of the studied global markets are presented in the following appendices. These projects were selected on the basis that they fit the four characteristics used to describe the buildings in this study: mainstream, modern, low-to-mid-rise, and commercial. The information presented in the case studies was gathered through responses from a questionnaire, presented in Appendix G, that was provided to parties who were familiar with the design and construction of the case study building enclosure. In certain instances, information was also derived from project documentations, such as drawings and specifications, when provided.

The case studies are provided to be illustrative in nature. The descriptions illustrate some of the salient findings that were derived from the interview process. These case studies are not intended to provide validation of interviewee perceptions, but the descriptions do display significant global differences in the design and construction of building enclosures across each studied global market.
APPENDIX A: NORTH AMERICAN CASE STUDY: BUTZ

CORPORATE CENTER

Building Information

Location: Allentown, Pennsylvania

Client: Alvin H. Butz, Inc.

Architect: Roberson Butz Architects (Allentown, PA)

Project Manager: Alvin H. Butz, Inc. (Allentown, PA)

Structural Engineer: O’Donnel & Naccarato, Inc. (Philadelphia, PA)

Façade Contractor: Hutt’s Glass Company, Inc. (Bechtelsville, PA)

Total Floor Area: 12,077 m² (130,000 ft²)

Number of Stories: Six

Building Enclosure Cost: 1,279,735 € (1,700,000 USD)

Introduction

Butz Corporate Center, shown in Figure A.1, is an office and retail facility constructed to house multiple tenants. The project is being constructed in two phases, with the first phase completed in 2006 and the second phase to be completed during mid-summer 2013. Located in Allentown, Pennsylvania, the top two levels of Butz Corporate Center will serve as the headquarters for Alvin H. Butz, Inc., a large construction company that has operated in the Lehigh Valley region since its founding in 1920. Alvin H. Butz, Inc. belongs to a family of companies under the umbrella of Butz Enterprises, Inc., each providing construction management services throughout Pennsylvania (Butz Enterprises 2013).
Roberson Butz Architects was selected to provide architectural services for the project. The company, based out of Allentown, PA, has been providing architectural, planning, and interior design services since 1998 (Roberson Butz Architects 2013). The firm’s primary market consists of designing commercial, institutional, and residential projects. Roberson Butz Architects values innovative, modern design that reflects the unique value and objectives of each of its clients.

Figure A.1: Butz Corporate Center (Images courtesy of Roberson Butz Architects)

In addition to the top two floors serving as a corporate headquarters, floors two through four comprise Class A office spaces for rent to prospective tenants. The first floor for Butz Corporate Center is designed to provide retail spaces. In relation to its site, the building
is surrounded by adjacent commercial buildings on three sides, while the fourth side faces an urban plaza.

**Architecture**

The architectural style that best describes Butz Corporate center is modern, similar to many projects completed by Robeson Butz Architects. The project consists of two phases, with a building finished floor plan of 12,077 m² (130,000 ft²) over six floors. The building geometry is simple, with the building footprint forming a rectangle, as shown in Figure A.2. All four faces that make up the exterior of Butz Corporate Center is smooth, void of any significant extrusions. The exterior of Butz Corporate Center is marked by rectilinear faces that form a grid-esque pattern. Modernity is exemplified through the lack of curved surfaces. In the absence of curves, horizontal elements dominate, providing simplicity and clarity. The only interruption on the planar surface of the building lies on the first floor. A series of colonnades are provided along the ground level, shown in Figure A.3.

![Figure A.2: Rectangular Floor Plan of Butz Corporate Center (Image courtesy of Roberson Butz Architects)](image-url)
For the interior of Butz Corporate Center, the architect wanted to incorporate an environment that provided views to the surrounding urban area. Transparency was expressed through the use of long beads of windows present on the north and south face. The large amounts of window on the façade of Butz Corporate Center allows for natural light to illuminate the spaces located within, as seen in Figure A.4. In addition, a large multi-floor atrium is incorporated into the building that allows for more light to penetrate into the interior space, shown in Figure A.5.
Building Enclosure Physical Description

The appearance of the building enclosure for Roberson Butz Architects reflects the desired aesthetic appearance for a modern building. As mentioned in the previous section, the architectural appearance of the building enclosure is characterized by perpendicular intersections. The modern aesthetics of the building enclosure are further emphasized by the contrast of two dominate color schemes: white for the opaque portions of the façade and clear, which comes from the extensive use of glazing.

The building enclosure is comprised of glazed aluminum curtain walls provided by Tubelite®, which are supported by the steel frame structural system. The system used for this building project belongs to Tubelite’s 200 series, an economical stick built system that is used for low-to-mid-rise building enclosure applications. The system is characterized as providing snap on finishes that are available in a wide variety of colors (Tubelite 2013). The
glazing used on Butz Corporate Center consisted of clear argon-filled, double pane insulating glass units with a low E-coating. The insulating glass units are fastened into the aluminum window frames via the use of mechanical fasteners in the form of rubber gaskets.

At surfaces on the façade where floor levels would be visible from the outside, spandrel glass units are provided to shield this view. Located behind the solid surfaces of the building enclosure is a layer of batt insulation for thermal protection, as shown in Figure A.6.

Figure A.6: Section Depiction of Batt Insulation (From Architectural Drawing A5-5; Courtesy of Roberson Butz Architects)
The roof on Butz Corporate Center consists of an adhered thermoplastic (TPO) membrane over rigid insulation, on top of a structural deck. The exposed surface of the roof, the TPO is specified as being a GAF Everguard TFO TSR-60 in white and is 1.5 mm (0.06 in.) thick. The rigid insulation is designed to have a tapered slope of 1/8 in. per 12 inches (1:96).

**Building Enclosure Function and Performance**

The components of the building enclosure had to go through independent testing and verification before it could be used for construction. According to project documentation, the curtain wall was subjected to six different tests carried out by Architectural Testing, Inc. (ATI). The tests evaluated the performance of the curtain wall system in regards to air infiltration, water resistance, and structural performance. Each test was carried out according to relevant specified American Society for Testing and Materials (ASTM) and American Architectural Manufacturers Association (AAMA) testing procedures.

Allentown, PA is defined as having a mixed climate, with an average high temperature of 28.8°C (83.9°F) in July and an average low temperature of 17°C (62.6°F), as shown in Figure A.7. Internal environment temperatures are moderated using the building enclosure and gas-fired rooftop mechanical units, the latter also providing ventilation for the building. Project specifications required all curtain wall systems to have a thermal conductance not exceeding 3.75 W/ (m²·K) (0.66 BTU/ (hr·ft²·°F)). For the Tubelite 200 Series curtain wall systems employed on Butz Corporate Center, the maximum thermal conductance value for the assembly (glazing and framing) was 2.67 W/ (m²·K) (0.47 BTU/ (hr·ft²·°F)). This value for the 200 Series was established through independent testing of the
product conducted by Tubelite with ATI in accordance with NFRC 102 (2010). For the project, to reduce heat transmission through the large bands of glazing on the building, 1 in. insulating glass units were used throughout construction. Unwanted solar heat gain was controlled through the application of a low-emissivity coating to the exterior glazing. The building enclosure was designed and tested to mitigate water intrusion into the building. The geographic location in which Butz Corporate Center receives 1,147 mm (45.2 in.) in precipitation yearly, also shown in Figure A.7.

![Figure A.7: Average Temperature and Precipitation in Allentown, PA (Climate Charts 2013)](image-url)
To control unwanted moisture penetration into the building, the building enclosure used two primary mechanisms. The first was providing (3) ¼ in. weep holes at each horizontal pressure plate for each lte of glass. This provided the building enclosure with a means to drain water away from the building using aluminum flashing. The second mechanism to waterproof the building enclosure consisted of using exterior silicone sealants throughout joint interfaces. Verification of water tightness for the building enclosure was conducted through the use of two tests carried out in accordance with ASTM E331-00 (2009) and AAMA 501.5 (2005). The first test consisted of subjecting a full scale mock-up to a 718 Pa (15 psf) static positive air pressure differential while water at 5 gal/ft²/hr is sprayed on the system for a 15 minute duration. AAMA 501.5 is a dynamic water leakage tests, where a 718 Pa (15 psf) equivalent dynamic pressure is applied to the system for 15 minutes as water is sprayed at a rate of 5 gal/ft²/hr, as shown in Figure A.8. In both tests that were performed, no uncontrolled leakage was observed in the mock-up.

Figure A.8: Full-scale Mock-up Subjected to Dynamic Water Test (Image courtesy of Roberson Butz Architects.)
Structural requirements of the building enclosure consisted of mockups being subjected to static pressure tests, interstory differential horizontal movement tests, and thermal cycling. The structural performance of the building enclosure was tested according to ASTM E330-02 (2010), which permits deflection of a framing member not to exceed L/175 for clear spans up to 13 ft 6 in. Although Allentown, PA is characterized as being a low seismic region (USGS 2013), the building enclosure had to be designed for interstory drifts induced by seismic loading. Testing procedures to determine design displacements using simulated earthquake loading followed AAMA 501.4 (2001) standards. Finally, the thermal cycle of the building enclosure followed AAMA 501.5 procedures, which subjected the mockups to a thermal cycle from 0°F to 150°F, without experiencing any behaviors of cracking, buckling, distortion, glass fallout, etc.

Although the Butz Corporate Center is not a Leadership in Energy and Environmental Design (LEED) rated building, aspects of the building enclosure had to meet LEED requirements. Product data for the sealant used in weatherproofing and all recycled products and materials had to be submitted to the general contractor. Also needed in the submittal process was proof that the materials met requirements for regional material and information regarding the distance of the material manufacturer to the site of the building project. From the construction aspect of LEED, all contractors, subcontractors, and their personnel were responsible for separating, collecting, and transporting waste.

**Building Enclosure Design and Construction Participants**

The building enclosure design was performed by Roberson Butz Architects. The planning of the building enclosure began in the preplanning phase of the project, where
initial decisions were laid out. For the model building codes used for this project, the architects used the International Building Code (IBC) to determine minimum seismic and wind requirements for the building enclosure. Structural engineering for the curtain wall system was performed by Pany & Lentz Engineering Company to verify the curtain wall met strength and deflection requirements.

To construct the building enclosure, Hutt’s Glass Co., Inc. was selected to be the façade contractor through an open bid process. They were chosen based upon their qualifications and their bid price. The company, based out of Bechtelsville, PA, was founded in 1950 and focused on the installation of auto glass and residential glass (Hutt’s Glass Co. 2013). Since then, the company had shifted its focus towards commercial glass projects. In addition to providing building enclosure construction process, the company also possesses its own fabrication shop.

Quality assurance and field quality control for the project were specified during the construction of the building enclosure. In addition to the mockup tests by ATI described in the previous section, field tests and inspections were performed by an independent testing agency working for the owner. During construction of the building enclosure, air infiltration tests in accordance with ASTM E783 (2010), water penetration tests in accordance with ASTM E1105 (2008), and water spray tests in accordance with AAMA 501.2 (2009) had to be performed to verify that the building enclosure was performing as intended. Field tests were also specified to ensure that the building enclosure met construction tolerances set forth in the specifications.
North American Building Enclosure Design and Construction Characteristics

Through examining the above case study description, several characteristics of the design and construction of the Butz Corporate Center and its building enclosure correlated with interviewee responses regarding North American building enclosures in the main portion of this thesis.

Although owner occupied, the majority of the building floor area was designed to be rentable to prospective clients. This was an agreement with interviewee perceptions about North America: a majority of buildings are still speculative in nature. Although not clearly articulated on how the case study building’s speculative nature impacted the building enclosure’s design and construction, many interviewees stated that being a speculative building has a significant impact on decisions affecting the final building enclosure product.

Analyzing the geographical effects on the building enclosure design, the use of insulating glass units and well insulated curtain walls elements help condition the interior environment from the temperature highs and lows prominent in Pennsylvania. The use of mechanical systems as opposed to operable windows to ventilate the building was a common perception in North American building enclosures. The utilization of silicone sealants to prevent water from breaching the building enclosure is almost exclusively employed in North America. Using additional laboratory testing for mock-up building enclosure components is also in agreement with interviewee statements regarding North American practice. It was noted by interviewees that North America employs stringent testing programs to assess building enclosure performance. On the Butz Corporate Center, the curtain wall systems being subjected to further testing at ATI help validate some of the perceptions on North
American testing. Even though the region is categorized as being low for seismic activity, interstory drift tests still had to be conducted. This was in agreement with perceptions that North America is typically conservative.

Analyzing participant roles in the building enclosure, the architect provided final decision making regarding the building enclosure. This was in agreement with interviewee statements that the design process of the North American building enclosure is relatively well defined as compared to other less developed markets. The project manager and façade contractor have many years of industry experience. This too was in agreement that North America has a relative rich tradition for construction, in particular as it relates to the building enclosure.

Acknowledgements

Sincere gratitude is extended to Alexander Construction and Roberson Butz Architects, who provided this case study project, images, and related documentation for educational use. The author would also like to thank Eric Butz and Patrick Boyle, who provided insight into the design and construction of Butz Corporate Center.

References

“200 Series Curtainwall.” Tubelite®.


APPENDIX B: EUROPEAN CASE STUDY: VEREINIGTE
SPEZIALMÖBELFABRIKEN (UNITED SPECIAL FURNITURE
FACTORIES) CASE STUDY

Building Information

Location: Tauberbischofsheim, Germany

Client: VS Vereinigte Spezialmöbelfabriken GmbH & Co.

Architect: Behnisch, Behnisch & Partner (Stuttgart, Germany)

Project Manager and Structural Engineer: Gey + Partner

Façade Consultant: Erich Mosbacher

Façade Contractor: Schindler Fenster + Fassaden GmbH (Roding, Germany)


Total Floor Area: 8,250 m² (88,770 ft.²)

Number of Stories: Five

Building Enclosure Cost: 2,300,000 € (3,055,320 USD)

Introduction

Located in the north-east of the German state Baden-Württemberg in the town of Tauberbischofsheim, Vereinigte Spezialmöbelfabriken (VS), which in English means United Special Furniture Factories, is the headquarters of VS Vereinigte Spezialmöbelfabriken GmbH & Co., shown in Figure B.1. The company, founded in Germany, has been in existence since 1898 and continues to operate today. Originally started as a merger between four furniture manufacturers, VS Vereinigte Spezialmöbelfabriken GmbH & Co designs,
develops and manufactures furniture for schools and commercial buildings (VS International 2013).

To mark the centennial anniversary of the company, VS Vereinigte Spezialmöbelfabriken GmbH & Co. sought to establish a new building to act as its headquarters. Behnisch & Partner (now known as Behnisch Architekten), based out of Stuttgart, was commissioned to provide architectural services for the new project. Günther Behnisch, who had previously collaborated with the company in furniture design, was selected to be the lead architect for the new project. Previous to working on VS, Behnisch had been known nationally in Germany for his work, including designing the site of the 1976 Olympic Games in Munich, the chamber of the German Bundestag in Bonn and the Museum of Communication in Frankfurt.

Figure B.1: Vereinigte Spezialmöbelfabriken (Image courtesy of Behnisch Architekten)
Behnisch and his team were tasked with providing work spaces for the company’s 100 employees (Behnisch Architekten 2013). Also needed to be included in the new building were conference and meeting rooms to conduct business and also a restaurant to serve both management and employees. In addition to acting as the home base of VS Vereinigte Spezialmöbelfabriken GmbH & Co., the building was to serve as a showcase space, where prospective clients could view furniture that would be exhibited in a pleasant, informal environment.

The client of the project originally envisioned a central office building that would act as the hub of the company and provide a direct link to the rest of the surrounding offices, as shown on the site plan in Figure B.2. The existing site of the building had consisted predominantly of various smaller office buildings scattered throughout, with a large factory in the vicinity that manufactured furniture for the company.

Figure B.2: Site Plan of Vereinigte Spezialmöbelfabriken (Image courtesy of Behnisch Architekten)
Architecture

What was born from the vision of the client was a building that was simple and eloquent in appearance, yet provided a central focal point that intertwined the surrounding buildings and natural landscape. The finished building footprint is approximately 8,250 m² (88,770 ft²), spanning five floor levels. The length of the building is very long, approximately 110 m (361 ft.). Conversely, the perpendicular dimension is slender and consists of a narrow floor plan section, as depicted in Figures B.3 and B.4.

Figure B.3: Longitudinal Section of VS (Image courtesy of Behnisch Architekten)

Figure B.4: Section through the Short Dimension of VS Illustrating the Narrow Floor Plan (Image courtesy of Behnisch Architekten)
The appearance of the building form is similar to that of a bridge, spanning a long distance, with each end connecting to an existing building. Under the building’s span lies a preexisting safety pond, a nod to new creation while maintaining the existing landscape. The arrangement of the building was done to produce a courtyard, which after finished construction was later developed in the complex’s green center.

In the north part of the building, towards the courtyard, the form in appearance is planar and smooth, providing a backbone to the workshop and park. In the south end, where VS faces smaller single-family homes and household gardens, the building’s mass is more fragmented. To accentuate this part of the building, terraces are employed, which contribute to a more finely articulated appearance.

The presence emanating from VS is that of a very light structure. The building environment is designed to elicit a cheerful, ambient environment for the building occupants and those that come into contact with VS. Openness, transparency, and informal structures prevail over orderliness and rule observance in the building system and the organization of the offices contained within. In keeping with the theme of maintaining a very light environment for the building occupants, the interior is free from obstructions such as high solid walls and visibly obtrusive structural systems, as shown in Figure B.5.
The first floor of VS contains the exhibition space used to showcase new furniture, seen in Figure B.6. The area is open, allowing for prospective clients to view the products in a free manner. One is able to view from one end of the building to the other due to the openness of the exhibition space. Accentuating the showcase space are large amounts of glazing. This allows for the space to be illuminated with soft, natural sunlight. The only forms that interrupt the flow of the space consist of the structural reinforced concrete columns.

The project received two awards for its architectural achievement. The first came in 1999, as the project received the Franken Prize from the Association of German Architects (BDA). The second came in 2004, when the project was awarded the “Exemplary Building” building award from the German district of Main-Tauber-Kreis.
To create the desired feeling of lightness and transparency for VS, the building enclosure had to be designed accordingly to achieve these goals. The reinforced concrete structure was designed so that supporting columns were offset into the interior of the building. This provided an uninterrupted, homogenous appearance to the exterior façade. The building enclosure itself is very simple, with little form changes and a mostly smooth surface appearance. The building enclosure is adorned with long window beads and parapets. The neutral color scheme employed on the exterior is designed to mirror the surroundings. Towards the north, white surfaces dominate the façade, while the south contains a mixture of light blue and green, intended to interact with the flowing gardens onto the terraces of the building, as seen in Figure B.7.
The façade consists of a stick-built system, employing a mullion-transom system manufactured by WICONA. The exterior is a curtain wall system, with the façade supported by the interior columns, which can be seen in Figure B.8. Inserted into these vertical and horizontal elements is double pane, insulating glass units. The glazing is attached to the aluminum mullions and transom through the use of mechanical gaskets. Batt insulation is provided behind the solid façade panels to reduce heat flow through the façade due to thermal gradients.
The materials used in the mullion-transom facades consisted mostly of either aluminum or wood. The wooden construction is predominantly found around the restaurant portion of the building. The solid units used along with the glazing are made up of light, sharp-edged façade sheet metal. Finally, the doors located throughout VS are made up of wood and glass.

**Building Enclosure Function and Performance**

At times, it is apparent there is inherent conflict between the clients’ desires and the effects of the natural environment. The desired light atmosphere that is present in VS lends itself to be susceptible to a large amount of solar penetration. Another concern is the glazing, which accounts for a majority of the façade construction, can present challenges in mitigating heat loss through the building enclosure.
Tauberbischofsheim’s climate can be characterized as being mild to cool. Yearly temperatures in the region fluctuate between a low of 2.7°C (37°F) in January to a high of 24.4°C (76°F) in July, as seen in Figure B.9.

![Temperature Diagram](image)

**Figure B.9: Average Yearly Temperature for Tauberbischofsheim, Germany (Tauberbischofsheim 2013)**

To counteract the effects of heat entering and leaving the building enclosure, WICLINE 60E© double-pane, insulating glass units were utilized as the predominant windows on the building (WICONA 2013). In Germany at the time of VS’ construction, double-pane glazing was the norm in glazing construction according to those familiar with the project. The use of two lites of glass, with an argon filled cavity achieves superior thermal performance compared to monolithic units. The glazing used in construction is rated as Class 2.2 in accordance with DIN 4108-7 (2011), which requires the glazing unit to have a thermal conductance value between 2.8-3.5 W/(m²-K) (0.49-0.62 BTU/(hr-ft²-°F)). The windows are specifically designed to break up thermal bridges, while presenting a low cost solution that can be easily used because the systems are easy to install.
The mullion and transom system also had to reduce heat transmission through the building skin. WICTEC 50 stick-built glazing systems were chosen by the architect for the project because this system provided a flexible range of façade solutions. According to WICONA, the WICTEC 50© system is described as a basic stick façade system, which can be modified to accommodate a wide range of applications. The system is rated as having a thermal conductance value of .74 W/(m²-k) (0.13 BTU/(hr-ft²-°F)). The framing is also detailed to minimize thermal bridges throughout building enclosures, as depicted in Figure B.10.

![Figure B.10: Section Detail of Mullion-transom for VS (Image courtesy of Schindler Fenster + Fassaden GmbH)](image)

Passive solar design techniques were employed to mitigate the effects of unwanted solar penetration through the building enclosure. This concept is most evident in the use of external louvers on the south face of VS, seen in Figure B.11, where the employee restaurant and dining area are located. The louvers are strategically placed to provide shading from unwanted light in VS, while allowing for the building enclosure still to possess a high amount of transparency that was desirable to the client. To accommodate the aesthetics of the louvers and present a solution that appears integrated with the rest of VS’ architecture, the louvers are manufactured out of wood, providing a similar appearance to the interior façade trims and flooring located in the dining area. A vertical structure fashioned in the same form
of the wooden louvers is placed in the interior, providing a homogenous appearance in this part of VS.

![Image](image1)

Figure B.11: External Louvers on South Face (Images courtesy of Behnisch Architekten)

Although VS contains a mechanical system to maintain the interior environment, operable windows are strategically placed throughout the building enclosure, shown in Figure B.12. According to the architects who worked on the project, this was a very important feature of VS’ building enclosure. The use of operable windows provides the building occupants freedom to determine how much ventilation the interior space receives without relying heavily on the mechanical systems.

![Image](image2)

Figure B.12: Operable Windows in VS (Window Market 2013)
Additional performance tests were not required by the architect and client beyond the standard product rating tests of WICONA’s systems. The WICTEC 50 is rated as class AE for air tightness in accordance with British Standard EN 12152 (2002), which is the highest rating granted by the standard. Tauberbischofsheim receives a high amount of precipitation in the region, with yearly rainfall averages of 631 mm (25 in.) as shown in Figure B.13.

![Figure B.13: Average Yearly Rainfall in Tauberbischofsheim (Tauberbischofsheim 2013).](image)

Waterproofing for VS is provided through overlapping on system interfaces and draining water streams at intersections. The systems provided by WICONA are rated as RE 1200, according to BS EN 12142 (2000), meaning the system can withstand a static pressure upwards to 1200 Pa (25 psf) before leakage through the system is detected.

A main design focus of the building enclosure according to those familiar with the project was incorporating sustainability. With this in mind, product selection and planning for VS were done to stress sustainable concepts. In addition to the flexibility afforded by its façade systems, WICONA products were also selected due to the manufacturer’s commitment to environmental responsibility and stressing energy usage reduction through the building enclosure. WICONA incorporates sustainability in their aluminum systems.
through offering energy efficiency and climate protection, while at the same time using the most economical solution for the use of natural resources.

Finally, sustainability in VS’ building enclosure is accentuated through smart design. Many passive design techniques are employed in the planning and design of the building and its enclosure to ensure the environmental impact of VS is minimized. Starting with orientation, the building is aligned so that its long dimension receives maximum solar exposure. With the highly transparent façade that is employed on VS, natural lighting is able to penetrate the interior space, of the narrow plan, reducing the need to use artificial lighting to illuminate the space while also providing the building users a connection to nature. The aforementioned solar louvers and operable windows further reduce the need to condition the interior space of the occupants by mechanical means. This, in turn, reduces the amount of energy needed to provide a comfortable environment for the building occupants, providing cost savings to the client through the life-cycle operation use of VS. Investment into the use of insulating glass units and thermally insulated façade system further reduces the reliance on mechanical means to condition the interior space of VS.

**Building Enclosure Design and Construction Participants**

All final decisions for the design and construction of the VS building enclosure were determined by Günther Behnisch, who began planning the building enclosure in the preplanning stage of the project. Throughout the design of the project, Behnisch and Partners emphasized sustainability of the building. Sustainable concepts was carried through during the construction of VS. Schindler Fenster + Fassaden GmbH was selected as the façade contractor for this project through an open bid submission. Their familiarity with the type of
systems employed on VS provided a smooth process for construction of the building enclosure. The company, located in Roding, Germany, was founded in 1931 by Michael Schindler as a workshop to construct small projects and furniture (Schindler Fenster + Fassaden GmbH 2013). Today, the company employs 300 highly skilled employees who undergo thorough training that focuses on delivering successful window and façade projects. Sustainability is a major focus of the company, valuing economic construction of windows and facades relating to the complete product life cycle, supplying regional materials if possible, using timber from sustainable cultivation, optimizing the use of work equipment and using low carbon-emission materials. As a commitment to the company’s stance on sustainable construction practice, Schindler Fenster + Fassaden GmbH is also a certified environmental manager in accordance with DIN EN ISO 14001 (2010). For VS, their fabrication facility allowed them to design and construct the façade in accordance with Behnisch’s specifications.

To ensure construction quality, Erich Mosbacher was contracted by Schindler to be a façade consultant and assist in overseeing the building enclosure construction process. Mosbacher aided in monitoring the construction of the project through site supervision. In addition to façade services he provided on VS, Mr. Mosbacher also owns his own façade consulting firm, Mosbacher + Roll, which provides a full range of services for the building enclosure, including evaluation of façade technologies, planning and advising, site supervision, and assisting with procurement (Mosbacher + Roll 2013).
European Building Enclosure Design and Construction Characteristics

Similar to the North American case study, the VS building enclosure possesses characteristics that agree with research interviewee perceptions of European building enclosures.

First and foremost, the design of VS was largely driven with the intention to reduce energy throughout the life of the building. According to research interviewees, it was expressed that Europe tended to have more emphasis on energy reduction and long term performance compared to other global markets. Some European characteristic means of achieving energy reduction was through selection of mullion and transom systems specifically detailed to avoid thermal bridging. The large use of glazing in conjunction with the shallow floor plans to provide natural lighting instead of relying heavily on artificial lighting is characteristic of European design.

Solar design was heavily incorporated into VS, agreeing with interviewee perceptions of Europe. To minimize unwanted sunlight into the interior space, external louvers, which was noted to be a common feature on European building enclosure design, were strategically placed on the south face of VS. Also incorporated into the building enclosure is the prevalent use of operable windows. It was stated by interviewees that Europeans still prefer to rely heavily on natural means to condition the interior space as oppose to relying solely on mechanical systems support.

Refocusing on the glazing, double-pane insulating glass units were used on this project. The architect noted that at the time of this projects construction, double pane was the conventional glazing construction used in Europe, although current practice sometimes employs triple glazing, similar to interviewee perceptions on Europeans considering double
and triple pane glazing. In addition, the thermal conductance of the frame and glass were separately rated for the curtain wall systems. Interviewees noted that Europeans tended to focus heavily on glass framing compared to other global markets. Other markets will employ ratings for the entire building enclosure assembly, grouping the windows and frames into single units. However, in Europe, because the frame can be prone to high heat loss, the separate rating for the frame illustrates that Europeans do indeed care about its thermal performance in separation from other building enclosure components.

The architect, Günther Behnisch, made all final decisions regarding the building enclosure design and construction. This agreed with interviewee perceptions that Europe had better defined roles for decision making. The façade contractor, Schindler Fenster + Fassaden GmbH, also possessed a rich history of over 80 years related to building enclosure services. They possessed the ability to fabricate the curtain wall systems on VS as needed. As noted by interviewees, many European fabricators possess sophisticated skills and equipment to carry out most architectural designs. In addition to using an experienced façade contractor, the use of a façade consultant was also in agreement with interviewees that Europe tends to employ more parties when designing and constructing the building enclosure.

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References


APPENDIX C: MIDDLE EAST CASE STUDY: JORDAN KUWAIT

BANK HEADQUARTERS

Building Information

Location: Amman, Jordan

Client: The Jordan Kuwait Bank

Architect: Bilal Hammad Architects (Amman, Jordan)

Project Manager: Haddadinco (Amman, Jordan)

Structural and MEP: Haddadinco

Planning and Construction: 1999-2002

Area: 3,017 m² (32,475 ft²)

Number of Stories: 3 (Main Building); 5 (Tower)

Building Enclosure Cost: 1,531,980 € (2,000,000 USD) - total cost of project work

Introduction

Originally constructed during the 1980’s as a routine retail and office building (shown in Figure C.1), the Jordan Kuwait Bank Headquarters was transformed with a complete exterior facelift (shown in Figure C.2) and expansion on the original premises that better reflected its building owner (Al-Asad 2012). The Jordan Kuwait Bank was originally founded in 1976 as a public shareholding company as a way to generate revenue for wealthy states, such as Kuwait, by investing in a country with a highly developed workforce, such as Jordan (Jordan Kuwait Bank 2013). The company has been providing 35 years of banking activities within Jordan, with over 50 branches located across the country, and additional branches in Palestine and Cyprus.
Bilal Hammad Architects was approached by the bank to provide architectural services for the upgrading of the building. The architecture firm was founded in 1976 by Bilal Hammad based out of Amman, Jordan (Bilal Hammad 2013). The firm’s scope is wide in range, offering services in urban planning, landscape and architectural design, and interior
design. They had worked previously on a number of diverse rehabilitation and restoration projects, including, commercial, residential, hotels, cultural centers.

The architects on the project faced a challenge of transforming the aesthetics of an ordinary building project into one that presented a more modern appearance on a limited budget. The expansion of the facilities also included providing executive offices and a meeting room for the board of directors in the company, which totaled a floor area of 600 m$^2$ (6,458 ft$^2$) and expanding the parking facilities by an additional 2,400 m$^2$ (25,833 ft$^2$). Additional challenges were faced due to the fact that the client wished to interfere as little as possible on the existing reinforced concrete structural system and the preexisting building enclosure.

**Architecture**

The aesthetic transformation of the Jordan Kuwait Bank Headquarters shows a juxtaposition of traditional imagery with modernity. The lower level exterior of the building includes traditional carved stone supporting a lightweight glass and aluminum curtain wall, emphasizing the modern appearance of the building. To further emphasize the transformation of the building, a free standing tower was placed at the corner of the site facing towards the street, as shown in Figure C.3. The tower provides an additional entrance into the building, as well as acting as a strong visual presence announcing the stature of the building owner.

The free standing tower consists of the same materials as the main building and is connected to the main building through the use of a steel bridge, shown in Figure C.4, which connects the two structures at the third story level. The interior was also redesigned to reflect the owner’s vision of being a modern company, as shown in Figure C.5. The transformation
of the architecture for this building provided the surrounding area with an aesthetic rejuvenation. As noted by those familiar with the project, a key architecture goal was to provide an inspiring project that would encourage other Jordanian architects to practice and create more modern designs.

Figure C.3: Jordan Kuwait Bank Tower (Image courtesy of Bilal Hammad Architects)

The remainder of the original building premises remained untouched. The views away from the street consist predominantly of the old stone building enclosure that was on the original building. Limiting the redesign to the views where the building was most visible helped establish a modern identity, while at the same time minimizing project costs.
Figure C.4: Steel Bridge Connecting Main Building to Tower (Image courtesy of Bilal Hammad Architects)

Figure C.5: Interior View of Main Lobby (Image courtesy of Bilal Hammad Architects)
Building Enclosure Physical Description

The redesigned façade of the Jordan Kuwait Bank Headquarters consisted predominantly of three materials: glass, metal, and stone. Much of the redesign was focused towards the main street side of the site plan, where the building would be most visible, as shown in Figure C.6. The stone façade is predominantly centered at the base of the building and acts as a structural feature, supporting the upper light façade structure. The stone materials that make up the base is germane to the area and was cut and fabricated locally in Jordan, helping reduce costs to stay within the owner’s budget.

Figure C.6: Third Floor Plan of Jordan Kuwait Bank (Image courtesy of Bilal Hammad Architects)
The main street aesthetics of the façade is accentuated by horizontals, predominantly in the form of steel external louvers found on the free standing tower addition. The glass curtain wall is supported by a fixed glass spider system, which acts as the predominant structural system for the façade. The portion of the building enclosure over the existing building consists of a steel grid canopy, meant to further accentuate the modern appearance of the building. The building roof over the main structure is constructed out of concrete ribbed slab, while the tower roof consists of a steel structure and corrugated sheets topped with 10 cm (3.94 in.) reinforced thick concrete layer. Between the tower and main building, a tent structure, as seen in Figure C.7, is placed over the entrance into the main building.

Figure C.7: Tent Canopy (Image courtesy of Bilal Hammad Architects)

**Building Enclosure Function and Performance**

The main reason for the façade facelift was driven more by aesthetic needs rather than function. The prevalent use of glass and metals diverges from the traditional construction
materials of the region, as previously shown in Figures C.1 and C.2. The new façade was meant to show that the company, Jordan Kuwait Bank, had a significant presence in the modern world and the high use materials of glass and metal incorporated into the new façade was meant to illustrate that point.

Although the overall building enclosure was heavily driven by an aesthetic renovation, functional requirements were incorporated in the new construction. The climate of Jordan is characterized as having long, hot, dry summers and short, cool winters (Weather Online 2013). January is the coolest month, with temperatures ranging from 5 to 10°C [41°F to 50°C]; August the warmest, with temperatures from 20 to 35°C [68°F to 95°C] as shown in Figure C.8.

![Yearly Temperature Profile for Jordan](image)

**Figure C.8: Yearly Temperature Profile for Jordan (Weather Online 2013)**

The high warm temperatures during the summer months give rise to the Shirocco, a hot, dry wind that has the potential to cause sandstorms. In addition to potential sandstorms in the region, Jordan does receive some annual precipitation between the months of November and March. The region receives 270 mm (10.6 in.) of rainfall a year, as seen in Figure C.9.
Figure C.9: Annual Precipitation for Jordan (Weather Online 2013)

The extensive use of glass makes Jordan Kuwait Bank Headquarters susceptible to large penetrations of sunlight. This is problematic, especially considering the high temperatures that are prevalent in the region, which are further exacerbated by direct solar gain. As mentioned, external louvers, like the ones shown in Figure C.10, were placed on the Southwest facing elevation, helping to reduce sunlight penetration into the building. Further, the steel canopy and tent structures mentioned earlier were placed to provide shading for building occupants. Mechanical heating and cooling HVAC systems and electrical system upgrades were also implemented.
The glass façade placed over the main building section is designed to act as a ventilated wall system, similar in performance to a double-skinned wall system. This ventilated wall approach is aimed to reduce heating loads on the building due to the warm climate that is prevalent in the area. For the thermal rating of the new façade assemblies and performance level for moisture intrusion, no specific values were able to be provided by the project architect or contractor. However, it was noted that measures during design and construction were implemented to ensure some level of performance in both categories. The facade was designed to meet the Jordanian Ministry of Public Works & Housing Code, but assessment of its performance used ASTM and British Standards.
Building Enclosure Design and Construction Participants

For the Jordan Kuwait Bank Headquarters, Bilal Hammad led the architectural direction for the exterior renovation from the beginning of the project. Haddadinco, the primary contractor on the project, provided a variety of services, including façade consulting and construction, providing structural engineering services, and performing new mechanical, electrical, and plumbing design and construction. The company was selected through a bid-build contract. The company is based locally in Amman, Jordan. Originally founded in 1980, the company has 32 years of experience executing projects such as offices, residential, commercial and industrial complexes. The company also provides civil and mechanical engineering services. They are especially proficient at executing fast track projects with limited budgets and tight time constraints.

The contractor and subcontractor handled many aspects of the building enclosure design, but the project architect had final say on the project. The stone façade on the project was erected by Haddadinco, while the glass façade and supporting spider system were erected by local specialists. Haddadinco oversaw quality assurance during the construction process by daily monitoring of the connection methods employed, in addition to verifying thermal and moisture protection and checking component alignments.

Middle Eastern Building Enclosure Design and Construction Characteristics

The before and after images of the Jordan Kuwait Bank Headquarters display a significant change in the architectural imagery. As mentioned by many interviewees who have worked in the Middle Eastern market, they noted that there was greater emphasis on utilizing glazing and metal in the building enclosure. The new façade for this case study
reflect interviewee sentiments. The stone façade used at the base of the building is representative of historically traditional Middle Eastern building enclosures, but the glazing and metal elements were incorporated to display a more modern image.

It was acknowledged by both the architect and contractor that measures had to be implemented to account for the warm clients in the area, in agreement with the sentiments of the research interviewees about the Middle East. This building incorporates some passive designs into the building enclosure, such as external louvers and canopies to account for the high amount of transparency in the new façade. However, the need for mechanical and electrical upgrades emphasizes that energy savings were sacrificed for architectural expression, which interviewees noted as being characteristic of the Middle East.

Haddadinco provided much expertise in regards to the building enclosure final design and construction. Although the architects were not completely disconnected from the construction process (as many interviewees stated) it can be seen that the contractor in this instance still controlled many aspects of the final construction. The contractor noted that Haddadinco is especially proficient in fast tracked projects. Although it is difficult to determine the time constraints on this project, the need to work on fast tracked projects was a common sentiment by research interviewees in the Middle East that ultimately affects the building enclosure design and construction. Finally, local Jordanian building codes provided baseline levels for the façade design; however, to assess the performance, international standards were utilized, agreeing with interviewees who stated that most standards in the region are either vague or non-existent. Therefore, products often had to be rated using international standards.
Acknowledgements

Sincere gratitude is extended to Mr. Bilal Hammad, who provided this case study project and related images for educational use. The author would also like to thank Mr. Zeid Haddadin of Haddadinco for providing insight into the building enclosure design and construction of the Jordan Kuwait Bank Headquarters.

References


APPENDIX D: LATIN AMERICA CASE STUDY: PABELLÓN VERDE

(GREEN PAVILION)

Building Information

Location: Medellín, Colombia

Client: Plaza Mayor

Architect: Javier Vera

Project Manager: Convel (Medellín, Colombia)

Structure Engineer: Industrials ZENO

Façade Designer: Rolformados S.A. (Medellín, Colombia)

Planning and Construction: 2011-2013

Area: 4,100 (44,132 ft²)

Number of Stories: 4

Building Enclosure Cost: 765,990 € (1,000,000 USD)

Introduction

Medellín, Colombia is the second largest city in all of South America and thrives as a tourist attraction for the region. Within the city, Plaza Mayor is the site of a collection of exhibition spaces designed and constructed to host conventions, trade fairs, and live performances. As part of the growing interest in the area as a tourist attraction, the Pabellón Verde (Green Pavilion) is in its final stages of a three phase construction sequence before the building will be opened for use in the summer of 2013, as shown in Figure D.1. The planned building premises is roughly 4,100 m² (44,132 ft²) and spans four floor levels, with a below
grade parking facility. The new facility will provide services similar to other buildings in Plaza Mayor, primarily functioning as an entertainment center.

Figure D.1: Pabellón Verde (Convel 2013)

The architect for the project was independent designer Javier Vera, who was awarded the project through winning a design competition. Javier Vera has over 20 years of experience in architectural design in Latin America. He has entered over 220 design competitions worldwide and has received over 80 awards for his work. Vera is known to be an innovative architect who has been known to push the boundary of construction in Latin America. For Pabellón Verde, Vera faced the challenge of providing a facility that was large enough to accommodate large crowds and provide natural lighting into the interior space, while providing acoustical barriers to confine sound generated from large gatherings within the building. As the name implies, a large goal for the building was to incorporate “green” measures, predominantly in the form of providing systems that would reduce energy consumption.
Architecture

Architecturally, Pabellón Verde is intended to resemble the form of a boat in the form of conceptual modernism. This was done to draw parallels with the Medellín River, which is directly adjacent to one side of the building. The top of Pabellón Verde consists of two cantilevers, supported by four columns extending 22 m (72.2 ft) from the main building structure. These large forms visually resemble the body of a boat. The presence of the large cantilevers provides an awe-inspiring view for onlookers to the building.

180 parking spots are provided below the facility, while an unloading dock is provided that can accommodate two trucks. The substructure and first floor structural system consists of reinforced concrete walls. The rest of the superstructure is comprised of galvanized metal piping with a screw coupling system. The whole system is assembled without the use of welding. The majority of the façade on the cantilever forms utilized galvanized metal panels. The metal panels are purposely perforated, as shown in Figure D.2, to allow light to penetrate into the building space, as well as generate a thermosyphon for natural cooling.

Figure D.2: Perforated Metal Panel Façade (Image courtesy of David Del Valle)
Building Enclosure Physical Description

The top portion of Pabellón Verde consists exclusively of metal. The metal panels are all galvanized steel, with a powder coated surface. The metal panels, both solid and perforated, are trapezoidal rather than rectangular configurations. The geometry of the panels forms three dimensional folds, as opposed to providing direct planar surfaces. The roof of the building consists of metal decking fastened to the pipe-like structure, as shown in Figure D.3. The roof itself was described as being an Italian *lucarna*, which is essentially a protruding skylight from the main structure.

![Figure D.3: Pabellón Verde Metal Roof Deck Fastened to Pipe Structure (INARE 2013).](image)

The lower level of Pabellón Verde diverges from the upper level metal panels, and instead uses three materials that are more common to the area: aluminum, concrete, and glass. The insulating glass unit glazing components are adhered to the supporting aluminum
framing through the use of structural silicone. The concrete predominantly acts as a structural base for the pavilion. However, due to its natural thermal mass properties that are conducive to performing well for insulation, the concrete also performs as a thermal barrier to the exterior environment.

**Building Enclosure Function and Performance**

Two main requirements were expressed by the client for the building enclosure: (1) provide lighting into the interior and (2) provide an acoustical barrier. For the first requirement, parametric modeling was done on the metal panels to calculate how much light would enter the building based upon the size of perforations into the building. The desire for providing as much natural lighting as possible was due to client’s wish to incorporate energy-saving measures into the overall building design. For sound control, acoustical insulation was placed behind the interior gypsum wall boards in the building to reduce noise transfer through the building enclosure.

The city of Medellín has an elevation of 1,538 m (5,046 ft). Because of the city’s high altitude, its climate is much milder compared to other cities located on the same latitude near the equator (Medellín Traveler 2013). Instead of being defined as a tropical climate, Medellín and the surrounding region is best described as a humid, subtropical climate. Due to the city’s close proximity to the equator, it’s temperature is relatively constant year round, with an annual average temperature of 22°C (72°F), ranging from a low of 15°C (52°F) to a high of 30°C (86°F). This relatively constant temperature has a significant effect on the finished enclosure project. Due to the near-ideal, yearlong temperature conditions in the area, the façade designer on the project noted that the use of thermal insulation was not needed.
The region does experience significant precipitation, as shown in Figure D.4. To prevent water from penetrating the building enclosure through the perforated metal panels, windows are placed behind the façade and sealed with intumescent sealants, which are substances that expand when exposed to heat. Also, the seals act as additional acoustical protection for the building. The water that accumulated between the metal panels and the windows is collected with a grey water system collector system that is incorporated into the roof to collect the rainwater for reuse in the building’s facilities. This further helped reduce the embodied energy costs to operate the building.

![Figure D.4: Average Yearly Precipitation for Medellín, Colombia (Discover Colombia 2013)](image)

**Building Enclosure Design and Construction Participants**

The city of Medellín, Colombia has a long, rich history of architecture and construction. Many of the parties involved with the building, especially the building enclosure were locally found in the city or surrounding region. Javier Vera led the overall architectural design, but the façade design was conducted by Rolformados S.A., a company that specializes in delivering metal products using digital fabrication methods. Rolformados performed many in house calculations for the top of Pabellón Verde, including calculating day lighting, thermal effects, and structural analysis, as shown in Figure D.5.
Convel oversaw the construction of the project. The company was founded in 1961 and works under international standards based on ISO 9000, ISO 14000, and OHSAS 18000. They also provided daily on site monitoring for the construction of Pabellón Verde. It should be noted that for this particular project, the construction schedule was delayed, forcing the cancellation of several booked conference events. The current timeline for the building’s grand opening is expected to be sometime in early summer 2013.

All of the metal cladding panels were prefabricated using digital fabrication techniques. Instead of having the local workers weld the cladding panels to the supporting structure, the systems incorporated a “screw and assembly” approach to make it easier to erect on site. It should be noted that even though digital fabrication and a simplified construction method were used, there was still some notable misalignments of verticals and horizontals on the finished building enclosure, as seen in D.6.
Latin American Building Enclosure Design and Construction Characteristics

Pabellón Verde represents a more progressive Latin American project led by a forward-thinking architect in Javier Vera. Many considerations were included for the building enclosure, which, according to the interviewees, was not often the case when conducting building enclosure work in this market. Sustainability and green practices, such as using a grey water system and incorporating more natural lighting into the interior space illustrate Latin America is slowly integrating long term performance considerations into how the building enclosure is being designed and constructed.

As mentioned by the interviewees, Latin America is largely categorized as a one-climate region, where building occupants are comfortable living in interior environments where the temperature is warm. This is especially true for Medellín, whose weather is typically spring-like all year long. This justified not needing additional thermal insulation,
such as batt insulation in the building enclosure, which would be found normally in other
global markets. This helped illustrate some interviewee comments that thermal protection,
with the exception of some countries such as Argentina, Chile, and Brazil, is not typically
given a high priority in Latin America due to the relatively mild climate.

Although parametric modeling was incorporated into the design of the building
enclosure (especially the metal panels), the construction quality of the market still lends itself
to issues, as shown previously in Figure D.6. The misaligned verticals and horizontals
illustrate interviewee sentiments that the local labor may not be able to carry out
sophisticated designs. The use of components instead of welding was also done to facilitate
easier erection of the building enclosure for the local labor. This case study project shows
that more long term building enclosure design considerations are being implemented, but the
quality of labor has not caught up to successfully implement these designs.

Acknowledgements

Sincere gratitude is extened to Dr. Daniel Cardoso Llach who helped the author get in contact
with the building façade designer. The author would also like to thank Mr. David Del Valle
for providing insight into the case study building enclosure, as well as providing related
images and documentation for our educational use.

References

(March 22, 2013).


“Weather in Medellín.” Discover Colombia.
APPENDIX E: FAR EAST CASE STUDY: HUGA FAB III

HEADQUARTERS

Building Information

Location: Taichung, Taiwan
Client: Huga Optotech, Inc.
Architect: J.J. Pan & Partners, Architects & Planners (Taipei, Taiwan)
Project Manager: Fu Tsu Construction Co., Ltd. (Taipei, Taiwan)
Planning and Construction: 2007-2009
Area: 31,860 m\(^2\) (342,938 ft\(^2\))
Number of Stories: - 6 stories (office area); 3 stories (fabrication facility)

Introduction

Huga Optotech, Inc. Headquarters Building is located in the Central Taiwan Science Park in Taichung, Taiwan, as seen in Figure E.1. Huga Optotech, Inc. is a manufacturer of light emitting diode (LED) semiconductor devices (Huga 2013). The company was founded in 1998 and is based out of Taiwan. The building, which was completed in 2009, is the first part of a two phase project to expand Huga Opototech’s corporate identity. The first phase of construction consisted of developing an office building acting as Huga Opototech’s headquarters, in addition to creating a main fabrication facility connected to the workspace. The second phase of the project will see a further expansion of fabrication facilities for the company.
The architectural firm on the project, J.J. Pan and Partners, was founded in 1981 by Mr. Joshua Jih Pan, FAIA (J.J. Pan and Partners 2013). The company, which is based out of Taipei, Taiwan, offers services in the following areas: master planning, programming, architectural design and supervision, interior planning and design, sitework and landscape architecture, project management, and engineering consulting. The firm currently employs over 200 staff members who perform a full range of building services for residential, college campuses, industrial parks, office buildings, research laboratories, and healthcare facilities.

The new headquarters and fabrication facility was intended to convey the company’s technological and intellectual advancements. In addition to providing a visual representation for Huga Optotech’s corporate image, the new headquarters facility would include office space, conference rooms, areas for research and development, and also a cafeteria for the employees. The new building was intended to provide an example for other industrial
buildings on the Science Park, as well as take advantage of providing scenic views of the adjacent Dadu Mountains.

**Architecture**

The finished architecture for Huga Optotech’s Fab III and Headquarters Building consists of two components: (1) the fabrication facility and (2) office spaces for employees. The building is oriented so that the main face is aligned with the main North-South roads of the Science Park as shown in Figure E.2. This orientation also provides scenic views of the Dadu Mountains. The two building components are designed to represent an abstraction of the LED manufacturing process, resembling the electric discharge between electrodes. The predominant exterior color scheme on the Huga Fab is black and light gray. This was intentionally done by the architects to convey a dark visual contrasting with a brighter one to represent a high-tech impression, similar to color schemes found on machines.

The interior of Huga Fab III reflects modern architecture merged with traditional imagery. For the client, it was important to express strong ties to Taiwanese cultural roots, while at the same time expressing the technological advancements that symbolized the company. A majority of the decorative interior is illuminated through the use of the LED products, as shown in Figure E.3.
Figure E.2: Site Plan of Huga Fab III (Image courtesy of J.J. Pan and Partners)

Figure E.3: Interior View of Huga Fab III (Horizon Design Co., LTD. 2013)
To address the 6 m (19.7 ft) in elevation change from north to south, the lower ground level towards the southeast acts as an entrance for the parking garage and provides space for loading services. The northwest face of the building serves as the location of the fabrication facility, which is recessed in 15 m (49.2 ft) from the property boundary. This portion of the building contains three levels, with the first floor 9 m (29.5 ft) high, and second and third levels are each 5 m (16.4 ft) high. This facility acts as the main production area for LEDs. The office building headquarters is six-stories high, and contains a grand lobby, staff office areas, conferences rooms, areas for research and development, and a cafeteria for the employees, shown in Figure E.4.

Figure E.4: Office Building Floor Plan (Image courtesy of J.J. Pan and Partners)
Building Enclosure Physical Description

Much of the physical composition of the building enclosure was influenced by the desire to portray a technonological-savy image. Aside from the use of external solar louvers on the East facing elevation, the building enclosure is essentially flat. As stated previously in the Architecture section, the color scheme employed on the building enclosure consists mostly of black and gray, contrasted with a blue tinted glazing system. This was done to portray an imagery of the LED manufacturing process.

The glazing curtain wall with insulating glass units is predominantly located around the office area of Huga Fab III. This was done to maximize the views of the surrounding Dadu Mountains. The solid areas found on the building enclosure consist of aluminum metal insulated panels. The exterior walls around the fabrication facility are completely solid, blocking any across the building enclosure, as shown in Figure E.5. The curtain wall system is connected to a reinforced concrete supporting structure.

Figure E.5: Elevation of Huga Fab III (Image courtesy of J.J. Pan and Partners)
Much of the building façade is illuminated with LEDs. For Huga Fab III, ornamental strips with lighting fixtures are attached throughout the building enclosure. This feature is most prominently seen in large LED lettering that spells “HUGA” along the main street of the business part, as shown in Figure E.6. Such use of LED serves as exterior lighting advertising for Optotech.

![Huga Fab III Illuminated with LEDs](image)

Figure E.6: Huga Fab III Illuminated with LEDs (Image courtesy of J.J. Pan and Partners)

**Building Enclosure Function and Performance**

According to J.J. Pan and Partners, two main objectives were set for the building enclosure: (1) provide an image for the building that matched the company; and (2) be energy-efficient. Much of the architectural details describing Optotech’s corporate imagery in relation to the building enclosure has been mentioned in the previous sections. From color selection, form of the building, and the use of LED products to display the company’s name,
Optotech’s position as a premier manufacturer of lighting products is communicated to the public.

The desire to present a corporate identity had to be balanced with the realities of a modern building being situated in Taiwan. As of 2008, Taiwan imports 99.3% of their energy (Tsai 2010). For the owners of Huga Fab III, they realized early on that the systems used on the building would have to be energy efficient to comply with the Taiwanese government’s desire to make the nation highly efficient, while being less dependent on foreign sources for energy. In addition, Taiwan had made it a priority to make the country carbon neutral in accordance with the 1997 Kyoto Protocol.

The metal insulated panels used on the majority of the building enclosure were manufactured by a company named Kirin, a global manufacturer of panel systems for the building façade (Kirin 2013). The company was started in 1981 in South Korea. Similar to Taiwan, South Korea is a nation that relies heavily on imported energy. The metal insulated product lines were originally developed as an energy-efficient solution for building enclosures.

The climate in Taichung is categorized as mild, subtropical. The average temperature ranged from an average low of 16 °C (61°F) in January and an average high of 28°C (82.4°F) in August (Climate Zone 2013). In general, the region can be defined as a cooling climate. To deal with the relatively warm climate, the exterior metal used on Huga Fab III is made of aluminum with an anodized, fluorine resin coating. The specific metal panels belong to the Polymetal-F Panel system line, as shown in Figure E.7. The interior consists of galvanized steel. For insulation, the system used rigid polyurethane foam. The thermal conductivity of
the assembly is rated at 0.023 W/ (m-K) (3.3x10^{-3} \text{ BTU*in.}/(\text{hr*ft}^2\cdot{}^\circ\text{F})). Kirin touts that their metal insulated panels provide energy savings due to the low conductivity of the system as well as ensuring that the product is carbon neutral in compliance with the Kyoto Protocol.

Figure E.7: Kirin Polymetal-F Panel (Kirin 2013)

To ensure that the building would not be negatively affected by weathering issues, the specific product employed an open joint method for water protection. Essentially, overlapping tongue joints between panels provided redundancy to prevent water from penetrating the metal insulated panel assembly. The water prevention is needed because the region experiences an annual rainfall of 624 mm (24.6 in.) a year, as indicated in Figure E.8.
Figure E.8: Average Precipitation in Taichung, Taiwan (World Weather Online 2013)

Although it was desirable to have as many scenic views of the surroundings as possible, it was necessary to incorporate passive solar shading devices into Huga Fab III. The large arrays of insulating glass units are inset into the surrounding metal insulated panel façade, essentially making the metal panels act as sunshades. Horizontal grills are also incorporated into the glazed areas to help reduce direct sunlight into the space, depicted in Figure E.9.

Figure E.9: Horizontal Grills for Shading (Image courtesy of J.J. Pan and Partners)
Building Enclosure Design and Construction Participants

Two main parties were involved with the design and construction of Huga Fab III. The designs were all completed by J.J. Pan and Partners, who carried out energy and solar studies to determine optimal solutions for energy usage. In order to carry out the design of Huga Fab III as intended, a contractor who had significant experience working on projects of this magnitude was required. For this project, the construction company Fu Tsu International was selected to deliver the building, including overseeing the construction of the building enclosure.

Fu Tsu Construction was formed in 1949 after World War II (Fu Tsu Construction 2013). The company employs over 600 employees who all undergo corporate sponsored education and training programs to improve their skills in construction management. For Huga Fab III, they closely monitored construction to ensure that systems were properly installed and correctly aligned to maintain the project’s desired image.

Far Eastern Building Enclosure Design and Construction Characteristics

Sustainability and imagery were two prominent descriptions associated with the Far East from the interviews. For the Huga Fab III’s building enclosure, both characteristics were heavily emphasized. Because of Taiwan’s limited natural resources and its desire to become a carbon neutral nation, the building enclosure for the case study project in turn had to address these issues. The use of metal insulated panels and strategic passive solar design helped the building enclosure address the energy-conscious environment for Taiwan. In this instance, imagery was not compromised due to the energy constraints on the project.
Several interviewees expressed that the construction in the region was overall of lower quality as compared to North America and Europe. For this case study, the Huga Fab III project avoided the negative connotations associated with Far East construction quality by hiring a reputable construction management firm to oversee the building enclosure construction. As seen from the photos of the building, it can be seen that a satisfactory job was done by the contractor. It is likely that this can be attributed to the company’s rich tradition in construction and its in-house training programs as opposed to using unskilled local laborers, which appears to be more commonplace in other parts of the market.

Acknowledgements

Sincere gratitude is extended to J.J. Pan and Partners who helped the author get in contact with the building façade designer. The author would also like to thank Genie Huang and the team at J.J. Pan and Partners for providing insight into the case study building enclosure, as well as providing related images and documentation for educational use.

References


Recruitment Script

Dear ___

I am working with Professor Richard Behr at Penn State doing research on global differences in building enclosures for mainstream low- to mid-rise commercial buildings. As such, I am collecting information from several professionals about their firsthand experiences in designing building enclosures across the world. Due to your experiences with building enclosures, I believe you could provide valuable insights and relevant information that will help me with my Master’s thesis in Architectural Engineering. Would you please be able to meet with me by phone for a short interview on your international experiences with building enclosure systems? This should take less than an hour of your time.

As mentioned, I am focusing my research on global differences in building enclosures. The aim of my research is to determine contributing factors that would result in understanding how and why a building enclosure on a mainstream commercial building in one region of the world might differ from that in another region.

In addition to participating in the phone interview, any information, references or past experiences that you could provide will be greatly appreciated. Would you please contact me by email (dht5010@psu.edu) or phone (215-527-4737)? I look forward to hearing from you soon. If I do not hear back from you within 10-14 days, I will attempt a follow up contact.

Thank you for considering my request.
INFORMED CONSENT FORM FOR SOCIAL SCIENCE RESEARCH
The Pennsylvania State University

Title of Project: Global Differences in Building Enclosures

Principal Investigator: David H. Tran, dht5010@psu.edu
105 Engineering Unit A
University Park, PA 16802
(215) 527-4737

1. **Purpose of the Study:** This study will determine differences in building enclosures in different regions of the world and will identify the factors that underlie these differences.

2. **Procedures to be followed:** You will be asked to participate in an interview over the phone or internet that will require less than an hour of your time. You will be asked a series of questions regarding the design or construction of building enclosures in various parts of the world.

3. **Discomforts and Risks:** No risks are anticipated beyond everyday normal activity.

4. **Benefits:** The information you provide in this study might be used to develop a course for undergraduate students who wish to pursue a career in the design of these systems and wish to gain more understanding at the academic level.

5. **Duration/Time:** You will be asked to participate in interviews either in person, via telephone or through the Internet where you will be asked a series of question with a maximum duration of one hour.

6. **Release of Confidentiality:** Do you agree to permit the use of your name and quotes to be used the research? If yes, indicate below. All opinions expressed during the interview do not reflect those of your employer or that of Penn State.

7. **Permission to be Recorded:** During the interview, your conversation will be recorded with an electronic device. All recordings will be kept confidential.

8. **Right to Ask Questions:** You may ask questions about the research at any time by contacting David Tran, Graduate Research Assistant in the Department of Architectural Engineer, 105 Engineering Unit A, dht5010@psu.edu, (215) -527-4737.

9. **Voluntary Participation:** Participation is voluntary. You may withdraw from the study at any time by notifying the principal investigator. You may decline to answer specific questions.

You must be 18 years of age or older to consent to participate in this research study.
If you agree to the conditions and statements noted above, please provide your signature and the date below. You will be given a copy of this consent form for your records.

Please complete the section below.

Please check one of the following:

___ Yes, I agree to have my name and quotes from the interview to be utilized in this study.

___ No, I do not agree to have my name and quotes from the interview to be utilized in this study.

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Building Enclosure Professionals Interview Protocol

*This document will be presented to the interviewee for review prior to the interview*

**Study Name:** Global Differences in Building Enclosures

**Principle Investigators:** David H. Tran, Dr. Richard A. Behr

**Purpose:** This study consists of identifying global differences in the design and construction of building enclosures located in the following global markets: Europe, Far East, Latin America, Far East, and North America. The building enclosures that are the focus of this study are limited to buildings with the following characteristics:

- *Modern* – Constructed within the last twenty years
- *Mainstream* – the building uses designs and techniques which are common of the specific global market. Buildings which are avant-garde, landmark, or special in nature are beyond the scope of this research
- *Low-to-mid-rise* – the building is limited to ten stories above grade
- *Commercial* – the building functions as an office, retail, or entertainment space

**Interview Questions**

1. What is your name and current position title?

2. Who is your current employer?

3. How many years do you have building enclosure related experience?

4. What services does your current company provide and what are some specific aspects of your role in the company?

5. Could you provide a brief history of your industry experience, especially detailing work you have conducted regarding building enclosures?

6. Of the five global markets listed above, which one(s) do you have firsthand familiarity of conducting building enclosure work?

7. Irrespective of global market, what are some building enclosure design and construction differences you have noticed when working in a different global market?

*Note: This question is intended to be open-ended. Please list things you have noticed to “change” regarding the building enclosure when working in different global markets.*
markets. Some examples are design considerations, prevalent construction techniques, client views, etc. Feel free to use specific examples if you believe it would help to illustrate your points.

8. Considering the differences you have listed above, how do these differences apply to each global market in which you are familiar? (Example: if design considerations was listed as perceived difference, what specific attributes of design are applicable to a certain global market that would not be in a different market?)
APPENDIX G: CASE STUDY INTERVIEW MATERIALS

Case Study Interview Protocol

Project Name ________________________________

Project Location ____________________________

Project Construction Date____________________

Background Information

1. What is your name and job title?
2. What is the name of your company?
3. Where is your company located?
4. What is the general nature, extent and scale of your company?
5. Please provide a short history of your company.

Case Study Building Project Background

1. Please provide a brief description of the case study building in terms of physical characteristics.
2. Can you describe the primary function of the building?
3. What was the final construction cost of the building?
4. Can you describe the building’s physical surrounding environment?
5. What is the primary structural system in the building?
6. What mechanical systems are used in the building?
Case Study Building Enclosure Description

1. Can you give a description of the overall building enclosure?

2. How would you describe the architecture/ aesthetics of the enclosure?

3. What type of system is the building enclosure, stick or unitized?

4. Do you know the approximate cost of the building enclosure, in context of the overall final construction cost, including material and labor?

5. If yes, what was the approximate cost?

Design Professional Role in the Building Enclosure

1. Who made the final decisions on the building enclosure?

2. Who specified and let contracts for the building enclosure?

3. What role did you play in the overall design/construction of the building enclosure?

4. At what construction phase (preplanning, planning, schematic design, design development, construction documents) did you first assume role in the design/construction of the building enclosure?

5. Were than any building enclosure consultants used on the project? If so, who?

6. What were their responsibilities?

Building Enclosure Characteristics

1. What materials are used in the building enclosure?

2. What wall type is the exterior wall (cavity, mass, barrier)?

3. What type of glazing is used in the building enclosure?

4. Please describe any special systems used in the building enclosure (BIPV, double skin-façade, etc.).
5. Where is the origin of the materials/ systems that the building enclosure consists of?

6. Why were these products chosen?

Building Enclosure Design

1. What are some of the functions that the enclosure was designed for and why?

2. What were the owner’s requirements of the enclosure?

3. Were there any codes used to design the enclosure? If so, which ones?

4. What standards was the building enclosure specified to?

5. What performance tests was the building enclosure specified to?

6. What climatic conditions were the building enclosure designed for?

7. How is the building enclosure weathering and durability addressed?

8. Was the enclosure designed for extreme events (e.g. blast, earthquake, severe windstorms, etc.)?

9. Aside from physical conditions, were there other constraints and considerations that needed to be addressed for the design of the enclosure?

10. If so, what were these constraints and/or considerations?

11. Did any concerns/issues arise during the design/ construction of the enclosure? If so, what were they?

12. How were these concerns/issues addressed?

Building Enclosure Construction

1. Who was the contractor for erecting the building enclosure?
2. Are you aware of why they were chosen?

3. How would you describe their familiarity of the building enclosure systems used on this project?

4. Were any parts of the building enclosure changed in order to be carried out for construction? If so, what were these changes?
VITA

David Hoang Tran was born on September 23, 1988, in Hatfield, Pennsylvania, to Hau Tran and Huong Dang. He received his primary education in Hatfield, Pennsylvania and secondary education in Lansdale, Pennsylvania, and graduated from Lansdale Catholic High School in June 2007. He then enrolled at The Pennsylvania State University.

As an undergraduate student in Architectural Engineering with a focus on structures, he obtained membership to Tau Beta Pi, the engineering honor society and Phi Alpha Epsilon, the architectural engineering honor society. He passed his Fundamentals of Engineering exam in April 2010 and will become a registered Engineer-in-Training in Pennsylvania upon graduation from The Pennsylvania State University.

He enrolled in the integrated Bachelor of Architectural Engineering/ Master of Science in Architectural Engineering program at The Pennsylvania State University in August 2012, where he also served as a Graduate Research Assistant during his graduate course of study.