Water Penetration Through Masonry Walls
Field Investigation

Biochemistry – Biophysics Building
Texas A&M University

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Introduction

Is Poor Workmanship also Poor Customer Service?

- **Who is the Customer?**
  "A customer is anyone who is affected by a product or service."(1)

- **What Defines Customer Satisfaction?**
  Customer satisfaction must become the focus of corporate thinking. Providing customers with goods and services that meet their expectations and needs at a price they are willing pay is paramount....If you satisfy customers, profits will increase in the long run; but don't forget, satisfying customers, not increasing profits, must be your primary goal...A price tag cannot be put upon the advantages of a satisfied customer extolling the virtues of your company's products or services.(2)

- **What is the Cost of Poor Construction Quality?**
  The cost of quality divides logically into two areas: cost associated with not doing things right, and costs associated with trying to prevent them from going wrong.(3)

This Case Study investigates the Owner's concerns with water entering though the brick veneer and glazing systems one year after the completion of construction.

Goals and Objectives

Problem

- In the Fall of 1990, reports were received by The Texas A&M University Physical Plant regarding rainwater penetration through the second-floor glazing assembly - a brick veneer clad facility. Several investigations conducted exposed the causes of several problems.

Project Goals

- Determine why water is entering the building?
- Recommend the solution options.

Objectives

- Identify areas of severe water penetration using high-pressure water applied to the glass systems of the building at specific areas.
- Use minimal destructive investigation methods to remove portions of the brick veneer exposing the wall cavity and flashing.
- Conduct the work in a manner minimizing disruption of building operations.

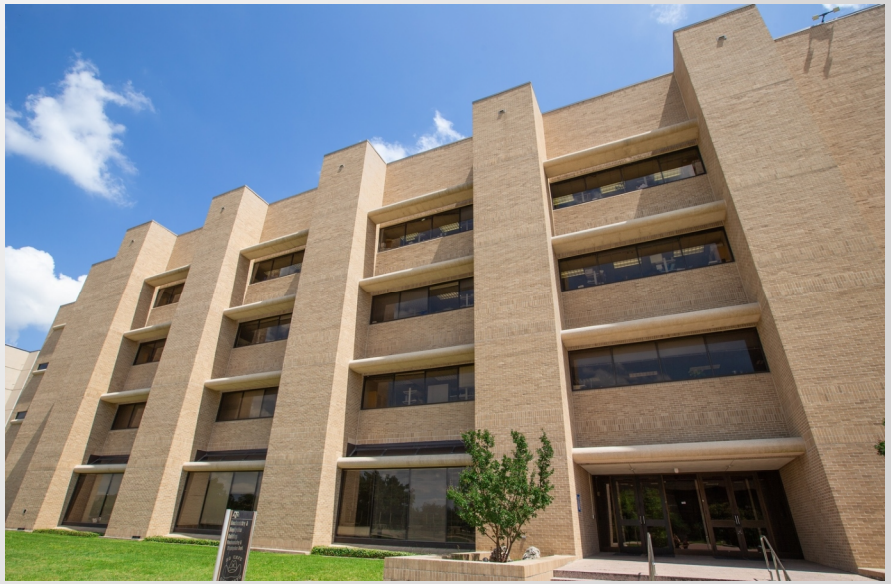

Figure 1 – Main Entry – North Side

Parameters

❑ Building Conditions

- ❍ The building opened for occupancy in the Fall of 1995, and an area of over 60,000 square feet.
- ❍ Four floors above the ground floor consisting of classrooms, lecture halls, dining facilities, faculty offices, and laboratories.
- ❍ Various areas of the building's facade displayed staining and efflorescence as evidence of water entering and exiting the brick veneer cladding.
- ❍ The building's main entry faces north is subject to wind-driven rains forcing large quantities of water through the brick and into the building.

Figure 2 – Stains from water intrusion

❑ Project Conditions

- ❍ Faculty and students are not inconvenienced and sometimes displaced after rainstorms, disrupting schedules, and class continuity.
- ❍ Damage to the interior finishes and materials increases with each storm. Physical Plant postponed repairs until a resolution to the leakage.
- ❍ Openings into the brick veneer cladding are located on portions of the building away from public view.

Figure 3 – Opening above the soldier course.

❑ Project Materials - Hand tools and a pressure washer below 600 PSI.

Parameters

Project Criteria

- The building is situated on the West Campus and in a prominent location.
- The investigation cost is absorbed by Physical Plant's Maintenance and Operations Budget.
- The Owner's base project criteria
  - Conduct investigation operations in the least obtrusive manner.
  - Restore openings with materials from the building's reserve stock.
  - From the information gathered, determine if the contractor's work followed the building architect's specifications.

Figure 4 – Opening at the floor belt course.

Figure 5 – Opening at the floor belt course.

Solution - Discovery

Medium Evasive Investigation

- First step - Several random selected areas of the exterior wall.
  - Apply medium pressure (600 PSI) water along the perimeter of the glazing assembly and the brick veneer.
  - Observation of the water infiltration revealed potential defects with the construction of the glazing flashing assembly details.
  - Observations noted the water entering the building's interior along the floor of the exterior wall.
- Second Step - Remove brick prisms and observe the workmanship of the assembly's construction.
  - The brick used, an Economy Norman has dimensions of 3-5/8"H x 3-9/16"W x 11 5/8"L.
  - The average prism, two (2) bricks long and four (4) brick tall is about twenty-four inches (24")L x sixteen inches (16")H.

Figure 6 – Front of typical prism

Figure 7 – Back of typical prism

Solution - Discovery

❑ Medium Evasive Investigation - Continued

- ❍ Third Step – Investigate the openings in the walls and observe the cavity and flashing assemblies.
  - ❖ Supported by the steel floor angle, two (2) soldier courses define the belt-course on every floor.
  - ❖ Typically a two-part steel flashing assembly diverts water collected in the cavity to the openings in the mortar joints called weep-holes. The wall-cavity should be clear of mortar and the back-side of the brick veneer clean of mortar so as not to catch water.

Figure 8 – Wall cavity at the belt course

Figure 9 – Wall cavity at the belt course

❑ The Architect's Specification Requirements

- ❍ Comply with the Masonry portion of the project specifications - Section 04. Particularly the workmanship requirements.
- ❍ Install each assembly per the approved Shop Drawings and Flashing Details.

Solution - Observations

Observations of the Prisms

- Front Side - Figure 6.
  - Looks good. Implying the same attention and care for all facets of the masonry work complies with the architect's specifications. The brick is clean and laid using and 3/8" tooled concave joints.
  - Boat-shaped holes in the bed joint.
- Back Side - Figure 7.
  - An abundant amount of mortar protrudes from the bed joints.
  - There are marginal amounts of mortar in the head joints.
- End - Through the Head Joints - Figure 10.
  - Boat-shaped holes in the bed joint and a fresh-mortar line (emphasized in black).
  - There are marginal amounts of mortar in the head joints, some with mostly void.

Figure 10 – Head joints

Figure 11 – Back of typical prism

Solution - Observations

Observations of the Empty Wall Openings

- Wall Cavity - Figure 5
  - The cavity (space between the brick and the wall sheathing) has mortar debris and partially clear. Water collects and impeded from leaving the cavity through the weep holes.
- Wall Cavity - Figures 12 and 13.
  - The cavity has mortar debris full and not clear up to one-half to three-quarters the soldier course's height. Water collects and blocked from leaving the cavity through the weep holes.
  - The flashing, at the lintel level is improperly installed.

Figure 12 – Wall cavity at the belt course

Figure 13 – Wall cavity at the belt course

Summary

Is Poor Workmanship also Poor Customer Service? YES

- **Previous Research**

  The field investigations conducted at Texas A&M University, College Station, supports the view that if the workmanship and detailing of masonry are substandard, the masonry work will leak regardless of the quality of materials and the joint profiles used. The **workmanship** is the single most crucial factor in obtaining water-resistant walls. Several other researchers have reported this fact. The destructive testing of samples of the leaky portions of the masonry form the actual buildings adds scientific evidence to the existing knowledge.

- **Workmanship**

  Proper bricklaying techniques, masonry detailing, and appropriate specifications for good practice should be inherent with the masonry trades. Throughout the construction design industry, there is a lack of understanding of its importance and, to some extent, the masonry contracting community. An aggressive strategy to educate architects and engineers on the benefits of proper **workmanship**, wasteful, and costly avoidable errors, such as those in this Case Study , are eliminated.

Highlights

Of Note

- The purpose of this case study is to discover the problem and not solve the problem - **Why is water entering the building?**
- Poor workmanship and execution of the details is **Why is water entering the building**. Once the water passes through the poorly constructed mortar joints and into the wall cavity, there are no paths for the water to drain to the exterior.
- Expecting to discover some flashing details poorly constructed, the extent across the majority of the building walls was troubling.
- The recommended solution is to remove all the brick veneer cladding, flashing assemblies; repair damages, and properly install the brick veneer cladding as originally specified by the architect and bid by the general contractor.
- Also troubling is the amount of money paid to the masonry contractor for such mediocre work and falsely representing to the owner value received.
- The Texas A&M University Vice-President for Finance and Administration was not please to know that a one-year old building, costing the citizens of Texas millions of dollars required extensive work to stop the water entering the building.

Highlights

❑ References

1 - Juran on Leadership for Quality, An Executive Handbook (1989).

2 - The Deming Guide to Quality and Competitive Position, Howard S. and Shelly J. Gitlow, (1987).

3 - The Deming Management Method, Mary Walton, (1986)

Additional information from the following documents by the author:

Hines, S.T., 1992, Texas A&M University Physical Plant Report on Water Leakage from the Exterior of Biosciences Biophysics Building.

Hines, S.T., 1991, Relative Water Permeance of Mortar Joints in Masonry Walls, M. Arch., Thesis, University of Texas at Arlington, USA