TWO STRATEGIES FOR CONTAINING MOISTURE MIGRATION

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ABSTRACT

For the building team, the design of library, archives and museum facilities brings with it special responsibilities. Archive and conservation facilities require the highest levels of preservation and maintenance of the building environment. Understanding how to maintain and preserve vulnerable materials is a key component to developing a successful design solution. Separation of clean and dirty processes, indoor air quality, control of volatile organic compounds (VOC) and other potentially damaging chemicals, storage methodology and equipment, building envelope issues, integrated fire and safety concerns, and ultra-violet light are all also significant issues which challenge the design team. This paper will compare and contrast an overview of the design solutions of two facilities; one a renovation, the other new construction. It compares the renovation of USDA's National Agricultural Library special collections storage (NAL), using a buffer zone solution to achieve 50% relative humidity to the National Museum of the American Indian's (NMAI) Cultural Resources Center, where the program required the entire facility to provide 50 % relative humidity, necessitating the construction of a sophisticated building envelope. Rare book, archives, and museum facilities require the highest levels of development and maintenance of specialized, controlled environments. The following article focuses on these issues, specifically at NAL and NMAI, and provides an overview of two diverse, innovative solutions to resolve the needs of special collections and museum storage space.

KEYWORDS

Conservation, Collections, Relative Humidity, Air/Vapor Barrier, Archive, Indoor Air Quality

INTRODUCTION

The National Agricultural Library (NAL) resides in the Abraham Lincoln Building, a United States Department of Agriculture (USDA) owned fifteen-story building built in 1968. As the primary information resource for all of USDA, it is NAL's goal to maintain and protect the various resources within the building for research, reproduction and other uses. Housing the world's largest collection of agricultural materials, the library facility found itself in a state of transition in 1999. One floor of the existing building was to be redesigned for records storage of materials in need of the highest level of security and the strictest environmental controls.

The NAL renovation project focuses on the adaptation of 12,000 sq. ft. of office space into a storage facility for rare books, maps, manuscript collections, photographs, works of art, and a variety of other documents and artifacts. The environment in this space will be strictly regulated to best retard the deterioration of the documents. The primary function of the space is storage, but a small work area will be included to provide for review and processing of materials into and out of the space. At the forefront of the NAL's requests included the need for a separate secured area within the storage space for exceptionally rare books and documents. In addition, the NAL identified the importance that all walls, surfaces and finishes meet or exceed the National Archives and Records Administration (NARA) standards for environment and security.

The key components guiding the design of a successful archival storage environment are consistent temperature and relative humidity, air filtration, fire protection, security, control of ultraviolet light, efficient use of space, and allowance for specialized processing functions. In addition, particular attention must be given to the finishes and materials used in the construction to eliminate the off-gassing of volatile organic compounds or other potentially damaging chemicals.

ANALYSIS

A. Maintaining the integrity of the building envelope and environment is central to the design of an archives storage facility. Incorrect design or maintenance can lead to damaging consequences such as mold growth, insect infestation, deterioration of stored items, and deterioration of the building envelope due to its inability to withstand repeated freeze-thaw cycles. Providing an air vapor barrier to limit the movement of moisture through the building envelope is key to the design of the wall system. Climate and vapor pressure conditions may lead to condensation on the exterior of a building, which in winter months can be subject to repeated freeze-thaw cycles, causing spalling and cracking wall system components. Dampening of the insulation diminishes its insulating value, causing condensation on the interior walls, triggering mold growth, rotting and corrosion of wall components. Finally, moisture can be drawn to the exterior, bringing with it dissolved solids, which can be deposited on the surface, causing staining called efflorescence.

The difference in water vapor pressure between the outdoor and indoor air causes the diffusion of air and moisture through the building envelope. This flow occurs from high moisture content areas to low moisture content areas. The point at which the outside air and inside air meet at a common temperature becomes our dew point. The air vapor barrier blocks this diffusion, and eliminates the warm air migration to the dewpoint location. Every air/vapor barrier system must be specific to the building's purpose and environment, however one can study a typical detail to understand the importance of the vapor barrier within the wall system. If a building is in a cold environment with 50% humidity inside and 20% humidity outside, there is a natural diffusion of moisture from the interior to the exterior. In this case, the vapor barrier is typically placed on the inboard side, in constant contact with the insulation. Through the use of dew point calculations, it can be determined at what precise RH, temperature, and location the air can no longer hold this moisture. At this point, the saturation moisture content is reached and condensation will occur. It is the goal to isolate this point of condensation within the insulation, which can either be closed or open cell. Open cell insulation must be specified as a water resistant type, as occasionally moisture will condense, and then dissipate. Closed cell insulation does not allow this process, and thus provides some additional longevity.

Alternatively, if a warm environment is considered, the inside air may have 50% RH while the outside air has 75% RH. Due to the vapor pressure difference, the vapor drive is from outside to inside. Using dew point calculations, it can be concluded that the dew point is within the insulation within the wall system. In this case, the insulation needs to be protected behind the vapor barrier, which is placed on the outboard side so as not to allow condensation to moisten the insulation. Since the build up of pressure can cause deterioration to the wall as well, the cavity wall will need to be ventilated to equalize the air and vapor pressure behind the finished exposed material and the outside environment. Careful analysis and consideration of these issues is recommended when attempting to provide high humidity in cold climates, or a controlled environment in warmer climates.

B. Decisions about the materials used within a special collections or museum facility are also vitally important. It is essential that material which off-gas Volatile Organic Compounds (VOCs) not be used within these spaces. The NARA standard requires that any materials that are unstable or slow curing are not acceptable for archive and record storage facilities. For this reason, materials with water-based solvents are specified. The goal of these standards is to restrict pollutants and damaging gases from entering the controlled environments and degrading the artifacts or documents. Various solvent-based materials and adherents of materials do not cure rapidly and therefore emit gas during the curing process. It is these gases, which when mixed with the moisture of the air, create acids that can increase the rate of deterioration of paper, causing embrittlement and discoloration. This is to be avoided.

C. The codes and standards governing the building systems for an archival or conservation facility are slightly different than those of a typical office building. Although human life safety is important, the primary focus is on the preservation of historic materials, thus the design goals must be adapted accordingly. The air in the records storage area must be properly filtered to remove all harmful gases and particulates. The process of prefiltering, filtering, carbon filtration, and final filtration is designed to remove any gaseous and particulate contaminants from the air. In regards to fire protection, there are five critical factors to consider. They include limiting the sources of ignition and smoke, providing early warning of fire and smoke, minimizing exposure from one storage area to another, controlling and extinguishing the fire, and smoke removal.

The NARA standards provide an in depth look at the specifics of fire safety with a goal of archival preservation. Other codes include NFPA 911 *Recommended Practice for Protection of Museum & Museum Collections,* NFPA 909 *Code for Protection of Cultural Resources,* and NFPA *232 Standards for Fire Protection of Records.* The fire protection systems become an extremely important, integral component of a design of this type.

Once the air/vapor barrier is designed to control the movement of moisture and air through the exterior and interior of the building, to achieve the desired RH within the facility, one incorporates a mechanical system capable of maintaining indoor air quality, including a constant relative humidity and temperature as well as the appropriate level of particulate and gaseous filtration. Fluctuation of relative humidity may have detrimental effects on the collection materials and will affect various materials differently. For example, book components tend to fall apart due to stretching and shrinking, while photographic materials flake and fall off of their backing. This controversial topic should be explored on a case by case basis with each institution. Some believe seasonal oscillation of humidity is acceptable, 30-40% in the cooler seasons to 50-55% in warmers seasons, and that it is the daily and weekly change in humidity that should be kept to a minimum. Under any circumstance, a conservator will need to decide if temperature or humidity should be kept constant as a goal, allowing the other to fluctuate at a slightly higher rate. Ideally the humidity should remain as constant as possible, however some conservators accept a narrow range of plus or minus 5%. Extensive literature exists regarding this issue.

CASE STUDY #1: NATIONAL AGRICULTURAL LIBRARY

The design of the existing NAL building consists of an uninsulated concrete masonry unit wall with a brick veneer finish. The present conditions fail as an archives facility largely due to lack of insulation and moisture regulation. The original, single glazed windows and poor wall conditions, which were state of the art at the time of construction, have led to condensation within the wall, and efflorescence and leaking on the façade walls. NAL challenged SmithGroup to redesign the fifth floor space adhering to the strict guidelines developed by the National Archives Record Administration (NARA), Cite Publication TIP 13. The design solution suggests demolishing the existing office space and creating a building within a building. By creating a buffer zone between the existing exterior walls and the newly constructed interior space, a protected environment can be created within, controlling temperature and RH, providing another layer of security, fire protection, moisture protection, water vapor containment and ultraviolet light protection as well. The interior wall has an integral cove to prevent damage caused by chronic window leaks. The wall also is insulated even though they are theoretically at the same temperature year round, to allow the mass of the books and the air contained to act as a thermal flywheel maintaining a more stable environment should building systems fail.

The typical wall separating the buffer zone from the collections room consists of two layers of gypsum board on either side, continuous 8GA expanded steel mesh on the buffer zone side and fiber glass insulation with foil vapor barrier on the archive side. Continuity of the vapor barrier is maintained by the use of flanges taped to the side of the stud. The buffer zone is conditioned to 70 degrees F by the building wide system, while a dedicated mechanical unit on emergency power supplies the archival areas. With the NAL located in the mid-Atlantic region, experiencing both warm and cold climates, this design is intended to allow the existing envelope to mitigate the extreme cold conditions, without subjecting it to a 50 % relative humidity environment. This strategy reduces the possibility of additional cracks and damage due to condensation and icicle formations within the existing walls.

The archives storage room has only one window, facing a lobby without exterior windows, to control natural light infiltration to minimize any deterioration of the archived materials. In the buffer zone, a solar film will also be added to the existing windows on the façade of the building to reflect the natural light, diminishing solar heat gain.

The choice of architectural materials and finishes within conservation/archive space is essential to the life of the collection. The construction process began by removing all hazardous materials from the floor. While wood and other visually interesting finishes were considered, the option of using these materials were eliminated after consideration of their unstable properties. Instead, a simple palette is used, including a Corian work table with stainless steel structure, stainless steel mesh for the secured collections area, and a variety of colors of latex paint applied to drywall, each inspired by colors found in natural plant life. The library has selected a simple storage system of fixed powder coated files, and map cases to best fit for the NAL archives room based on the space, financial, aesthetic, and safety restrictions.

To achieve fire protection for the Special Collections at NAL, the design was developed in compliance with Boca National Building Code, Life Safety Code (NFPA 101), and various other NFPA standards. Accordingly, the collection is required to have two-hour fire rated walls around all perimeters, walls, floor and ceiling, and the area must have a sprinkler system on the floor above and below the storage space. Within the fifth floor archival space a preaction sprinkler system will be installed in accordance with NFPA 13. The preaction sprinkler lines are dry until a fire is detected by two devices, either smoke detectors or heat sensors, at which time the pipes are filled with water and sprinkler heads actuate. In addition, sprinkler and plumbing mains are located in the buffer zone, only penetrating the space where required.

CASE STUDY # 2: NMAI CULTURAL RESOURCES CENTER

This new 200,000-square-foot building serves both as a museum/conservation center and as a cultural and religious center for Native Americans. In developing the design concept, SmithGroup, in joint venture with another firm, worked with Native Americans from throughout the Americas to distill a series of design principles from diverse tribal traditions, beliefs, and practices. The final design, in keeping with Native American traditions, makes symbolic and physical connections with the natural and man-made landscape, creates an appropriate and respectful home for the artifacts, and provides a welcoming environment for tribal people throughout the hemisphere.

The building includes many disparate functions: ceremonial areas, artifact storage, conservation laboratories, office/administrative space, a library, an enclave for visiting scholars, photograph studio and photograph archive. To stimulate interaction, a facility which operates seamlessly was desired. In fact, tribes often visit the facility, to use items in rituals performed in one of the ritual rooms, or outside in the inter-tribal ceremonial circle. Artifacts are allowed in all rooms of the building, but must be stored overnight only in designated, secured areas. Because of this unique cultural requirement and because the client wanted to co-locate the functions to make the divisions between functions as transparent as possible, a relative humidity of 50% is required throughout the entire building. This indoor environmental quality requires careful consideration of the components of the building envelope.

Walls are detailed with a continuous air/vapor barrier, insulation, and a series of vented cavities which are open to the exterior of the building. By venting these cavities, the negative pressure which forces air and water into buildings is diminished over a very small time period, and continuously, as the wind blows. This system is called a pressure equalized rain screen. The walls are designed for both summer and winter conditions. Wall systems include flat seam aluminum panels, precast concrete block, flat seam and standing seam Terne coated stainless steel, and corrugated aluminum panels. Different wall types include split face masonry, blue stone veneer, precast concrete panels and poured in place concrete. Special attention is paid to attachments, which are thermally broken to prevent condensation on the interior. In addition to highly efficient mechanical systems, the building's fully sealed continuous air/vapor barrier will contribute to its energy efficiency.

The glazing systems, both aluminum storefront and aluminum windows, are insulated glass with an ultraviolet protective film on the inner layer. The system ties into the air/vapor barrier, but does not provide adequate R value or Condensation Resistance Factor to prevent condensation. Only triple glazing could provide the insulating qualities necessary, however, by providing supplemental heat through the use of fin tube or forced air, condensation is reduced or eliminated.

The roof responds to both programmatic and symbolic requirements. The stringent program required that the building carefully protect the one million-item George Gustav Heye

Collection in a number of ways, including the prohibition of roof drains over any artifact storage area. Three different roofing systems are used; flat seam copper, modified bitumen sheet, and fluid applied asphalt. All assemblies place a vapor barrier on the winter warm side and minimize penetrations and thermal bridges.

Similar issues regarding codes and VOC's are addressed at the Cultural Resources Center as at NAL, though with an additional degree of complexity due to the size of the building, the variety of programmatic pieces and the numerous additional trades involved.

CONCLUSION

Developing and maintaining conservation-quality environments requires substantial extra design effort. Through the integration of NARA standards and a preservation conscious design, the NAL will become an attractive environment for archival storage and retrieval research. The National Agricultural Library renovation has supported its mission of protection of special collections by creating a successful yet sensitive space. At NMAI, a sophisticated client with a highly detailed building, requiring a design representative of native cultures. Because the design was driven by cultural concerns, a host of techniques, components and systems were employed to maintain the indoor air quality, and provide a building capable of withstanding the climate of Washington D.C., the freeze-thaw capital of the free world.

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