Design Considerations for Zero-Lot-Line Building Envelope Protection

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ABSTRACT

Designs for the types of walls in conjunction with the type of waterproofing, concrete, and property line limitations will be discussed. I will discuss the various types of “blindside waterproofing” including the impact of the use of shotcrete and cast-in-place (CIP).

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INTRODUCTION

Construction of new buildings often requires the building owner to build below grade space to accommodate for parking or additional building use. In high density areas, this also means that builders try to maximize square footage by building directly on the property line. Zero-lot-line (ZLL) below grade construction requires the application of blindside waterproofing to various types of shoring conditions.

Photo: Zero-lot-line property development in Hollywood, CA

Waterproofing consultants are hired to work closely with the owner, architect, and waterproofing manufacturer to provide the appropriate "elixir" as dictated by several site-specific factors; some of the factors discussed include:

1. *Shoring Methodology:* The proximity of the adjacent property, site geology, and cost can be determining factors in selecting the appropriate shoring methodology.

2. *Concrete Application:* When constructing below grade foundation walls, concrete can be poured in place or it can be shot through a nozzle. These different approaches create efficiencies that help save time during the construction process, but can also adversely impact the waterproofing.

3. *Hydrostatic Conditions:* Sites with shallow groundwater or deep excavations require site drainage during the construction process and for the functional use of the building if local codes allow. However, in many high-density areas it is becoming cost prohibitive to continue dewatering upon completion of construction. Design considerations should be considered when waterproofing systems are subjected to hydrostatic pressure.

Photo: An example of wood lagging

Environmental factors can also be a major consideration when dealing with contaminated soils (brownfield sites). Local or state regulations can impact the treatment and/or disposal of contaminated soil and/or groundwater, which can lead to design modifications for the dewatering system, and impact the type of shoring system selected.

WHEN DO WE NEED A BLINDSIDE WALL?

A ZLL wall is primarily used to maximize the building area by allowing the builder to construct directly on the lot line; it is designed to resist soil and water pressure for the life of the building and serves as the last line of defense against unwanted water ingress. In ZLL construction, the process occurs from the outside in by first constructing the shoring wall. A shoring wall is most commonly constructed using two methods, commonly known as “wood lagging” and “shotcrete shoring.” Wood lagging is constructed by placing treated wood (2” x 12”) between steel piles. Shotcrete shoring is achieved by temporarily securing the earth with soil nails or tie backs and then applying gunite mixture for reinforcement. Upon completion of the shoring wall, the application of the waterproofing membrane is completed, reinforcement steel is placed, and the structural wall is put in place using cast-in-place concrete or shotcrete.

SHOTCRETE VS. CAST-IN-PLACE WALLS

Shotcrete is generally chosen because of its ability to fast-track construction, elimination of form tie penetrations, and cost. While shotcrete provides advantages to the construction team, it can adversely impact the previously installed waterproofing system. A very durable membrane is required to help resist the pressure and impact of pneumatically sprayed concrete. Creating proper consolidation of the concrete is critical to help prevent damage to the waterproofing system and associated water stops and penetrations.

Photo: Application of shotcrete to a waterproofing system. (Photo courtesy of EPRO)

Cast-in-place (CIP) concrete is generally more expensive. However, it is applied in a more uniform manner that creates better contact between the waterproofing system and the structural wall. A more uniform application creates less stress on the waterproofing system during application.

VARIOUS TYPES OF WATERPROOFING SYSTEMS FOR ZLL WALLS

Many waterproofing consultants believe that creating redundancy will increase the chances for success.

Historically, waterproofing materials fall under two categories, passive and active. Passive, or inert, systems seek to create a physical barrier between water and concrete. Some common examples include PVC, Modified Bitumen, Plastic Sheeting with latent adhesive, etc. Active, or reactive, systems respond to contact with water, in most cases, by swelling – bentonite clay-based membranes are the most common example. Passive or active systems seek to accomplish the same goal, but do so in different ways. Each can be successful, but each comes with its own advantages and disadvantages. Some manufacturers have decided to create redundancy by combining both active and passive methodologies to create a backup waterproofing system when properly designed for specific performance criteria.

Performance criteria for blindside ZLL waterproofing requires the product attributes, hermetic[1] capabilities, adhesion to substrate (mechanical and/or chemical bonding), and intermittent hydrostatic pressure resistance. Active waterproofing systems rely on compression for proper performance, therefore they require minimal gaps as described in "Standards Development for Impermeable, Constructible, and Durable Waterproofing," *Journal of ASTM International 1546-962X.* Other considerations for the use of bentonite require the existence of saline or brackish water that may impact the bentonite's ability to activate (swell when in contact with water).

Manufactures of waterproofing systems conduct performance testing, common testing procedures include water vapor permeability, hydrostatic head resistance, tensile strength, puncture resistance, adhesion, etc. Testing methods, however, are difficult to compare. ASTM standards are often created around one type of waterproofing material, so the exact testing method used on a passive waterproofing system might not be achievable with an active waterproofing system.

Many testing standards have been the same for many years, but there have been some recent developments. In 2014, the International Living Future Institute (ILFI) created a "Red List" of building materials to promote a green building initiative called the Living Building Challenge. Included on the "Red List" are common waterproofing materials such as Polyvinyl Chloride (PVC) and Chloroprene (neoprene). Living Building Certification is certainly not a requirement of all buildings, but it may be an indicator of the future. Another example of how building materials might impact the environment is the requirement of National Safety Foundation (NSF) Certification for below grade waterproofing applications. Obtaining an NSF Certification means that the waterproofing system will not leach any chemicals that would make the ground water unsafe for drinking.

For sites with contamination present, diffusion and permeability studies provide an indicator into the waterproofing system's ability to protect structures against aggressive solvents, petroleum hydrocarbons, or methane gas. Water vapor permeability is not a reliable indicator of a product's ability to resist contamination.

One consideration not discussed in detail are the various admixtures that can be added to concrete. While admixtures can be used without a waterproofing membrane, using them in conjunction with a waterproofing system can help create redundancy in problematic areas. Concrete additives can also be advantageous when making repairs to concrete. Additional information on crack repair for specific site

[1] *Hermetic: Totally sealed against the escape or entry of air. Derived from the name Hermes, the Greek name for the Egyptian god Thoth, who was regarded as the originator of the science of alchemy.*

conditions can be found in the following standards: ACI American Concrete Institute, 224R[2] and BS-8007 British Standard Code[3].

RECENT ADJUSTMENTS

The target for creating the ideal waterproofing system continues to change, and the need to make "adjustments" will continue. This is due to the need for the developers to build where never thought possible using new methodologies to fast-track construction.

For a ZLL wall, assurance of performance can be tested by methods and means that include but are not limited to:

- Continuous inspection by a certified third party.
- Capacitance testing by installing a copper line with current in vulnerable seams etc.
- Injecting pre-formed panels to prescribed limits.
- Smoke testing.

ONGOING OBSTACLES

Additional design factors can come into play when specific engineering is required. These include various penetrations and attachments such as Nelson Studs and Whalers.

Photo: Complex shotcrete shored wall with whalers

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[2] *ACI 224R cites 4 mils as reasonable crack in the water table with 16 mils to receive a protective membrane.*

[3] *BS 8007- "This British standard provides recommendations for the design and construction of normal reinforced and prestressed concrete structures used for the containment or exclusion of aqueous liquids" Maximum crack width is 0.2 mm or 7.87 mils for water exposure.*

Tie backs and soil nails are generally used creating specific detailing and additional materials for backup waterproofing (i.e.: water stops/injection tube placement).

Photo Left: Tie-back sealed prior to wall placement. Photo Right: Post installation

SUMMARY:

This article provides a brief insight into the design solutions for building on a zero-lot-line property. As stated, most often these are areas located in tight conditions with little or no room to provide adequate safety, production performance, and watertight systems. They also are generally located near or in the water table where most of our major cities were built.

To overcome these challenges, one should begin the waterproofing selection process by prioritizing material selection based on the structural wall type. Best practice would err on the side of redundancy, because redundancy provides a wider range of adaptability to the site-specific conditions. With budget concerns, redundancy may allow for cost savings for other scopes of work that interact with the waterproofing system.

One needs to consider the implications if leakage does occur inside the structure; what is the impact of that to the operation or inhabitants of the building? Most design professionals would agree that in the short or long term, leakage can occur and a plan should be in place for how to best contain or mitigate any ingress. Manufacturers have created more robust warranty offerings to provide assurance to building owners, but a prudent first step in a successful project is to retain a professional waterproofing consultancy to address the myriad of concerns addressed in this paper.