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Wall Templeton & Haldrup, P.A. has designated Neil S. Haldrup to accept responsibility for this website. He may be contacted at 843-329-9500 or at Neil.Haldrup@WallTempleton.com

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I. Introduction

A. Construction Defects Defined

What is a construction defect? The answer likely depends on the person you ask and where they fall in the construction process. At one end of the spectrum, an owner expects perfection. At the other end, a contractor expects some leniency in the standards, and some allowed deviations in the final product. Both positions have some merit.

In the litigation context, a property owner must show that the work complained of either failed to meet the specified contract requirements, or violated applicable building codes or recognized industry standards. The owner also, of course, must show that the defect caused some damage to his property. Some construction defects—cracked stucco, for example—are easily identified. Yet at that point the hard work remains: determining if the crack is a construction defect for which the owner can recover damages. Owners, designers, developers, contractors, product manufacturers, and others can and do disagree on that fundamental question.

Parties typically retain expert witnesses to explain the contract constructability and performance requirements, to identify the applicable building codes, and to declare the applicable industry standards. Because experts routinely promote the interest of their clients, the proper interpretation of the alleged defect is frequently a contested matter. Is the condition at issue a defect? If so, what was the cause of the defect? What damage was caused by the defect? What is the proper remedy for the defect? Which defendant or non-party bears the ultimate responsibility for the defect? These questions form the contours of the construction defect litigation dispute, which can involve an infinite variety of fact-specific permutations and scenarios.

This chapter will explore some of the defects typically encountered on commercial and residential projects. We will describe the typical defendants, provide an introduction to each of the five categories of defects, review some of the typically disputed issues, and discuss the causes, damages and solutions related to each category of defect. Finally we will provide an index of typically referenced guides and standards. These standards and resources provide the technical basis for identifying construction defects, but the construction practitioner must determine if the identified defects are merely technical defects without recoverable damages, or if they are defects for which the law provides a remedy.

B. Common Targets in Construction Defect Claims

Throughout the chapter you will encounter references to common targets in construction defect claims. While the specific person or work alleged to have been the cause of the defect varies from project to project, the following are the broad classifications which plaintiffs typically target.

1. Design Professionals. The design concept is sometimes difficult to convey in writing or in plans. While a design may appear aesthetically pleasing or interesting, the reality may be that the design is inherently deficient, is inappropriate for the location or intended use, or is difficult or impossible to achieve without some deviation from the design intent. The design itself can be a defect causing damage and potential liability for the design professionals. In addition, design professionals who are charged with construction administration are potentially liable for their services in the construction process.

2. Material. The installation of defective materials or improper products may cause damage to a project. The defect in the product may not manifest itself for a period of time after installation, so the cause and resulting damage due to defective materials can be difficult to determine. The tidal wave of synthetic stucco litigation over the last several decades is a

testament to the viability of inherently defective products as a target to construction effect plaintiffs.

3. Workmanship. The most common target in this type of case is defective workmanship. The design may be adequate, and the materials used fully appropriate. Very commonly, however, contractors and their subcontractors will utilize manpower which fails to conduct its work in accordance with the plans, the building codes, industry standards, or installation instructions. The somewhat bitter irony is that the very factor which produces the eminently desirable low-cost housing—contractors' deployment of a low-cost workforce—also generates the bulk of construction defect litigation.

So architects, engineers, contractors, subcontractors, material suppliers, and material manufacturers are the common targets in construction defect litigation. The next section focuses on the specific types of construction defects these targets typically are alleged to have caused.

C. Basic Categories of Construction Defects

The following five categories designate the common construction defects at issue in this type of litigation. Each category is generally described below, and a section on each of these defects is contained within this chapter.

1. Site Performance Failures. Problems with site design, with preparation of the foundation, or that are inherent in soil conditions can generate or compound problems in vertical construction (from the foundation up through the shingles on the roof). Therefore, geotechnical engineering and site design are critical to the success of a project. Site failures such as unstable soils, poorly designed foundations, or drainage shortcomings can cause

damage to the building as it shifts. In extreme cases, site failures can cause catastrophic building failure or collapse, rendering the building uninhabitable.

2. Building Envelope Failures. Failures associated with the exterior cladding, roofs, and some of the penetrations through those surfaces such as windows, doors, skylights, and other glazing components are categorized as building envelope failures. This type of defect is the most commonly complained of, and is truly at the heart of the typical construction defect claim. Damages in such cases typically involve water intrusion into the building components, and, in some cases, into the interior of the building. The water—rain and ambient water vapor—which is supposed to be kept outside by the building envelope, can cause wood rot in the building frame, which in turn can produce structural weaknesses, mold and a host of other problems. Multi-family developments and condominiums are prime targets for this type of construction defect litigation due to the potential for extensive damages and verdicts.

3. Failures of Building Structural Systems. Deficiencies involving the framing, walls, floors, and other components used to support the structure, vertically and horizontally, are classified as the failure of building structural systems. These issues range from failure to install a proper number of nails in framing members, to non-plumbness of door jambs, to inadequate loading design, to the complete collapse of the building.

4. Failures of Building Mechanical and Electrical Systems. Problems occurring with a building's heating, ventilating and air conditioning systems ("HVAC"), its plumbing systems, and its electrical systems fall under this category. Mechanical and electrical defects are similar to the other categories in that they typically involve property damage; however, these defects can also involve bodily injury claims. In the HVAC context, bodily

injury claims are typically due to indoor air quality issues. In the electrical defect context, failures leading to a fire in the building may result in bodily injuries and death.

5. Failures of Building Life/Safety Systems. Failure to follow the building code provisions regarding fire resistance, building egress, fall protection, fire detection, or fire suppression are categorized as failures of building life/safety systems. These issues are significant to the construction practitioner because violation of legislated building codes usually gives rise to a claim for negligence *per se* and, in some states, a statutory cause of action.

To understand more fully the manner in which these claims are prosecuted, a more detailed explanation of each type of claim is presented below.

II. Site Performance Failures

A. Introduction to the Various Elements of Site Development

For purposes of this section, the term "site development" is intended to include the traditional elements of site selection, evaluation, master planning, and the design and construction of the finished topography and infrastructure systems. "Site development" is not intended to include the design or construction of buildings to be placed on the site. Technical activities associated with site selection are generally conducted by the developer, with the assistance of other consultants in the areas of marketing, real estate, engineering, and architecture.

For projects of substantial size or complexity, it is normal to include preliminary subsurface geotechnical explorations to evaluate the environmental history, the presence and extent of rock formations, and the physical characteristics of subsurface soils. Depending upon preliminary geotechnical report findings, additional geotechnical explorations may be undertaken before the actual site selection is consummated. Following final selection of a site, but prior to the commencement of detailed plans and specifications, additional geotechnical studies may be performed to provide specific recommendations related to site grading, roads, pavements, utility placements, and building structural parameters for foundations and seismic response.

Subsurface site conditions that differ materially from those anticipated for design and construction of the project can cause expensive delays, redesign, and alternative construction solutions. In the litigation context, these problems can produce claims, in essence, for the reconstruction of the entire project. Therefore, many site-work related construction defect claims involve large sums of money and very complex theories

B. Typical Site Development Claims

1. Site Grading, Preparation, and Drainage. Site preparation includes everything from clearing, grubbing, and grading the site, to topographical contours established on drawings customarily prepared by the civil engineer of record. Associated with these activities are environmental protective measures intended to control erosion and stormwater drainage that might harm neighboring properties. Construction documents typically establish requirements for the construction phase, temporary protective measures and the permanent arrangements for controlling the post-development flow of stormwater. The grading contractor relies upon the contract documents for horizontal and vertical controls, and for the grading and stormwater management requirements. Significant failures in any of these systems typically lead to disputes that could involve the grading contactor, general contractor, civil engineer, land surveyor, and others from the design and construction team. Claims related to site selection or geotechnical representations—most commonly, claims against the geotechnical engineer—typically take the form of breach of contract or professional negligence claims.

2. Infrastructure – Roads and Bridges. Development of major land tracts into facilities such as residential subdivisions, industrial parks, office parks, institutional campuses, and townships will typically include a network of roads and utilities. Topographical constraints may

impose requirements for bridges, culverts, streams, and other land features. Disputes concerning infrastructure are common. With roads and bridges, allegations typically focus on workmanship defects, geotechnical representations, and/or structural design. Issues in dispute generally are pavement failure with roads and excessive settlement with bridges.

3. Infrastructure –Underground Utilities. Typically disputed utility issues include claims for time and costs arising from differing site conditions, disputes arising from early failure of materials (especially pipe), site safety violations associated with excavation bracing, and ground, pavement or building settlement caused by insufficiently compacted fill in utility trenches. Like many construction defect disputes, these issues may involve a large number of people or companies as potentially culpable parties.

4. Site Structures – Retaining Walls, Swimming Pools, and Other Below Grade Structures. Site development includes retaining walls, swimming pools, and other below grade structures not considered part of the building system. Retaining walls vary significantly in terms of construction material and structural design. Around water features, the retaining wall is referred to as a bulkhead. Like landside retaining walls, bulkheads vary widely in material and design. In-ground pools of any significance are generally of concrete or gunite construction. The performance of in-ground pools (especially when the pool is not filled with water) is similar to a retaining wall or bulkhead. Defects generally involve waterproofing and the lack of proper drainage.

5. Elevated Tanks. Elevated tanks involved in disputes are generally those that are constructed as part of a potable water distribution system. These tanks usually are constructed of steel or concrete sitting on a foundation designed to resist gravity, seismic, and wind loads. Because the major weight of elevated tanks is located at the top of the structure, earthquake

induced (seismic) forces can create large overturning moments, which give rise to potential defects in the design, materials, and/or workmanship.

C. Causes, Damages and Typical Solutions in Site Development Claims

1. Site Grading, Preparation and Drainage. Unknown subsurface conditions generally cause the problems associated with site grading and preparation. Occasionally, there are disputes when the actual quantities or classifications differ materially from those indicated by the contract documents. The causes associated with differing quantities or classifications of earthwork include inaccurate topographical benchmarks, inaccurate pre-construction quantity surveys, and the removal and replacement of unsuitable materials.

   Site drainage claims generally occur when changes to the existing site are underway. Most clams are brought by off-site property owners alleging damages to their property resulting from storm drainage discharged from the property under development. During the development process, both the volume and direction of pre-development rainwater flow changes. Previously pervious surfaces (unimproved, grassy land) become impervious (as a result of paving), and previous rainwater that flowed in sheets becomes channelized.

   Post-development site drainage issues are usually related to flow rates and discharge into the watershed. At this phase of construction, water is usually directed to stormwater retention ponds where the volume of rainwater is released at a standard flow rate. However, even when the prescriptive standards regarding the discharge and flow of water are followed, downstream damages may be caused by stormwater flows which have been converted from multiple sources (non-point discharge) to a single new water retention and discharge system (point discharge). Solutions typically involve improvements to and maintenance of stormwater retention facilities, downstream channel improvements, remediation of damaged property, or a combination of actions. Implementation of these solutions generally involves government entities responsible for the publically owned drainage features and the owners/developers of other properties in the watershed.

2. Infrastructure – Roads and Bridges. The cause of most site claims involving roads and bridges are geotechnical problems (soil and/or foundation settlement and erosion), or roadway surfaces that do not last or perform as intended. Damages typically manifest in settlement, pavement cracks, potholes, and other deformations that disrupt safe driving conditions and accelerate maintenance cycles.

   Solutions for resolving serious conditions typically include the removal of damaged material, the establishment of proper foundation materials, and the replacement of the deficient pavement. Occasionally, redesign is required when the original system is found to be inadequate for the weight and volume of traffic, and erosion or excessive saturations of foundation soils is a cause of the defect. Solutions can involve installation of under drainage systems or modifications to the storm water management system.

3. Infrastructure – Underground Utilities. The causes of most underground utility claims are geotechnical problems such as the excavation of unidentified materials (usually rock), or unanticipated water (dewatering and shoring). As such, they are typically contract-based claims for changed conditions. Trench settlement problems may be caused by similar issues or may be the result of a defect in the compaction. Solutions for these claims may be as simple as compacting the upper portion of existing fill and placing additional controlled fill to establish the proper grade. However, if the back fill placement methods compromised the structural properties of the underground piping or culvert systems, more extensive solutions (including excavation and replacement of the conduit) may be necessary.

4. Site Structures – Retaining Walls, Swimming Pools and Other Below Grade Structures. The primary cause of retaining wall failures is the unanticipated lateral pressure on the fill side

of the wall. The two main sources of such pressure are water (ground water or surface water) not properly intercepted and managed, and surcharge loads occurring within the critical zone. Other causes are deficiencies in the design or construction of the retaining wall, or problems with the soil beneath.

Depending upon the cause and severity of the problem, solutions may be as simple as controlling placement of surcharge loads, drilling moisture relief holes, or the installation of buttresses or tie backs. More severe conditions may require excavation of fill side materials, demolition of the wall, and reconstruction of at least a portion of the wall.

5. Elevated Tanks. Structural deficiencies are the most common causes of failures involving elevated tanks.

III. Building Envelope Failures

A. Description of Commonly Found Envelope Systems

1. General. Building envelope systems consist of roofing, cladding and fenestration components. The envelope system provides the exterior cosmetic appearance, the building weather protection, and a thermal barrier for the interior spaces. Failures in the envelope system can lead to moisture intrusion and excessive air infiltration, causing damage to the building materials, building contents, and building air quality.

2. Roofing Systems. We categorize roofing systems as either low slope or steep slope roofs. For this discussion, roofs with a slope of less than 3 (Vertical) to 12 (Horizontal) are Low Slope. Roofs with slopes greater than 3:12 are Steep Slope. In addition to providing moisture protection, roofing systems must be capable of resisting wind uplift pressures caused by significant wind events such as tropical storms and hurricanes.

Low Slope roofing systems are typically constructed as membrane assemblies. There are many types of membrane assemblies: built-up systems, single-ply membrane systems, and fluid-applied membrane systems among them.

Steep Slope roofing systems typically include either composition shingles, tile (slate, clay of other material), or metal roofs. In some regions of the world, thatch is still found on Steep Slope roofs. Typically, Steep Slope roofs have underlayments of building felts or other moisture barrier material (secondary barrier) to prevent moisture, which breaches the primary barrier (shingles, tile or metal), from reaching the roof decking. Building codes provide prescriptive instructions for underlayment protection on Steep Slope roofs and should be referenced for the applicable jurisdiction.

Exterior decks and balconies located above interior spaces are considered to be roofs for the spaces below them. Thus, the balcony membrane systems and associated components must be designed for weather protection, traffic, and furniture and equipment that will be placed on the decks and balconies.

3. Cladding Systems. Materials used for exterior wall claddings should be cosmetically pleasing while providing the requisite protection from the elements (weather, building thermal differentials, and wind movements). Cladding systems in single and multi-family buildings include horizontal lap siding, brick veneer, stone veneer, and stucco. Cladding systems for commercial applications include stone, precast concrete and metal wall panels.

Stucco claddings continue to form the basis for construction defect litigation and are generally divided into "traditional" cement plaster systems and "proprietary" stucco systems. A traditional cement plaster stucco must meet the prescriptive standards published by the American Society for Testing and Material (ASTM) The ASTM standards are like a recipe that typically set forth exacting materials, design and construction techniques for traditional stucco. A prescriptive standard typically offers little flexibility and does not set for overall goals or objectives like a performance based standard or code.

Proprietary stucco cladding systems are alternative stucco systems that are developed by manufacturers. They differ from the exacting standards of a traditional stucco system, so they must be individually submitted to, and approved by, one or more building code organizations. Exterior Insulation and Finish Systems (EIFS) is one example of a proprietary stucco system. Another example is a “thin coat” system. A “thin coat” system is a cement stucco assembly similar to a traditional cement plaster system, but as the name implies, the requisite thickness is much less than what is required for a traditional stucco system. Like all proprietary systems, these thin coat stucco systems are subject to the code approval process before being placed into the commercial market.

Cladding systems are categorized as being either "moisture-management" or "face-barrier" systems. Moisture-managed claddings feature an external cladding component which has ornamental as well as moisture protective qualities. This exterior cladding is backed by a secondary moisture barrier, which intercepts and removes water that breaches the external cladding barrier. Moisture managed systems include brick, wood and manufactured wood cladding products.

Face-barrier claddings, on the other hand, have a single outboard plane which is designed to prevent moisture intrusion without the need for a secondary moisture barrier behind. Metal, stone and pre-cast concrete claddings are typically designed and built as face-barrier systems: the outside coating is designed. Likewise, early generation EIFS cladding systems were designed as face-barrier systems. While EIFS is still available as a face-barrier assembly, EIFS claddings are now most frequently applied as a moisture-managed assembly with a secondary moisture barrier. The current building codes recognize, after a flood of litigation on the subject, substantial limitations of EIFS face-barrier assemblies and restrict the use of these face-barrier EIFS claddings.

4. Fenestrations. For purposes of this section, fenestrations are intended to be windows, doors, skylights, and other glazing components installed in openings of the exterior wall and roof systems. Glass curtain walls and glass window walls are also considered to be fenestrations. Fenestration elements may be operable (window and doors) or fixed (curtain walls, window wall, fixed skylights and fixed windows). Like other envelope components, the fenestration systems must satisfactorily perform the intended purpose, while providing both weather protection and suitable resistance to wind pressures and building movements.

5. Integration of Envelope Systems. The roof systems, wall systems, fenestration, and various components within the envelope must be properly integrated with one another so as to provide continuity of the envelope. Shortcomings in the integration of these components is a common and significant complaint in construction effect litigation. In roof systems, continuity is provided by such means as coping, flashings, and counter-flashings. In wall systems, flashings and sealants are the most frequently used means of providing weather proofing where dissimilar materials abut one another.

B. Typical Building Envelope Claims

1. General. Construction defect claims involving envelope systems typically arise when the various components are not properly integrated with one another or are subject to wind-caused component displacement. These claims typically involve allegations of negligent design, defective construction, and defective products. Moisture infiltration damages may not be discovered for long periods following the onset of infiltration; they also tend to be cumulative, such that the extent of damage increases with each triggering event. Wind damages are generally discovered soon after the event causing damage.

2. Roofing Systems. Disputed issues related to roofing systems generally involve one or a combination of the following allegations: (a) Negligent Design, (b) Defective Construction, and (c) Defective Products.

   Claims of negligent design typically assert faulty or omitted details for interface conditions such as flashing, or involve allegations that an improper system was selected for the intended application. An example of an improper system selection occurs when a design professional specifies a roofing system which fails to comply with wind uplift resistance for the geographical location and height of the building. Frequent allegations include failure to detail flashing assemblies properly, failure to detail the attachment of the membrane to the structural roof deck properly and failure to detail the attachment of insulation to the structural roof deck properly.

   Claims of defective construction are generally brought alleging faulty workmanship, supervision, and coordination. In addition to claims of defective construction against the general contractor and trade contractors, claims of negligent construction phase services may be brought against the design professional.

   Claims for defective products for roofing systems are generally brought when product history or independent tests provide evidence to support such a claim. A premature wholesale failure of the roofing membrane may be sufficient to initiate a product failure claim.

3. Exterior Wall Systems. The categories of issues disputed in wall system claims are similar to those for roofing systems and involve negligent design, defective construction, and defective products. Claims of negligent design frequently relate to details of interface conditions involving sealant joints, flashings, and wall-to-slab terminations.

Claims of defective construction frequently involve allegations of faulty workmanship, improper sequencing of work, and negligent supervision.

Claims for defective products can and have been asserted against manufacturers of proprietary cladding systems and fenestration components. The impact of class action claims and class action settlements should be considered and evaluated when product defects are at issue. Claims involving face-barrier EIFS claddings and medium density fiberboard (MDF) trim materials are two examples of product defect class actions that continue to be issues in construction defect claims.

Another frequently disputed issue involving wall systems is the suitability of the cladding, cladding back-up structures, and fenestration components to resist the magnitude of wind forces required by the applicable building codes. Window and door systems are tested for design pressure and carry test rating certifications. Defect claims may be asserted against the specifying entity, contractor, and manufacturer when, for example, the window and door systems do not carry the proper test rating certifications.

C. *Causes, Damages and Typical Solutions in Building Envelope Claims*

1. Roofing Systems. For Steep Slope roofs, depending upon the type of membrane system selected, the causes of failure are frequently found to be one or a combination of:

    a) Water infiltration at eaves, rakes or ridges;
    b) Water infiltration around flashings;
    c) Water infiltration at seam folds or at exposed fasteners;
    d) Material displacement by wind (alone or in combination with rain, hail or snow); or
    e) Material displacement by thermal movement due to expansion/contraction.

    For Low Slope roofing systems, depending upon the type of membrane selected, the causes of failure are frequently found to be one or a combination of:

a) Water infiltration through membrane tears;

b) Water infiltration around flashings or counter-flashings;

c) Water infiltration at membrane seams;

d) Water infiltration at coping joints or fastener penetrations;

e) Material displacement by wind (alone or in combination with rain, hail or snow); or

f) Material displacement by thermal movement due to expansion/contraction.

Damages generally associated with roofing claims, in addition to the membrane itself, may involve allegations of:

a) Damaged insulation;

b) Damaged sheathing or substrate decking;

c) Damaged framing; or

d) Damaged interior finishes.

Solutions to roofing deficiencies depend upon the cause and extent of damages. In many circumstances, the solution is simply to correct the cause of infiltration. In other situations, where the underlying damages require repair or replacement, all or a portion of the membrane will have to be removed. Finally, when the cause of damage is the system's inability to resist required wind uplift pressures, remedies include partial or complete removal of the membrane, or the application of ballast to provide the additional uplift resistance needed.

2. Exterior Wall Systems. The cause of water infiltration in face-barrier wall systems will generally be one or a combination of:

   a) Cracks in the cladding material;

   b) Failure of elastomeric sealant joints; or

   c) Leakage through fenestration framing.

For moisture-managed wall systems, the cause of water infiltration beyond the secondary barrier normally will be one or a combination of:

a) Breaches in the secondary barrier material;

b) Reverse weather laps in the secondary barrier material;

c) Faulty rough opening flashings;

d) Leakage through fenestration flashings;

e) Leakage through fenestration framing;

f) Failure of elastomeric sealant joints; or

g) Failure of base flashings.

When cladding components become detached from the building, the causes typically involve an insufficient number or inadequate strength of attachment fasteners. In cases where the cladding is adhered to the substrate, the cause of detachment typically is debonding, caused by inadequate adhesive or degradation of substrate material due to moisture.

Damages generally associated with claims of deficient wall systems typically include:

a) Damaged substrate sheathing;

b) Damaged wall framing; or

c) Damaged interior finishes.

Solutions to exterior wall deficiencies depend upon the cause and extent of damages. In most circumstances, repairs can be accomplished with localized demolition and rework. In cases where the damages are extensive and repetitive, repair solutions may require complete removal and replacement of all or part of the cladding and fenestrations.

IV. Failures of Building Structural Systems

A. Introduction to Typical Building Structural Systems

1. General. Primary structural systems are those that resist the combination of vertical, lateral, and other principal loads applied to the building. Structural systems include the structural framing and barriers, the horizontal diaphragm (floor and roof systems), and the vertical diaphragm (all systems). The structural systems transfer the various loads and provide stability to the structure. For buildings constructed solely of load-bearing walls and diaphragms, these walls and diaphragms comprise the primary structural system.

   Secondary structural systems are those that resist applied loads at discreet areas of the building (floors, walls, etc.) and transfer those loads to the primary structural system. It is common for certain structural elements to be part of both the primary and secondary structural systems. Under circumstances in which a structural element is part of both the primary and secondary structural systems, the element must be designed and constructed to resist the most severe loading condition applicable to each of the separate structural systems.

2. Definition of Structural Failure. A structural element or a structural system is deemed to have failed when that component or system is not capable of safely resisting the various combinations of loads applied to it. Collapse is not necessary for a structural failure, although it is a classic example.

3. Typical Framing and Foundation Systems. A building structure is built from the ground up, but is designed from the top down. The magnitude of loads applied to structural elements increases with each level of the design, from the roof down to the foundation. Foundations, then, are designed and built to transfer the reaction of vertical and lateral loads placed on the building safely onto and into the ground upon which the building sits. Structural systems vary based on the type of construction involved.

Typical structural systems in high-rise construction are frames of structural steel or high-strength reinforced concrete. The foundation systems for these structures are likely to be deep foundations of piling or caissons. Foundation system recommendations for the building structure are generally included as part of predesign geotechnical explorations and accompanying report. Recommendations by the geotechnical firm with respect to design and construction of foundations, and with respect to other conditions of the site (water table influence, soil characteristics, and seismic response factors) usually become a part of the structural design criteria and should be referenced when investigating foundation issues.

For low and mid-rise buildings, structural framing systems may be as described above, or may be constructed of load-bearing walls with vertical and horizontal diaphragms. Horizontal diaphragms usually take the form of floor and roof systems, and are designed to transfer lateral loads to the vertical diaphragms. Walls designed to transfer lateral loads are referred to as shear walls. Not all walls in the buildings would necessarily be shear walls. Bracing may take the place of shear walls for transfer of lateral loads to the vertical diaphragm. Combinations of shear walls and bracing may also be found. Foundation systems for low and mid-rise buildings typically are shallow: spread footings or mat foundations. If the supporting subsoils are inadequate, deep foundations must be used.

In flood prone areas, where habitable living spaces must be placed above the base flood elevation, it is most common to find braced deep foundation systems. Alternatively, the design may call for load-bearing shear walls, built either on deep foundations or on shallow foundations designed to extend below the calculated scour line.

B. Typical Building Structural Claims

1. Structural Collapse. Needless to say, a structural collapse is a serious incident and one which is likely to result in claims against multiple parties. It is not uncommon for serious

injuries or deaths to occur in a structural collapse. When structural collapse occurs, both the design and construction tend to be called into question. If the collapse occurs during construction, the means, methods and techniques of construction (especially shoring and other temporary supports or restraints) are questioned. Fabrication errors and component assembly anomalies are suspect. Investigation to determine the root cause of failure can be extensive, expensive, and time consuming.

2. Non – Collapse Scenarios. Disputes alleging structural failure where no collapse or obvious signs of distress are evident are not unusual. Generally, such disputes arise incidental to some other complaint. In such circumstances, investigators observe conditions which bring the structural element or system into question. Examples of typically disputed issues are provided below:

    a) Wind Resistance of Light Gage Infill Wall Framing. These disputes involve structural issues relating to the attachment of the framing components to the primary framing system, the strength of framing members (especially at framed openings and at high wind regions of the building), the attachment of sheathing materials, the attachment of claddings, and the structural ratings of fenestrations in the wall system.

    b) Wind Resistance of Roof System. Generally, these claims allege that the roof was not designed or constructed to resist the wind uplift pressures required for the building location. The component involved typically includes the roof framing, roof decking, and/or roof membrane. Required wind uplift resistance is established by code.

c) Basement Walls. Cracks or leaks in basement walls spawn claims of inadequate structural integrity. Such conditions should be investigated to determine if they are associated with issues of structural significance.

d) Masonry Walls. Masonry walls may be single wythe or multi-wythe assemblies. The space between multi-wythe masonry walls may remain open (usually for moisture management provisions) or can be filled with grout (collar joint). Multi-wythe masonry walls may be designed to be structurally independent of one another, or they may be designed to perform compositely, with each wythe sharing loads and stresses based upon their relative stiffness. The differing assemblies and conditions exhibiting possible structural issues should be investigated to determine if there are any issues of structural significance.

e) Beams, Girders and Columns. The structural capacity of beams, girders, and columns may be challenged based upon an analysis of load paths. The structural analysis may be conducted in a manner which is different from the structural engineer of record, or can be based upon differences in design protocol. Investigations into any approved structural changes and the current structural capacity should be considered to determine if there are any issues of structural significance.

f) Seismic. Seismic failure typically involves issues that could lead to shear failure, sliding failure or overturning. Shear failure occurs when the bottom of a structure moves during the seismic event, but the top does not. Sliding failure occurs when the structure is not adequately secured to the foundation and slides off its foundation. Overturning occurs when the structure tips over and comes loose from the foundation. Such conditions should be investigated to determine if they are associated with issues of structural significance.

C. Causes, Damages and Typical Solutions in Building Structural Claims

1. Structural Collapse. For a structural collapse that occurs during construction, the cause most often is the means, methods, and techniques employed for the construction. Notwithstanding the preceding, it is critical that the investigator confirm the suitability of the structural design assumptions and construction requirements, which themselves can cause the collapse if they deviate from professional norms. In addition, the shop drawings should be reviewed to confirm that they are compatible with the design.

   For a post-construction collapse, causes are usually found in the construction workmanship or in the structural design. Other causes of post-construction collapses include: (1) change in use or loading conditions without a proper assessment of the building structure; (2) temporary loads which subject structural components to conditions beyond the design conditions; (3) a weather or seismic event beyond the design-rated conditions and (4) prolonged deterioration of structural elements and connections associated with the area of collapse.

   Solutions to a structural collapse usually require removal and reconstruction of the failed systems and damaged property. Depending upon the extent of the collapse, the entire building structural system may have to conform to the most current edition of the applicable building code.

2. Non – Collapse Scenarios. For allegations of structural failure in which collapse has not occurred and is not imminent, an assessment is necessary to determine the structural relevance of the claim. In certain circumstances, temporary shoring or other mechanisms may be necessary while assessments are undertaken.

   In viable claims of non-collapse structural failure, the cause may be design, construction or both. In most cases, remedial actions can be implemented without demolition of the structure, although some demolition may be required to provide access for repairs. Repair techniques vary. For steel elements, cover plating or sister members may be appropriate. For problems of shear and moment at points of support, saddles and other structural fabrications usually are sufficient. For reinforced concrete members, external reinforcements are available. For wood and steel trusses, methods exist which strengthen existing web and chord members and reinforce connections. For wood and glulam members, in-place repair options include epoxy injection, flitch plates, splices and sister members.

V. Failures of Building Mechanical and Electrical Systems

A. Introduction to Typical HVAC, Plumbing and Electrical Systems

Heating, ventilating, and air conditioning (HVAC) systems are designed and constructed to satisfy indoor environmental requirements. For most residential, commercial and institutional buildings, the primary purpose of HVAC systems is to provide for human comfort and health. For many industrial buildings, the HVAC system selection may be driven by operational demands of chemical or manufacturing process operations. HVAC systems are comprised of mechanical equipment to condition and filter the air, and the distribution system to supply and return air to the air conditioning equipment. Electronic and/or pneumatic controls are used to monitor air quality and to control equipment operations.

HVAC equipment can consist of a single, self-contained unit, or may function through various structures, each carrying out one of the basic functions of HVAC systems generally. Depending upon the equipment configuration and function, HVAC equipment may be fueled by electricity, gas, oil or coal. HVAC system designs and equipment selections are based upon the owner's requirements, the desired conditions to be established and maintained, the thermal properties of the building envelope, the fuel supply preferences, and the applicable regulatory standards.

Plumbing systems are designed and constructed for two principal purposes: to provide and distribute potable water within and around the building and to safely remove both solid and liquid wastes generated by the building occupants. Where public or private utility systems exist, the building plumbing systems will typically start at the property line, with connections to the utility company's water meter, and end at the utility company's wastewater collection line. When there is no utility system, the plumbing system will start with the water supply mechanism (usually a well or reservoir) and end with the disposal system (usually a septic tank system).

When natural gas is used within the building, installation of natural gas distribution lines is performed by the plumbing or mechanical trades and is subject to the requirements of the utility company.

The building electrical systems serve two principal purposes: to power equipment and appliances for which electricity is the energy source, and to provide lighting for the safety and convenience of occupants. For most applications, the source of electricity will be a public utility company. The equipment or device that provides the public utility company's electricity to the building is called the "service entrance point". Depending upon requirements for the building, incoming electrical service provided by the utility company will be either low voltage (under 600 volts) or high voltage (over 600 volts). For most residences and many commercial properties, the service entrance point will be the electrical service meter installed by the utility on the building structure. Building electrical systems, then, begin at the secondary side of the service entrance point and include the various panels, transformers, circuits, conduits, cabling, and termination devices necessary to distribute electricity to equipment, convenience outlets, and lighting fixtures throughout the building.

B. Typical Building and Mechanical System Claims

1. HVAC Systems. Disputes involving HVAC systems center on indoor environmental conditions involving comfort or indoor air quality. Such disputes may allege improper (negative) air pressures, which promote the infiltration of spore laden outside air, excessive humidity within the conditioned spaces, improperly sized air conditioning equipment or contaminated duct work. The interaction between HVAC systems and the building envelope features may have significant impact on HVAC system performance and perceived problems with the system. For facilities in which the HVAC systems have a more complex role (such as hospitals, laboratories, and process industries), disputed issues typically involve compartment pressurization, air particulate control, and/or acceptable tolerance ranges for set-point conditions where the differences between published data and field performance of HVAC equipment and distribution systems are questioned.

2. Plumbing Systems. Disputes involving building plumbing systems are relatively infrequent. When they occur, these claims typically involve failed pipe or tubing connections, which produce water damage to the other building components. In public buildings, disputes may also involve plumbing fixture installations that do not conform to regulatory standards, such as those published as part of the Americans with Disabilities Act. For facilities in which the waste stream may include acids or other reactive chemicals, disputes might also involve the suitability of materials used for conveyance of the waste stream.

3. Electrical Systems. Electrical system design and workmanship issues are a frequent component of disputes arising out of building fires. While such disputes generally relate to electrical faults (short circuits), a discussion of fire cause and origin is beyond the scope of this text. In the context of multi-tenant buildings, electrical disputes typically focus on fire safety issues regarding utility penetrations in rated walls, or separation of electrical devices on opposite sides of the demising walls. In more complex structures, disputes typically involve design assumptions for connected loads and diversity factors, design coordination of power data curves, fabrication and assembly of motor control centers, workmanship of power circuits and connections and similar issues which arguably cause equipment damage or performance failure.

C. *Causes, Damages and Typical Solutions in Building and Mechanical System Claims*

1. HVAC Systems. Damages related to HVAC claims may be in bodily injury (typically respiratory) or property damage (typically heat and moisture impact). For industrial processes, HVAC claims may also include elements of lost production, damaged product, and lost sales. The standard causes are typically alleged and include design negligence, workmanship defects, product (equipment) defects, or a combination of these causes. Depending upon size and complexity of the HVAC systems, solutions will vary. Before an effective solution is proposed, it is prudent to determine what external (to the HVAC system) factors may be impacting performance of the system.

   For claims involving general comfort HVAC systems, solutions may be as simple as cleaning duct work, changing filters, adjusting controls, modifying fan speeds, or adding humidity controls. Where HVAC systems are part of a more complex system design, solutions may not be so straight forward and more detailed analyses will be required to determine an appropriate solution. Where building compartmentalization and compartment pressures are critical to performance (as typical for hospitals and biological research facilities), it may be necessary to design or modify existing controls that monitor building pressures and adjust HVAC system performance characteristics as internal conditions change. In order to solve complex HVAC systems anomalies, a detailed engineering analysis in concert with the equipment manufacturer is typically required to assess and develop modifications to, or replacement of the system.

2. Plumbing Systems. In most circumstances, solutions to plumbing system deficiencies are easily identified and implemented. Generally, solutions include the replacement or repair of the defective materials. Where defects are underground and below the building footprint, access costs can be substantial.

3. Electrical Systems. Damages associated with electrical system disputes range from simple property damage to very serious electrical injury or death. In building system disputes, damages associated with electrical systems are generally associated with correction of life safety violations or repair of machinery or equipment. Remedial actions to correct electrical system deficiencies in residential and light commercial construction generally are not extensive or particularly expensive, unless electrical wiring requires complete replacement. In heavy commercial and industrial facilities, where power demands and service voltages require multiple service centers and modulation of the power supplies, solutions can be very complex and expensive, sometime involving substantial shutdown time.

VI. Failures of Building Life Safety Systems

A. Introduction to Building Life Safety Systems

For purposes of this section, building life safety issues are limited to general code provisions for fire resistance of constructed assemblies, building egress, fall protection, fire detection and fire suppression.

Regulatory provisions governing life safety in building design and construction are constantly changing. When evaluating disputes involving life safety issues, it is very important to determine the building code and regulatory standards applicable at the time and place of construction and, if relevant, at the time of subsequent building improvements. It is also important to determine whether or not regulations enacted subsequent to construction impose any retroactive requirements on life safety features applicable to the building.

The resolution of disputes involving violations of life safety regulations can be difficult. Such disputes frequently involve no damages to persons or property, and may not be subject to insurance coverage by policies other than those for professional malpractice.

B. *Typical Life Safety Claims*

1. Failure to Achieve Required Fire Resistance Rating in Assemblies. Roof, wall, floor and ceiling assemblies are subject to building code requirements for fire resistance ratings. Structural framing components of the building are also subject to requirements for fire resistance protection. A fire resistance rating is a measure of the time it takes for a fire of certain intensity (heat) to burn through the protective membrane and subject the adjacent space or structural elements to fire. The intent of fire resistant assemblies is to provide time for occupants exposed to a fire hazard to exist the building safely, and to mitigate fire damage to adjacent building spaces. Fire resistance rating requirements increase as the hazards increase. Hazards are evaluated based upon building use, height, structural system, and proximity to other property.

   Disputes involving the fire resistance rating of building assemblies typically surface when there are other claims of design or construction anomalies. Such disputes typically assert a breach of the rating caused by a discontinuity in the assembly, or a failure to configure the assembly properly for the required fire resistance rating.

2. Failure to Properly Seal Penetrations in Rated Assemblies. Utility systems that penetrate fire rated assemblies are required to be constructed in a manner which does not reduce the fire resistant rating of the wall, floor, ceiling or roof assembly. Where non-combustible pipe and tubing penetrate rated assemblies, fire rated sealants must be used to seal the penetration opening. Where combustible (plastic) pipe and tubing penetrate rated assemblies, intumescent devices or equivalent protective methods should be used to protect the opening. Duct work penetrations, depending upon size and material properties, generally require the use of fire dampers to protect the opening.

   Where utility penetrations through fire rated assemblies are not properly sealed, the rating of the assembly may be compromised. Disputes involving penetration issues typically relate to the extent and severity of the deviations.

3. Failure of Fall Prevention Measures. The building codes provide prescriptive requirements for the location, height and configuration of building elements such as stairs, handrails and guardrails. In addition to dimensional requirements for handrails and guardrails, the codes also impose structural requirements that prescribe minimum strength provisions for both vertically and laterally applied loads. When the prescriptive code provisions are not met, the resulting conditions may be unsafe.

4. Failure of Fire Detection, Alarm and/or Suppression Systems. Depending upon construction type, building use and height, provisions for detecting, annunciating, and suppressing fires vary. A common system is fire detection sensors wired to fire alarm panels, which in turn provide local alarm and remote notification. The fire alarm system also may be programmed to secure fire rated bulkheads, energize smoke relief dampers, deactivate HVAC equipment, position elevator cabs and control other building functions. Water is the most commonly used fire suppressant medium. Fire sprinkler piping and sprinkler heads are

the most frequently used distribution arrangement. For special hazards, foam and gaseous fire suppression systems can be employed. Fire sprinkler designs vary, depending upon the risk classification and environmental conditions existing where the system is installed.

Disputes arise when these systems do not react as planned, or when inadvertent activation damages property or interrupts operations. A frequent cause of disputes is the rupture of sprinkler piping located in unheated spaces.

C. Causes, Damages and Typical Solutions in Life Safety Claims

1. Failure to Achieve Required Fire Resistance Ratings. These conditions are generally caused by a failure to design and to specify the locations at which fire resistant assemblies are to be built, or by a failure to construct the rated assemblies properly. Without a triggering fire event, damages are not likely to be found. Solutions to resolve these conditions will vary by from one specific defect to another. A common remedy is the installation of non-combustible materials to fill wall or ceiling spaces. Ratings also can be increased with additional membrane thickness and spray-on fireproofing. Occasionally, demolition of defective conditions may be necessary to implement a solution.

2. Failure to Seal Penetrations Properly. In most circumstances, these conditions are caused by inattention in the course of construction. The solution typically is remediating the work and installing the proper sealants. Frequently, limited demolition of walls or ceilings may be necessary to access the work to be repaired.

3. Failure of Fall Prevention Measures. These conditions are most frequently caused by the workmanship of the various contractors on-site during the construction phase. For stair systems, these defects frequently involve erection and construction tolerances, which combine to violate prescriptive standards. In many cases, the dimensional violations will be *de minimis* and unrelated to any real hazard. In such cases, no repairs or modifications will

be needed. In other situations, alterations may be necessary to bring the stairs into compliance. For handrails and safety rails, the cause of deficient conditions are most frequently found in the connection of the rail system to the building structure, or the connection of rails to the balusters. The typical solution to these deficiencies is the reinforcement or reconfiguration of the connection details.

4. Failure of Fire Detection, Alarm and Suppression Systems. When sprinkler pipe rupture is caused by freezing conditions, the typical solutions include providing sufficient space heat to prevent freezing temperatures, insulating and heat tracing the sprinkler pipe, and converting to a dry pipe system for lines in the unheated space. Correction of deficiencies in the fire detection and alarm system may be more challenging. Solutions may be as simple as replacing detectors with models better suited for existing environmental conditions, or as complex as tracing the electronics to determine cause and solution.

VII. Index of Typically Referenced Guides and Standards

The following codes, standards, guides and instructions have multiple versions and have changed over time. In addition, this information changes depending on the location of the construction. As such, when referencing such documents you should ensure that the code, standard, guide or instruction was applicable at the time of construction for the location in dispute.

A. Building Codes

The building codes relied upon in construction and subsequent litigation include the following codes, including the predecessor codes for each. The predecessor codes include names such as the Standard Building Code, National Building Code, Uniform Building Code, and the CABO One and Two Family Dwelling Code, and others.

1. International Building Code
2. International Residential Code

3. Local Building Codes and Ordinances – These codes and ordinances vary by jurisdiction and are too numerous to list. The state, county, city, subdivision, and any other local governing body should be referenced to determine what codes have been adopted and implemented for the location of the project in dispute.

B. Industry Organizations

Many organizations publish standards for construction. The following are some examples:

1. ASTM - American Society for Testing and Material.
2. AAMA - American Architectural Manufacturers Association.
3. NRCA - National Roofing Contractors Association.
4. BIA - Brick Institute of America.
5. ASCE - American Society of Civil Engineers
   i. ASCE 7 – Minimum Design Loads for Building and Other Structures
6. AISC - American Institute of Steel Construction
7. ACI - American Concrete Institute
8. NDS – National Design Specifications for Wood Construction
9. AWPA – American Wood Product Association
10. SMACNA - Sheet Metal and Air Conditioning Contractors National Association

C. Product Manufacturers

Many products installed on a structure have specific installation instructions. The installation instructions for the product at issue should be referenced; however, below are some of the common manufacturers whose installation instructions are referenced in construction defect litigation:

1. James Hardie (siding, trim, weather barrier, flashing)
2. CertainTeed (roofing, siding, trim, sheathing, decking, foundation, windows)
3. Pella (windows and doors)
4. Anderson (windows and doors)
5. DuPont (weather barriers, flashing systems, attic wrap, roof liners)
6. Owens Corning (roofing, masonry, windows, insulation, stone)