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STRATEGIES OF EFFECTIVE MOISTURE CONTROL IN THE DESIGN OF AN AQUACULTURE CENTRE.

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ABSTRACT

It is well ascertained that for water to penetrate a wall, this three conditions must be true at the same time and location: Water on the surface of the wall, An opening through which water may pass, Any one of five external forces which include surface tension, momentum, air pressure differences, gravity flow and capillary action. Capillary Action (Capillarity) is the movement of water (or any liquid) through a tube. Moisture which is the relative amount of water vapor contained is the air is generated through several source and cause lot of harsh effect on the building and its content. Possible strategies that will mitigate this effect are what this paper seek to highlight and resolve critically by emphasising the possible guidelines that will that will mitigate regular occurrence.

Keywords: Relative Humidity, Moisture control, Capillary action Mitigation

INTRODUCTION

The term aquaculture refers to the practice of farming fish and other forms of aquatic life for food. It is part of the United Nations Vision 2020's Sustainability goals for Food for all. Grasso (2015), the earliest form of aquaculture practiced consisted of trapping wild aquatic animals in lagoons, ponds or small shallow lakes so they would be available at all times. This activity requires the use of water, which is the main source and causes of damp penetration in this building for this centre to function. Moisture control is fundamental to the proper functioning of any building especially in this kind of buildings where water is key for it to function. Controlling moisture is important to protect occupants ranging from humans to animals to materials from adverse effects and to protect the building, its mechanical systems and its contents from physical or chemical damage. Dampness cannot only cause collapse but it can cause a building undergo obsolescence therefore making it not to attain its building life cycle. This is so common in buildings that many people consider this effect inevitable. Researchers say it cannot be completely eradicated but can be mitigated. Especially in the Niger Delta region where the level of humidity is high.

To be successful, moisture control does not require everything be kept completely dry. Moisture control is adequate as long as vulnerable materials are kept dry enough to avoid problems. That means the building must be designed, constructed and operated so that vulnerable materials do not get wet. It also means that when materials do get wet, the building needs to be managed in such a way that the damp materials dry out quickly. While the severity of moisture problems varies greatly depending on climate, the situation in the Niger Delta region call for great concerns about the phenomenon of dampness in buildings. Air with high level of humidity can become trapped in a building's structural members, potentially leading to growth of mold, rot, or insect infestation and surface damage. The subject that is being addressed here is a paramount and has to be carefully looked at.

What is Moisture

Moisture as defines by Webster dictionary is the amount of water vapor in the air. This arise as a result of several factors of which some are listed below.

Rain

EPA (2013), Moisture control is an important aspect of designing an integrated building enclosure. Failing to properly design walls to manage moisture and failing to integrate moisture management system features with those of other building enclosure components, such as the roof and foundation, can lead to serious moisture-related damage. Correcting problems resulting from poorly designed walls can necessitate the replacement of multiple building components leading to high repair costs.

CAUSES OF DAMPNESS IN BUILDINGS

Absorption of moisture by the building materials is one of the chief causes of dampness. On account of granular nature of materials, moisture finds an easy access through the voids and this aided by ***capillary action*** assists the moisture to travel in different directions. Thus, either on account of faulty design of structure or bad workmanship or by use of defective structures or by use of defective materials, moisture may find its way on the interior of the building either through the wall, floor or roof.

SOURCES OF DAMPNESS OR MOISTURE PENETRATION.

The important sources of dampness may be summarized as below:

1. **Dampness Rising Through the Foundation Walling**.
   Moisture from wet ground may rise well above the ground level on account of capillary action.
2. Splashing rain water which rebounds after hitting the wall surface may also cause dampness.
3. Penetration of rain water through unprotected tops of walls, parapet, compound walls, etc may cause dampness.
4. In case of sloped roofs, rain water may percolate through defective roof covering. In addition, faulty eaves course and eave or valley gutters may allow the rain water to descend through the top supporting wall and cause dampness.
5. In case of flat roofs, inadequate roof slopes, improper rainwater pipe connections, and defective junction between roof slab and parapet wall may prove to be the source of dampness

Wall Design Goal 1: Design exterior walls to manage rainwater.

Guidance 1: Design walls to protect their inner portions from direct rain and seepage through the cladding.

• Design walls that have rainwater protection behind the cladding in the form of air gaps and barrier materials (i.e., the drain plane) to keep water from wicking further into the wall.

• Specify in the design drawings and specifications the flashing of penetrations—including windows, doors and roof-wall intersections—to a designated drain plane.

• Provide sections and specifications detailing flashing for all wall penetrations. Flashing for larger penetrations (e.g., windows, doors and exhaust and intake grilles) must be carefully designed and detailed. At the top, flashing must extend from beneath the drain plane material, across the top of the trim, and out past the siding and trim (See Figures 2-6 and 2-7). The bottom must have a pan flashing with end dams and a back dam. Side flashing must cover the rough opening, extend beneath the drain plane on the wall, and flash down over the end dams on the sill flashing. Among the most common problem areas for flashings in walls are Windows, Doors and trim. Outdoor air intakes, exhaust outlets and fans. Ducts, pipes and electric conduit entries and exits.

Through-wall flashings where a horizontal element (e.g., roof) intersects the wall of a taller portion of the building. Similar locations include exterior stairway-wall intersections as well as relieving angles, awning decks, and balcony and plaza intersections with the wall of a taller section of building.
The mitigation of moisture control on wall requires adherence to some principles as highlighted below:

- Design exterior walls to prevent condensation of water vapor on cool surfaces within the dry portion of the exterior wall assembly, on the inner surface of the exterior walls or within the interior wall, floor or ceiling cavities.
- Design walls to be sufficiently airtight to limit water vapor migration by airflow.

Based on the discussion in this article and personal experience in the design, construction, and investigation of natatoriums, the authors present the following summary of design guidelines for indoor swimming pools. (This is not an exhaustive list of all design concerns, but focuses on primary issues with the building enclosure and interior environment.)

STRATEGIES FOR MITIGATING MOISTURE PENETRATION.

Following methods are generally adopted to prevent the defect of dampness in a structure:
1. Membrane damp proofing 2. Integral damp proofing 3. Surface treatment 4. Guniting 5. Cavity wall construction

1. Membrane Damp Proofing

This consists in providing layers of membrane of water repellant material between the source of dampness and the part of the structure adjacent to it. This type of layer is commonly known as damp proof course (DPC) and it may comprise of materials like bituminous felts, mastic, asphalt, plastic or polythene sheets, cement concrete, etc.

Depending upon the source of dampness, DPC may be provided horizontally or vertically in floors, walls, etc. Provision of DPC in basement is normally termed as tanking.

General principles to be observed while laying damp proof course are:

1. The DPC Should Cover Full Thickness Of Walls Excluding Rendering.
2. The mortar bed upon which the DPC is to be laid should be made level, even and free from projections. Uneven base is likely to cause damage to DPC.
3. When a horizontal DPC is to be continued up a vertical face a cement concrete fillet 75mm in radius should be provided at the junction prior to the treatment.
4. Each DPC should be placed in correct relation to other DPC so as to ensure complete and continuous barrier to the passage of water from floors, walls or roof.

2. Integral Damp Proofing

This consists in adding certain water proofing compounds with the concrete mix to increase its impermeability. Such compounds are available in market in powdered as well as in liquid forms.
The compounds made from clay, sand or lime (chalk, fuller's earth, etc) help to fill the voids in concrete and make it waterproof.
Another form of compounds like alkaline silicates, aluminium sulfate, calcium chlorides, etc react chemically when mixed with concrete to produce water proof concrete.
Pudlo, Imperno, Siks, etc. are some of the many commercially made preparation of water proofing compounds commonly used. The quantity of water proofing compounds to be added to cement depends upon manufacturers' recommendations.

3. Surface Treatment

As described earlier, the moisture finds its way through the pores of materials used in finishing. In order to check the entry of the moisture into the pores, they must be filled up. Surface treatment consists in filling up the pores of the surfaces subjected to dampness. The use of water repellant metallic soaps such as calcium and aluminum oleates and stearates is such effective in protecting the building against the ravages of heavy rain. Bituminous solution, cement coating, transparent coatings, paints, varnishes fall under this category. In addition to other surface treatment given to walls, the one economically used is lime cement plaster. The walls plastered with cement, lime and sand in proportion of 1:3:6 is found to serve the purpose of preventing dampness in wall due to rain effectively.

4. Guniting.

This consists in depositing impervious layers of rich cement mortar over the surface to be water proofed. The operation is carried out by use of a machine known as cement gun. The assembly broadly consists of a machine having arrangements for mixing materials and a compressor for forcing the mixture under pressure through a 50mm diameter flexible hose-pipe. The hose-pipe has nozzle at its free end to which water is supplied under pressure through a separate connection. The surface to be treated is first thoroughly cleaned of dirt, dust, grease or loose particles and wetted properly. Cement and sand (or fine aggregates) usually taken in proportion of 1:3 to 1:4 are then fed into the machine. This mixture is finally shot on the prepared surface under a pressure of 2 to 3 kg per square cm by holding the nozzle of the cement gun at the distance of 75 to 90 cm from the working surface. The quantity of water in the mix can be controlled by means of regulating valve provided in the water supply hose attachment. Since the material is applied under pressure, it ensures dense compaction and better adhesion of the rich cement mortar and hence treated surface becomes waterproof.

5. Cavity Wall Construction

This consists in shielding the main wall of the building by an outer skin wall leaving a cavity in between the two. The cavity prevents the moisture from traveling from the outer to the inner wall.

Some Design Recommendation Against Moisture On Building.

The traditional way of preventing moisture problems in walls and roofs was the installation of what then was called vapor barriers, now more accurately referred to as vapor retarders. There are a few commonly quoted, prescriptive rules of thumb for locating vapor retarders in walls and roofs, some of which are listed below. While these rules still may be useful as first cut approximations, the designer must consider the entire array of good practices, needs to conduct a job specific analysis, and must understand local climatic conditions and building practices.

- Rainwater leaks and wetting of permeable wall exteriors are recognized as the major moisture transport mechanisms into walls. Therefore, shedding of rainwater, roof overhangs, and appropriate water repellant finishes should be considered to reduce moisture infiltration into wall constructions.
- Rainwater leaks are most common at the joints between components, notably between walls and windows and doors, at sills, and at roof/wall intersections. Specify appropriate sealants to prevent water infiltration.
- Some new materials have not withstood the test of time nor have reliable test methods. Therefore, designers specifying innovative materials must carefully review available data regarding performance, compatibility, and installation requirements.
- Building walls can be classified as "face sealed" or as "drained" walls. Face sealed walls have only one single defense against rainwater. An example is face sealed Exterior Insulation and Finish Systems (EIFS) aka synthetic stucco. Unless perfectly or near perfectly installed, face sealed walls will fail and so adequate provision for field quality control in the specifications is mandatory. Drained walls have a secondary barrier to water penetration and provide a means to drain water that may have penetrated the first water barrier. An example would be masonry veneer walls that include a drain cavity.
- To prevent water accumulation in basements and crawl spaces: seal the below-grade walls; install a vapor retarder and a capillary break on the floor of the crawl space or below the basement floor slab; install drains and sumps; drain downspouts and rainwater runoff away from the building; and slope the grade away from the foundation. See also WBDG Achieving Sustainable Site Design through Low Impact Development Practices.
- Movement of moisture-laden air into wall and roof cavities is the second most prominent moisture transport mechanism. Accordingly, select construction details that prevent moist air from infiltrating. In cold climates during the winter, this means prevent indoor air from exfiltrating through the wall; in warm climates, prevent moist outside air from infiltrating.

Pressurization and depressurization of the indoor space can assist in this effort. However, in high-rise buildings, stack effect may negate pressure gradients resulting from mechanical ventilation. See also WBDG Air Barrier Systems in Buildings.

- In cold climates, locate the vapor diffusion retarder on the warm side of the exterior insulation. Some building scientists suggest including an interior vapor retarder only in cold climate areas with 8,000 heating degree-days or above, but no long-term empirical data exists to justify this practice at this time.
- In cooling-dominated climates, install a vapor retarder on the exterior of the insulation. In mixed zones—climates with both significant heating and cooling requirements—omit a vapor diffusion retarder in favor of more attention to air leakage control. In warm and humid climates, consider installing a vapor impermeable finish on the exterior.
- As a rule, it is better to omit a vapor retarder than to install one where it is not required. Never install vinyl wallpaper on the interior of exterior walls in warm climates.
- Eliminate the possibility for water vapor to condense within a building assembly. This can be achieved a number of ways:
  - Seal building assemblies and/or install an air retarding membrane to reduce air leakage into wall/ceiling cavities. Pay particular attention to penetrations between conditioned and unconditioned spaces as a result of plumbing stacks, wiring, ductwork, electrical outlets, etc.
  - Incorporate vapor retarding membranes that inhibit the diffusion of warm, humid air into the building wall cavities;
  - Reduce open water sources and protect building materials from the elements prior to installation; and
  - Coordinate the performance of the building's heating and cooling system so as to control the indoor air humidity and the pressure of the indoor air relative to the pressure of the exterior. Ideally, maintain the indoor relative humidity between 30% and 50%. See also WBDG High-Performance HVAC.
  - Provide clear specifications that include appropriate and effective field quality control and inspection provisions,

which are as important as proper design and material selection. Clarify whether a vapor diffusion retarder, an air retarding membrane, an air retarder construction approach, or some combination of these strategies will be used in the building. Include requirements for environmental conditions when sealers and caulks can be applied.

CONTROLLING BELOW-GROUND DAMPNESS (INCLUDING RISING DAMPNESS)

Ground Works/Improved Drainage

There are many types of works outside a building that will remove, redirect or reduce the water that is causing a problem. These can range from grubbing out plants, trees and shrubs adjacent to the walls through to lowering the immediate levels around the building to at least 150 mm below the ground floors inside to form 'dry areas'. It may be beneficial to improve the drainage adjacent to a building. The structural consequences of ground-works or improved drainage should be considered, however. Foundation failures can occur due to ground movement and change in the level of the water table. The archaeological implications of excavation close to old walls should also not be overlooked.

Douglas (2018), French drains can, in certain circumstances, help control belowground dampness by redirecting surface and subsoil water away from foundations. Laid near a building, they may, for example, be an effective means of intercepting surface flow from uphill or dispersing liquid moisture in a clay soil that is not free-draining. It is important to ensure that water in a French drain is directed away from the building. The drain should be inspected annually and for this purpose care should be taken to arrange for well-sited inspection chambers. There is a serious risk that the drain could otherwise become blocked, especially in clay soil, thereby forming a moat around the building and increasing dampness.

Open drains can be a better solution than French drains if evaporation of moisture from the bottom of walls is needed where surrounding ground levels have risen. In other situations, the use of 'hi-tech' alternatives might be appropriate. These include drainage composites, reduce or eliminate the need for a granular backfill material so cut construction costs. Alternatively, a geodrain barrier can be fitted to the exterior of the wall to drain it if access for the excavation is available. Where below ground services enter, care needs to be taken to avoid trenches picking up ground water and leading this into the building fabric.

Breathability and Ventilation

Measures that help the fabric 'breathe', such as replacing hard cement render or pointing with a more suitable lime-based mortar, may be the best solution for controlling rising dampness in a traditionally constructed building. Conversely, applying water-proof renders and coatings, or repointing or re-rendering walls with a cement-rich mortar, can exacerbate dampness problems. Where a floor has a DPM that is displacing moisture into the bottoms of walls, this might be replaced with a 'breathable' construction. Alternatively, as a compromise, a 'breathing' strip for evaporation may be cut through the floor around the room perimeter and infilled with a material such as lime concrete or grated over.

OTHER STRATEGIES FOR MITIGATING MOISTURE PENETRATION.

1. Design a continuous air barrier system for the exterior enclosure, including exterior and interior components that separate the natatorium from adjacent spaces.
2. Design continuous insulation for the enclosure and minimize the incidence of thermal bridges and structural penetrations through the insulation.
3. Design an appropriate vapor retarder for the enclosure. This can be the same material as the air barrier, depending on the insulation's location.
4. Use high-performance fenestration systems aligned with the thermal insulation, combined with active systems such as warm air washes, to minimize the incidence of interior condensation.
5. Balance mechanical systems to provide negative air pressure within the natatorium for the full height of the space, not just at the pool deck level. Negative pressure levels must be sufficient (or adjustable) to overcome stack pressure down to the local exterior design temperature. Ductwork should be carefully

designed and systems balanced/confirmed before filling of the pool. Confirm, through a testing and balancing report, that the airflow into the pool space is less than the airflow back to the mechanical system. Confirm space pressures by direct measurement in addition to measuring supply/return quantities.

6. Avoid using stainless steel in applications that are deemed 'safety-critical' or where components will not be frequently wetted or cleaned. When stainless steel is employed for safety-critical or overhead applications, a specialty alloy is likely necessary.
7. Avoid specifying stainless steel for ductwork. Non-corrodible fabric ductwork, painted aluminum or painted galvanized steel is typically better options.
8. Write tight specifications for air barrier systems, including provisions for field-testing of mockups, installed assemblies, and the whole building enclosure. Testing should include both quantitative and (concurrent) qualitative methods to identify overall leakage rates as well as localized breaches in the air barrier system.

RECOMMENDATION AND CONCLUSION

Conclusively, every building deserves to attain it expected life-cycle, therefore it is expedient that all modalities, guide and principles be followed to achieving this. Moisture in building are indeed a treat to any structure having considered the it adverse effect. However, since eradicating the harsh effect on the building especially in a building of this type that is considered in this paper. Mitigating this harsh effect through adhering to the guide listed here will be of great guide.

It is recommended that the necessary professional in the construction industries that mainly include but not limited to architectural/Engineering/construction related industries should be enlightened about the concept of moisture dampness control. However, this paper should be considered for more research and critique.

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