THE LAW OF CONSTRUCTION DEFECTS AND FAILURES

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CHAPTER ONE

DEFINING CONSTRUCTION DEFECTS AND FAILURES

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DEFINING CONSTRUCTION DEFECTS AND FAILURES

I. Characteristics of a "Defect" and a "Failure"

A. *General Definition of Defect and Failure*

In the context of the construction industry, there is no one universally accepted definition of a construction "defect" or "failure." As between the two terms, it would seem that a "failure" implies something of a greater magnitude than a mere "defect." A failure of a building can range anywhere from the failure of a discrete part or a building system such as its heating, ventilation and air conditioning (HVAC) system to a complete structural failure resulting in the collapse of the building. Likewise, a defect can be minor or major. Other terms often used interchangeably with defect in the construction industry include "deficiency," "nonconformity," "deviation," and "fault." Relatively speaking, it is fair to note that a defect may be the cause of a failure. Thus, in terms of causation, a defect may at times properly be viewed as the root, or technical, cause of a failure. However, not all failures are the result of defects. In the absence of a defect, a failure may be caused by other factors such as extreme naturally occurring forces like an earthquake or tsunami.

Each party to a construction project may view a "defect" or "failure" differently, depending on each party's perspective or said in another way, from where each is located in the project's contractual "food chain." For example, in the traditional design-bid-build project delivery method, an owner (at the top of the chain) may consider any difference between a project's plans and specifications and the as-built condition to be a "defect," no matter how small or trivial. Similarly, an owner may consider any deviation from expected performance a "failure," even if it is easily remedied or does not substantially affect project performance. On the other hand, contractors and engineers (usually one step removed from the owner in the chain) would not expect absolute perfection in a completed structure and would expect the owner to accept some deviations from the plans and specifications short of perfect performance. Equipment and material suppliers, sub-consultants, subcontractors and others at various tiers in the food chain may have similar or different perspectives. Third parties completely outside of the contractual food chain may be impacted by a defect or failure and have a completely different perspective as well as rights. The divergence of these views may lead to disputes between and among the parties.[1] Nevertheless, various applicable legal principles strive to balance and harmonize such perspectives in a fair and just manner. These disputes may end up in the cauldron of dispute resolution (e.g., mediation, arbitration and litigation) creating a troubling witches brew of uncertainty, time-consuming exhaustion of valuable resources and cost.

General definitions of these terms may be found in Merriam-Webster's dictionary, which define "defect" as "an imperfection that impairs worth or utility" or "a lack of something necessary for completeness, adequacy, or perfection."[2] The dictionary defines "failure" as "an omission of occurrence or performance," "a state of inability to perform a normal function," or "a fracturing or giving way under stress."[3] Additional factors must be considered to determine whether a condition is a defect or a failure that would result in legal liability.

1. ***Defects***

Some state courts have defined what constitutes a "defect" under their state law, but Pennsylvania courts have not.[4] Factors that may be considered to determine whether a condition is a "defect" that would result in legal liability include:

a. The standards applicable to the construction, such as building codes, industry standards, written contracts, etc.;

b. The degree of deviation from any applicable standard, and the resulting impact from that deviation;

c. The cause of the condition, whether it is a result of the construction process (defective design, poor workmanship, faulty materials, etc.) or factors outside the control of the contractor or design professional (such as poor maintenance on the part of the owner, weather phenomenon, etc.); and

d. Whether the condition needs to be repaired.[5]

Consideration of these factors will often involve expert testimony.[6]

2. ***Failures***

The American Society of Civil Engineers (ASCE) Technical Council on Forensic Engineering has defined "failure" as "an unacceptable difference between expected and observed performance."[7] This definition includes catastrophic structural collapse, but also includes performance problems that are not necessarily catastrophic or life-threatening, including "serviceability problems such as distress, excessive deformation, premature deterioration of materials, leaking roofs and facades, and inadequate interior environmental control systems."[8] In the event of a significant failure, the parties typically retain experts to determine the cause of the perceived failure. Occasionally a failure results from a single condition, but typically, failures result from a combination of mistakes, oversights, miscommunications, misunderstandings, ignorance, lapses, slips, incompetence, intentional violations or noncompliance, and inadequate quality assurance. The causes for these conditions vary, but may include simple mistakes (such as sending information to a structural engineer when it should have been sent to the architect), conclusions based on faulty assumptions, an employee's "laziness, ignorance, or malevolent urge," fatigue from excessive workload, inadequate training, "time boxing" practices used to minimize fees to a client, overreliance on computer-aided design and drafting (CADD), failure to understand and deliver client requirements, time pressures to deliver a project by certain deadlines, and ineffective coordination and integration of the design team.[9]

Some contracts provide for specific performance guarantees such as turnkey design-build contracts which in industrial construction are often referred to as engineering, procurement and construction (EPC) contracts. Generally, the contractor guarantees that the project will be able to produce a specified quantity and quality of product under certain defined conditions. Whether the performance guarantees are met is generally determined during the running of a defined performance test. If passed 100%, then the contractor has fulfilled its performance guarantees. If performance is less than 100% but greater than a minimum guaranteed level of performance, say 90%, the contractor has the option to make changes to the project at its cost to increase the level of performance or to pay liquated damages to the owner. Performance below the minimum guaranteed level is deemed a failure and the contractor is required at its cost to make any and all changes to increase the level of performance to be at least equal to the guaranteed minimum. This is often referred to as a "make good" guarantee.

As in the case of nearly all written construction contracts, a general warranty that the work will be free from defects will invariably be included in a contract providing for performance guarantees.

B. *Defects, Failures and Warranty Obligations*

Defects and failures are customarily addressed in connection with a contractor's warranty obligations. Black's Law Dictionary defines "warranty" as "an express or implied promise that something in furtherance of the contract is guaranteed by one of the contracting parties."[10] Additionally, Black's Law

Dictionary defines “construction warranty” as “a warranty from the seller or building contractor of a new home that the home is free of structural, electrical, plumbing, and other defects and is fit for its intended purpose.”[11] Warranties may be express or implied.

1. ***Express Warranties***

A contractor and owner normally agree to specific warranty language in their written contract. The following are slightly modified examples of actual General Warranties provided for in two different turnkey engineering, procurement and construction (EPC) contracts:

Example 1:

Contractor expressly warrants to Owner as follows:

a. the Work shall meet all of the requirements set forth in this Contract;

b. the Production Facilities shall be of good quality in every aspect and **free from defects** in title, design, engineering, materials, construction and workmanship;

c. the Work shall meet all Governmental Requirements; and

d. all Materials, Equipment, Spare Parts and supplies furnished by Contractor or its Subcontractors of any tier shall be new, of good quality and suitable for the purposes and uses intended, and **free from all defects** in title, material or workmanship.

Example 2:

> Contractor represents and warrants that it is and will remain qualified and capable of performing the Work to complete the Project in accordance with the terms of this Agreement. Contractor warrants that services provided and procedures followed by Contractor hereunder shall be in accordance with the manufacturer or vendor’s warranty requirements, and GAEP.[12] Contractor further warrants that the Work, including each item of Equipment and other items furnished by Contractor, shall be new, the materials of construction meet or exceed industry standards be

> of the kind and quality described in this Agreement, shall be **free from defects** in design, engineering, materials, construction, workmanship, shall be of good and marketable title, free and clear of any liens, claims, charges, security interests, encumbrances and rights of other persons, and shall conform with applicable Laws and Governmental Authorizations, the Specifications, Scope of Work and this Agreement. Contractor further warrants that all utilities, pumps, tanks, piping and control systems are adequate to support the equipment and performance guarantees of the equipment suppliers as originally specified and supplied.

Several industry groups provide forms containing warranty provisions between a contractor and owner. Some examples of such form warranties include the following:

The American Institute of Architects (AIA), A201 "General Conditions of the Contract for Construction," at Article 3.5.1:

> The Contractor warrants to the Owner and Architect that materials and equipment furnished under the Contract will be of good quality and new unless otherwise required or permitted by the Contract Documents, that the Work will be **free from defect** not inherent in the quality required or permitted, and that the Work will conform to the requirements of the Contract Documents. Work not conforming to these requirements, including substitutions not properly approved and authorized, may be considered defective.

The Associated General Contractors of America (AGC), ConsensusDOCS 200, "Standard Form of Agreement and General Conditions Between Owner and Contractor," at ¶ 3.8:

> 3.8.1 Contractor warrants that all materials and equipment shall be new unless otherwise specified, of good quality, in conformance with the Contract Documents, and **free from defective workmanship and materials**. At the Owner's request, the Contractor shall furnish satisfactory evidence of the quality and type of materials and equipment furnished. The Contractor further warrants that the Work shall be **free from material defects** not intrinsic in the design or materials required in the Contract Documents. The Contractor's warranty does not include remedies for defects or damages caused by normal wear and tear during

normal usage, use for a purpose for which the Project was not intended, improper or insufficient maintenance, modifications performed by the Owner or Others, or abuse. The Contractors' warranty pursuant to this Paragraph 3.8 shall commence on the Date of Substantial Completion.

Engineer's Joint Contract Documents Committee (EJCDC), Doc C-700, at ¶ 6.19:

Contractor's General Warranty and Guarantee

A. Contractor warrants and guarantees to Owner that all Work will be in accordance with the Contract Documents and **will not be defective**. Engineer and its officers, directors, members, partners, employees, agents, consultants, and subcontractors shall be entitled to rely on representation of Contractor's warranty and guarantee.

B. Contractor's warranty and guarantee hereunder **excludes defects** or damage caused by:

1. abuse, modification, or improper maintenance or operation by persons other than Contractor, Subcontractors, Suppliers, or any other individual or entity for whom Contractor is responsible; or

2. normal wear and tear under normal usage.

C. Contractor's obligation to perform and complete the Work in accordance with the Contract Documents shall be absolute. None of the following will constitute an acceptance of Work that is not in accordance with the Contract Documents or a release of Contractor's obligation to perform the Work in accordance with the Contract Documents:

1. observations by Engineer;

2. recommendation by Engineer or payment by Owner of any progress or final payment;

3. the issuance of a certificate of Substantial Completion by Engineer or any payment related thereto by Owner;

4. use or occupancy of the Work or any part thereof by Owner;

5. any review and approval of a Shop Drawing or Sample submittal or the issuance of a notice of acceptability by Engineer;

6. any inspection, test, or approval by others; or

7. any correction of defective Work by Owner.

Construction Owners Association of America (COAA), Document B-300 – GC/CM, at ¶ 13.2:

> Express Warranties And Guarantees – Contractor. In addition to the warranties and guarantees set forth elsewhere herein, the Contractor expressly warrants and guarantees to the Owner:
>
> (i) that the Work complies with (a) the Construction Documents; and (b) all applicable laws, statutes, building codes, rules and regulations of all governmental, public and quasi-public authorities and agencies having jurisdiction over the Project;
>
> (ii) that all goods, products, materials, equipment and systems incorporated into the Work conform to applicable specifications, descriptions, instructions, drawings, data and samples and shall be and are (a) new (unless otherwise specified or permitted) and **without apparent damage or defect**; (b) of quality equal to or higher than that required by the Construction Documents; and (c) merchantable;
>
> and
>
> (iii) that all management, supervision, labor and services required for the Work shall comply with this Contract For Construction and shall be and are performed in a workmanlike manner.

Design-Build Institute of America (DBIA), Document 535, at ¶¶ 2.2.1, 2.9.1:

> 2.2.1 Design-Builder shall, consistent with applicable state licensing laws, provide through qualified, licensed design professionals employed by Design-Builder, or procured from qualified, independent licensed Design Consultants, the necessary design services, including architectural, engineering and other design professional services, for the preparation of the required drawings, specifications and other design submittals to permit Design-Builder to complete the Work consistent with the Contract Documents. Nothing in the Contract Documents is intended or shall be deemed to create any legal or contractual relationship between Owner and any Design Consultant.
>
> 2.9.1 Design-Builder warrants to Owner that the construction, including all materials and equipment furnished as part of the construction, shall be new unless otherwise specified in the Contract Documents, of good quality, in conformance with the Contract Documents and **free of defects in materials and workmanship**. Design-Builder's warranty obligation **excludes defects** caused by abuse, alterations, or failure to maintain the Work by persons other than Design-Builder or anyone for whose acts Design-Builder may be liable. Nothing in this warranty is intended to limit any manufacturer's warranty which provides Owner with greater warranty rights than set forth in this Section 2.9 or the Contract Documents. Design-Builder will provide Owner with all manufacturers' warranties upon Substantial Completion.

Upon close review of the above warranty provisions, what becomes clear is that they do not define the term "defect" and do not employ the use of the term "failure." What they do have in common is that they generally warrant the project will be **"free from defects."**

2. ***<u>Implied Warranties</u>***

In addition to express warranties contained in the contract between the contractor and owner, the law also provides for certain implied warranties. The primary implied warranties are the warranty of habitability, the warranty of fitness for purpose and the warranty of workmanlike construction. The implied warranty of habitability applies to residential construction, and the warranty of fitness for purpose applies to non-residential construction.[13] The implied warranty of workmanlike construction applies to all construction.[14]

The Pennsylvania Supreme Court has explained the underlying policy and defined the warranty of habitability (which is often intertwined with the implied warranty of workmanlike construction):

> [O]ne who purchases a development home ... justifiably relies upon the skill of the developer that the house will be a suitable living unit.... [T]he builder-vendor impliedly warrants that the home he has built and is selling is constructed in a reasonably workmanlike manner and that it is fit for the purposes intended – habitation.[15]

Examples of defects or failures that Pennsylvania courts held to breach the warranty of habitability include: a leaky, continually flooding basement, a cracked and leaking foundation, and an improper drainage system causing mold, mildew and odor throughout a house.[16]

The implied warranty of workmanlike construction has also been generally defined by commentators as the contractor's duty "to provide work that is of good quality, **free from defects**, and in conformance with the contract documents."[17] Pennsylvania courts have held that "[u]pon executing a construction contract, a contractor impliedly warrants that the construction work will be performed in a reasonably workmanlike manner."[18] Examples of work that Pennsylvania courts have held have not been done in a reasonably workman like manner include: stairs that had "appreciable separations, [were] not properly supported or braced, and [were] erected at a tilt"; patio pillars on which the caps had become dislodged, that had been set at a "marked tilt" and that had visible gaps between the top of the flagstone and bottom of the pillars; and the use of undersized wire nuts in an electrical system, which fell off, allowing the exposed wires to short and cause a fire.[19]

In the context of non-residential construction, Pennsylvania courts apply the implied warranty of fitness for purpose, which requires contractors (and design professionals upon whom the contractor relies for drawings) to "perform with reasonable care the duties for which he contracts, and that when called upon to prepare plans and specifications which will give the structures so designed reasonable fitness for its intended purpose, he impliedly warrants them sufficiently for that purpose."[20] An example of a defect that may be a violation of the implied warranty of fitness for purpose is when granite panels on the exterior of an office building were slipping, requiring the anchorage system and granite panels to be repaired or replaced.[21]

Implied warranties may be waived by "clear and unambiguous language in a written contract" that is "understandable and sufficiently particular" to provide adequate notice to the buyer of the warranty protections he is waiving.[22] To give "proper notice," the disclaimer must convey its impact on certain latent defects.[23] Any interpretation of waiver language will be construed against the contractor.[24] Implied warranties are customarily waived by owners in written construction contracts in the private sector.

Like express warranties, implied warranties seem to warrant a project to be **"free from defects."** The implied warranties in construction projects are discussed by the courts in relation to various standards such as "workmanlike manner" and "reasonable care" in order to achieve the project's objective of "reasonable fitness for its intended purpose." These standards and objective assist in judging whether a project contains "defects" or is a success or "failure."

C. *Summary of Defects and Failures Definitions*

It can be concluded that there is no one definition of the term "defect" in the construction industry. Perhaps the most helpful definition comes from its plain meaning set forth in the dictionary as "an imperfection that impairs worth or utility" or "a lack of completeness, adequacy, or perfection."[25] From the owner's perspective, a defect in the work means that it didn't get what it paid for – a project **"free from defects."** Whether a particular feature of a project amounts to a "defect" must be judged against various standards from which relevant questions can be formulated such as was the construction performed in a reasonable workmanlike fashion, was the design performed with reasonable care, does the alleged defect need to be repaired, replaced or redone, does it reduce the value or utility of the project, does it comply with applicable codes and industry standards and norms and does it comply with the contract documents. The answers to the majority of these questions must come from experts in the industry. In the end, the ultimate question that must be answered is whether the alleged defective condition is "acceptable" or not under the applicable standards and circumstances.

The term "failure" can be seen more as the "result" of some condition. That condition may or may not be a construction defect. In the absence of a defect, the cause of a failure may be due to naturally occurring events such as an earthquake or intentional wrongdoing such as terrorism. In its broadest sense, the ASCE definition of a failure may be the most instructive: "an unacceptable difference between expected and observed performance."[26]

Causes of, and the varying types of, defects and failures will be discussed further in **Chapter Two** below.

II. Legal and Practical Consequences of Defects and Failures

A. *General Legal Consequences*

We are all familiar with the old saying that "only two things in life are certain, death and taxes." You can add a third when talking about construction defects and failures, "lawsuits." In today's construction industry, the concept of a lawsuit where a dispute is tried before a judge and jury has expanded exponentially to embrace a myriad of alternative dispute resolution methods, including binding arbitration, non-binding mediation, executive dispute meetings, dispute boards, mini-trials, expert determination and so on. All of these alternative dispute methods are intended to resolve disputes over construction defects and failures faster, with less cost and with more predictable outcomes. Generally speaking, these alternative dispute resolution methods are less formalistic, less legalistic and more practical, involving independent third parties like mediators and arbitrators who have a great deal of experience with the construction and engineering industry and dispute resolution.

As mentioned earlier, various legal principles have developed over time to define the parties' rights and obligations with respect to construction defects and failures. Those principles will be discussed in some detail in **Chapter Three** below. Generally speaking, however, the parties' rights, obligations and remedies derive from their contracts, applicable statutes and the common law as formulated by judicial opinions. Theories of legal liability are often predicated on claims of breach of contract (e.g., breach of warranty), negligence (e.g., negligent design) and violation of statute (e.g., building codes). Often, the parties' legal rights, obligations and remedies with respect to construction defects and failures are dependent on the type of injury suffered. Broadly speaking, the law draws a distinction between injuries that are solely economic in nature from those that involve personal injury and property damage. An example of a solely economic injury would be a defect that requires a piece of equipment (e.g., a broken pump) to be repaired or replaced. The only injury here is economic, the cost to repair or replace the pump. No one has been injured and no property other than the pump itself has been damaged. Assuming that a breach of contract has occurred, the owner would have a simple claim against its contractor for the cost to repair or replace the pump. The contractor in turn has a claim against its supplier for supplying a defective pump. However, the contractor's claim in addition to being predicated on the terms of its purchase order will be governed by the Uniform Commercial Code (UCC), which as enacted in all 50 states is comprised of a series of statutes governing the sales of goods, as opposed to the common law which governs service contracts such as construction contracts. Thus, the rights and obligations between the owner and the contractor may not parallel those as between the contractor and its supplier. This scenario can change dramatically if the pump also causes personal injury or damage to property other than the pump.

Instead of a defect that simply causes the pump not to perform its function, let's say that the defect also caused the pump to explode injuring an operator and a passerby. Let's also say that pieces from the pump flew across the room and damaged a tank by penetrating its metal shell releasing a corrosive liquid which in turn damaged the floor covering material. Now you can posit the quintessential law school question: What are the parties' relative legal rights, liabilities and remedies? Without going into an overly detailed legal analysis, a few observations based on this expanded fact pattern may provide some insight into the law relating to defects and failures. The owner still has a claim for breach of contract against the contractor for installing a defective pump that must be repaired or replaced and the contractor has a breach of contract claim against its supplier.

Because the pump explosion also caused personal injury and property damage, a series of tort claims (not requiring the claimants to have a contract with any party) are presented. For instance, the operator and the passerby would have potential claims for personal injury against the owner, the contractor, the engineer and the supplier based on theories of negligence. The supplier that manufactured the pump and placed it in the stream of commerce may be held "strictly liable" if the product contained a defect determined to render the pump "unreasonably dangerous." The owner would have similar tort claims in negligence and strict liability for damage to its property other than the pump itself (i.e., the tank and the floor covering). Add to this the fact that there can be a myriad of cross-claims and defenses by and among the parties and you get the idea that construction defect and failure dispute resolution can get real complicated real fast and we haven't even discussed the different types of insurance policies that would surely come into play in our hypothetical pump case. Insurance will be discussed more fully in **Chapter Four**. Available insurance proceeds often hold the key to settlements prior to trial or other methods of dispute resolution such as arbitration.

B. *Three Case Studies*

Some construction projects are cast before the public eye for a variety of reasons, some good and some not. For instance, the Boston, Massachusetts infrastructure project commonly referred to as the "Big Dig" caught the public's attention for a host of reasons. It was the largest public works project in the history of the United States, it lasted nearly 20 years, it cost nearly $15 billion, it represented a marvel of engineering and construction achievement and it was mired in local, regional and national politics. Given the magnitude of the Big Dig, it will not come as a surprise to anyone that several construction defects and failures were encountered during the course of the project. The nightmare scenario for any project is that a construction defect or failure results in the loss of human life. Unfortunately, that occurred toward the end of the Big Dig project on July 10, 2006 when a series of large ceiling tiles collapsed in the I-90 Connector Tunnel killing a passenger in an automobile traveling eastbound towards Logan International Airport.

Other projects have become notorious where a construction defect and resulting failure resulted in the loss of human life. Perhaps the most studied project defect and failure was the 1981 Kansas City Hyatt Regency Skywalk Collapse which resulted in 114 deaths and more than 200 injured people. More recently, the August 1, 2007 collapse of the I-35W Highway Bridge in Minneapolis, Minnesota resulted in 13 deaths and more than 100 injured people.

A brief review of these three projects and their associated defects and failures will enable us to identify some relevant observations, practical conclusions and lessons learned with respect to our central topics.

1. 1981 – Kansas City Hyatt Regency Skywalk Collapse

Volumes have been written about this tragedy. It represented the largest loss of life resulting from a construction defect and failure in the history of the United States. All the details regarding the defect and failure leading to the skywalk collapse are beyond the scope of this paper. However, a high level summary is instructive to our topic.

The most detailed investigation into the technical cause of the failure is contained in the May 1982 report prepared and published by the National Bureau of Standards (NBS Report).[27] The collapse occurred on July 17, 1981, approximately one year after the hotel had opened to the public. The hotel was made up of three sections: a function block (containing conference rooms, a ballroom, health club, etc.) and a 35 story high rise (containing hotel rooms) separated by a four-story high, 120 foot long column-free atrium. The function block and the high rise were connected by a system of walkways on the second, third and fourth floors. The collapse involved the second and fourth floor walkways that were suspended from the atrium roof framing with the fourth floor walkway hanging directly above and parallel to the second floor walkway.

The original construction drawings, as approved by the local building authority, showed both the second and fourth floor walkways being suspended from the same continuous rods attached to the atrium roof framing. The rods were shown to run through box beams located under and perpendicular to the walkways with the loads of the walkways being transferred to the rods at the beam connections. While the rods carried the loads of both walkways, the box beam connections only carried the loads of one walkway.

During construction, the steel fabricator prepared shop drawings changing the suspension system from a single continuous rod to two interrupted rods – one rod running from the atrium roof framing and connecting to the box beam under the fourth floor walkway and a separate rod running from the same fourth floor box beam through to the box beam under the second floor walkway. This change from a single to double rod system represented the as-built condition and had the effect of doubling the load on the upper rod box beam connection at the fourth floor walkway. In essence, this connection now carried the loads of both the fourth and second floor walkways.

The NBS Report concluded that "the most probable cause of failure was insufficient load capacity of the box beam-hanger rod connections."[28] It was observed that the "fourth floor to ceiling hanger rods had pulled through both the bottom and top flanges of each box beam in the fourth floor walkway…."[29] There seems to be little if any debate over the technical or root cause of the failure as set forth in the NBS Report.

Nevertheless, there was considerable debate over who had "designed" the defective connection, why it was "designed" with insufficient load bearing capacity and who was "responsible" for the defective design. While the relevant case law and literature contains much debate over these issues, the simple answer to the first two questions appears to be that the connection was never "designed" because no one ever calculated the load bearing capacity of the connection prior to the failure. The engineer of record (EOR) and the steel fabricator each "assumed" incorrectly that the other had "designed" the connection.[30]

The question of who was "responsible" for the design of the failed connection was answered by the Missouri courts interpreting Missouri's professional licensing statute. In this case, the EOR had placed his stamp on the drawings for the project. The licensing board started legal proceedings against the EOR to revoke his license. The EOR argued that it was custom and practice in the industry for the steel fabricator to design the type of connection at issue. The EOR's license was revoked on a finding of gross negligence and the EOR appealed from the decision. On appeal, the court held that "[t]he structural engineer's duty is to determine that the structural plans which he designs or approves will provide structural safety because if they do not a strong probability of harm exists."[31] Rejecting the EOR's argument that he was not responsible for the design of the connection because custom in the industry placed that responsibility on the fabricator, the court held that:

> Design of connections is, under the [licensing] statute, a matter for which the engineer is responsible. Custom, practice, or "bottom line" necessity cannot alter that responsibility.[32]
>
> That Chapter [licensing statute] imposes on engineers a non-delegable responsibility for projects to which he affixes his seal.[33]

Thus, the appellate court upheld the revocation of the EOR's license and all but one of the related sanctions imposed by the licensing board.

One article on the Hyatt collapse attributed fault not so much on the technical cause of the failure but to human errors:

> The 1981 Kansas City Hyatt walkway collapse did not happen as a result of innovative design, construction, or material use, but rather as a result of the accumulation of project management errors that together allowed a fatal construction detail flaw to be installed into the support system of the sky-bridges crossing the hotel atrium.[34]

In addition to the license revocation of the EOR, the fallout from this tragedy included numerous lawsuits that were eventually settled for tens of millions of dollars,[35] the EOR was suspended from the ASCE by its board for a period of 3 years,[36] a revision to the ASCE Code of Ethics recognizing that engineers shall "hold paramount the health, safety and welfare of the public," a grand jury investigation that ended without the filing of criminal negligence charges,[37] and a continuing debate as to where the line is to be drawn between construction and engineering.[38]

2. 2006 – Big Dig and the I-90 Connector Tunnel Ceiling Collapse

The entire story of the Big Dig would fill volumes and therefore is also beyond the scope of this paper. Two series of events, however, are particularly pertinent to the topic of construction defects and failures.

The first series of events relates to what became known as the Big Dig's "cost recovery program." "In general, 'cost recovery' is the process by which 'public and private owners file claims against design and construction management professionals for the costs claimed to be attributable to errors, omissions, or other 'deficient' or unsatisfactory performance…."[39] These types of professional errors often manifest themselves as construction defects and failures. The Big Dig's cost recovery program began in 1994 and took a variety of forms over the years. In the beginning, the program was implemented by representatives of the project owner with the assistance of its private sector project manager. The project manager's duties included (i) performing preliminary section designs to the level of detail necessary (approximately 20 to 25%) for an outside section design firm to complete the final design, (ii) design management to coordinate all design disciplines, and (iii) construction management, including administration of the project's change process. As of August 2000 when the project was estimated to have a cost at completion of more than $14 billion, the project cost recovery program had recovered only about $30,000 leading the Inspector General for the Commonwealth of Massachusetts to suggest that the program was "ineffective."[40] The Inspector General also suggested that the project manager had a conflict of interest when it came to identifying professional errors and omissions since it was largely responsible for providing the professional services required for the project, or more graphically described as the proverbial "fox watching the hen house."[41]

In 2003, the public owner turned the cost recovery program over to a retired family court judge who initiated several lawsuits, including one against the project manager seeking recovery of $150 million. Legislation was passed in 2003 extending the time for the Commonwealth or the United States to file any action arising out of the "planning, design, management or construction" of the Big Dig project to 10 years from the date that the cause of action accrued or from the effective date of the legislation, whichever is the later, even if the action had already lapsed or was otherwise time barred.[42] By 2005, the retired-judge initiated cost recovery program had cost $8 million and recovered only $4 million.[43] In February 2005, the cost recovery program was shifted to the Attorney General for the Commonwealth of Massachusetts. Other state and federal agencies began investigation into construction defects such as tunnel leaks, including a criminal probe by the United States Attorney's Office in Boston.[44] By mid-2006, it was reported in the local papers that the Attorney General was about to enter into a settlement with the project manager for all cost recovery and related issues for approximately $90 million. Everything, however, was about to change as a consequence of a second, tragic series of events.

At approximately 11:00 pm on Monday, July 10, 2006, a passenger car occupied by a husband and wife was traveling eastbound through the I-90 Connector Tunnel heading for Logan International Airport. Toward the end of the tunnel, the tunnel ceiling tiles collapsed on the car killing the wife while the husband escaped with minor injuries. Approximately 26 tons of concrete and suspension material fell onto the car and the roadway.[45] The National Transportation Safety Board (NTSB) investigated the accident and concluded:

> The [NTSB] determines that the probable cause of the July 10, 2006, ceiling collapse in the D Street portal of the Interstate 90 connector tunnel … was the use of an epoxy anchor adhesive with poor creep resistance, that is, an epoxy formulation that was not capable of sustaining long term loads. Over time, the epoxy deformed and fractured until several ceiling support anchors pulled free and allowed a portion of the ceiling to collapse.[46]

The NTSB laid blame for the use of an unsuitable epoxy at the feet of several project participants:

> Use of an inappropriate epoxy formulation resulted from the failure of [the section design consultant] and [the project manager] to identify potential creep in the anchor adhesive as a critical long-term failure mode and to account for possible anchor creep in the design, specifications, and approval process…. The use of an inappropriate epoxy formulation also resulted from a general lack of understanding and knowledge in the construction community about creep in adhesive anchoring systems. In addition, [the supplier] failed to provide [the owner] with sufficiently complete, accurate, and detailed information about the suitability of … [its] Fast Set epoxy for sustaining long-term tensile loads. Contributing to the accident was the failure of [the supplier] to determine that the anchor displacement that was found in the [HOV] tunnel in 1999 was a result of anchor creep due to the use of [its] Fast Set epoxy, which was known by [the supplier] to have poor long-term

> load characteristics. Also contributing to the accident was the failure of [the general contractor] and the [project manager], subsequent to the 1999 anchor displacement, to continue to monitor anchor performance in light of the uncertainty as to the cause of the failures. The [owner] also contributed to the accident by failing to implement a timely tunnel inspection program that would likely have revealed the ongoing anchor creep in time to correct the deficiencies before the accident occurred.[47]

A brief summary of the background to the tunnel ceiling design and construction is a useful aid to understanding the NTSB's blame assessment for the accident. Although the section design consultant (SDC) originally wanted to use undercut anchors in the concrete tunnel roof to support the suspended ceiling, this was vetoed by the project manager because of problems allegedly encountered with the installation of undercut anchors earlier in the project by another contractor.[48] As an alternative to undercut anchors, the SDC specified in its performance-based specifications that the contractor was to "[p]rovide [a] chemical adhesive type anchor system to anchor [the] support system to [the] concrete structure" using an "adhesive consisting of [a] 2 component (plastic resin and catalyst hardener) mixture [i.e., epoxy]."[49] The adhesive supplier chosen by the contractor had two epoxy formulations, a fast set and standard (or slow) set. The supplier had test reports indicating that both formulations had been subjected to "creep" tests with the standard set passing and the fast set failing.[50]

The supplier's literature, which identified both of its epoxy formulations, was included in the contractor's submittals for the SDC's review and approval. The submittals did not identify which epoxy formulation (fast or standard set) was to be used for the ceiling support system. However, the contractor's fourth submittal contained materials that stated the supplier's fast set epoxy formulation was to be used only for "short term loads." Nothing in the contractor's submittals, including the epoxy supplier's materials and literature, specifically addressed the issue of creep. The SDC eventually approved the contractor's submittals, but none of the approval documentation identified which of the supplier's epoxy formulations (fast or standard set) had been approved for use in the tunnel.[51] Each installed adhesive anchor was to be proof tested at 125% of their design service load.[52] The actual epoxy supplied and used for the adhesive anchors in the tunnel was the fast set formulation.[53]

In August 1999, the contractor installed a mock-up of the ceiling using the adhesive anchor system. By October 1999, the contractor reported that some of the anchors used for the mock-up had begun pulling out of the concrete roof of the tunnel even though they had been properly installed and successfully tested. The obvious question to be answered was: if the anchors were properly installed and successfully tested, what was causing them to pull away from the concrete in which they were embedded. An investigation, which included the contractor, the supplier, the project manager and the SDC, ensued to answer this question.[54]

Remarkably, the investigation was closed in January 2001 without ever answering the key question of why the anchors in the mock-up had pulled away from the concrete, even though the design manager for the project manager in an internal email commented:

> You've noted the key piece of information that is missing from the [contractor's] package [addressing the mock-up failure]. That is the cause of the anchor failure and how the repair procedure will overcome that. I'll accept the fact that a single reason cannot be given with certainty, but an educated assessment made of probable causes and a description of how those are being prevented by the reinstallation procedure can be presented…. **We are not trying to hold up construction, we are trying to make a determination that the installation is safe and functional.**[55]

And, in a reply email, a structural engineer for the project manager stated:

> Glaringly absent from … [the contractor's deficiency report] is any explanation why the anchors failed and what steps are proposed to ensure that this problem does not reoccur.[56]

Even more remarkably, the supplier remained silent about creep as a possible, if not probable, cause of the mock-up failure when it **knew**: that it had supplied the contractor with its fast set epoxy formulation; that this formulation had failed creep tests in the past; and that this formulation was to be used only for "short term loads" and was not suitable "to resist long-term deformation" as was its standard set formulation. If you think that the supplier's **silence** was **criminal**, you would be correct. Following the accident, the supplier was indicted by the Massachusetts Attorney General and charged with manslaughter.

The NTSB mostly exonerated the contractor from responsibility for the accident because it was largely caused by the design team and the supplier. It placed blame on the project manager for allowing the installation to continue following the failure of the mock-up even though its own engineers knew that the cause of the failure had not been discovered and the corrective efforts suggested by the contractor, therefore, did not specifically address the cause of the failure. In other words, the project manager was willing to play a game of **"Russian Roulette."** Given this fact, the project manager was criticized for not, at a minimum, recommending a continuing inspection program that would have prevented the accident. The SDC was at fault because the use of an adhesive anchor system in this application was unique and should have alerted the SDC to be extra careful by addressing creep in its design documents. In addition to what has already been discussed, the supplier was found to be at fault for not clearly stating in its literature the difference between its two epoxy formulations and that its fast set formulation was not suitable for long-term load resistance. Finally, the owner itself was criticized for not implementing a tunnel inspection program.

All this resulted in the death of an innocent person. The project was closed for six months by the Governor of Massachusetts and all of the adhesive anchors were replaced. The legal fallout was immediate. A wrongful death lawsuit was filed against the project participants. Insurance claims were made. A property damage lawsuit was brought by the owner against the supplier, the contractor, the project manager, the SDC and others. Criminal proceedings were threatened against the project manager and the SDC. In the end, the project manager, the SDC and others paid the owner in a global settlement of the accident and all cost recovery claims about $450 million. The supplier resolved the wrongful death and criminal matters by paying more than $20 million. The other defendants in the wrongful death action paid about $22 million. As a result of the accident and other matters, the contractor ended up in bankruptcy. The contractor's surety recorded what is believed to be the largest loss by a surety in the history of the industry at over $600 million.

3. 2007 – I-35W Highway Bridge Collapse

On August 1, 2007, the I-35W highway bridge spanning the Mississippi River in Minneapolis, Minnesota "experienced a catastrophic failure in the main span of the deck truss."[57] The NTSB investigated the accident and issued a report dated November 14, 2008. The NTSB concluded that the probable cause of the failure of the bridge was the "inadequate load capacity" of the gusset plates at the main truss node "due to a design error" by the original bridge designer. The NTSB also concluded that "[c]ontributing to the design error was the failure of [the original designer's] quality control procedures to ensure that the appropriate main truss gusset plate calculations were performed…."[58] A review of the design documentation and design history led the NTSB to conclude that none of the main truss gusset plates "were designed correctly because the appropriate calculations were simply not made for these design elements." If during the design execution the proper calculations had been performed, they would have revealed that the gusset plates as specified and installed were “substantially undersized.”[59]

The NTSB also found that when the original designer designed the I-35W Bridge in the mid-1960s, it also designed a similar bridge in Venezuela that spanned the Orinoco River. A review of the design documentation pertaining to the Venezuelan Bridge showed that the same designer had correctly performed the design of that bridge’s gusset plates by making the appropriate design calculations.[60] The original designer also had in place what appeared to be appropriate quality control procedures for preparing, checking, back-checking and re-checking its designs for errors.[61] Nevertheless, the NTSB concluded that the original designer’s design review process was inadequate because it failed to detect the error in the design of the gusset plates.[62] Thus, while the technical cause of the failure was the undersized gusset plate, the design error, or in this case more properly an error of omission, was the product of human error – the omission to design the gusset plate in the first instance by performing the appropriate design calculations followed by a chain of human errors that failed to detect the original error during the design review process.

The I-35W Bridge had been in service from 1967 until its failure in 2007. During that 40-year period, the original designer was merged into another design firm which for legal liability purposes became the original designer’s successor in interest. The design defect that caused the bridge’s collapse was not discovered until after the failure in 2007.

Nearly all states have enacted laws to prevent the prosecution of stale claims. Generally speaking, these laws fall into two categories, statutes of limitation and repose. In Pennsylvania, the statute of limitation relating to a breach of a construction contract is four years from the accrual of the claim which is generally deemed to be from the date of the breach.[63] The statute of limitation is two years in Pennsylvania for a professional negligence claim and is generally deemed to run from the date of the breach of a duty (e.g., duty of due care) owed to the injured party.[64] A statute of repose is not concerned with when a cause of action has accrued. It is an absolute bar to a claim whether it has or has not accrued so as to become actionable. In Pennsylvania, the statute of repose for construction project claims is 12 years from the project’s completion.[65]

Not surprisingly, a series of lawsuits was brought on behalf of the victims against the bridge inspection contractor and a bridge maintenance contractor that had been working on the bridge at the time of its collapse. These suits were consolidated into one lawsuit. The inspection and maintenance contractors joined the State of Minnesota and the bridge designer to the lawsuit. The State then filed a cross-claim against the designer under legislation enacted by the State in 2008 known as the "compensation statutes." Under these statutes, the State was authorized to compensate the survivor-claimants of the collapse. The State made payments to the survivor-claimants in the amount of approximately $40 million. The compensation statutes also authorized the State "to seek reimbursement from third parties for these payments, to the extent the third party caused or contributed to the Bridge collapse."[66]

The designer moved to dismiss the State's cross-claim on the grounds that Minnesota's applicable 15 year statute of repose had extinguished any claims against the designer. The Minnesota Supreme Court agreed that the statute of repose had extinguished any claims against the designer as of 1982 but held that the 2008 compensation statutes specifically revived such claims.[67] The designer also challenged the constitutionality of the compensation statutes on due process grounds under both the Minnesota and United States Constitutions. Rejecting this constitutional attack, the Court stated:

> We recognize that [the designer] has a protectable property interest in the defense of the statute of repose. But that right is not absolute and must be balanced against the State's legitimate interest in addressing a Bridge collapse that was a "catastrophe of historic proportions." [Citation omitted.] We acknowledge that it may be economically unfair to allow a cause of action previously extinguished by a statute of repose to be revived by subsequent legislation, but we find nothing in the Due Process Clause to preclude this result.[68]

As you might imagine, the Court's holding sent shock waves throughout the construction and engineering industry. Potentially, contractors and engineers now faced liability for defects and failures unbounded by any time limitations. Arguably, this liability only applied to "catastrophic" failures but those are exactly the "bet your company risks" that a statute of repose is intended to protect against. The designer petitioned the United States Supreme Court to take up the matter and to overturn the Minnesota Supreme Court's holding. Industry trade associations, such as the Associated General Contractors of America (AGC), the American Society of Civil Engineers (ASCE) and the Construction Industry Round Table (CIRT), rallied to the industry's defense and filed a "friend of the court" brief urging the Supreme Court to accept the designer's petition. In its brief, the industry argued:

> If allowed to stand, the decision below will set a very troubling precedent. It will greatly complicate the design and construction of the public and private works vital to the American economy. If a statute of repose can be nullified retroactively, architects, designers, and construction firms will have to bear unknown and unknowable risks of liability extending into the indefinite future. The construction projects which serve as the starting point for so much of America's economic activity are far too important to reduce to such a riverboat gamble.[69]

This seemingly compelling argument fell upon deaf ears. The Supreme Court denied the designer's petition on May 29, 2012.

C. *Observations, Practical Considerations and Lessons Learned*

From the above case histories, we can divine various common observations, considerations and lessons.

1. Seemingly small oversights during the design and construction process can lead to construction defects and failures.

2. A construction defect may remain dormant and unnoticed for months, years and even decades before it surfaces, sometimes with devastating consequences.

3. While statutes and case law provide guidance and rules for judging our conduct, these may all be tossed aside in the event of a catastrophic failure resulting in a loss of life. In appropriate cases, federal and state authorities will not hesitate to use criminal statutes and proceedings to punish willful misconduct or gross negligence. State legislative bodies may enact laws with retroactive application to create or revive causes of actions against responsible parties.

4. Schedule and cost pressures can lead to mistakes that can result in defects and failures.

5. There is no substitute for industry experience which is necessary to train, supervise and educate young professionals.

6. Early warning signs that something is amiss in a project's design and construction should not be lightly ignored or dismissed.

7. Even if a potentially dangerous phenomenon cannot be easily or readily understood, the implementation of a proper inspection program may in time uncover a defect and avoid a failure.

8. Novel or unique designs or material applications require a heightened sense of study, investigation and inspection.

9. A root cause analysis may lead to uncovering the technical cause of a defect or failure, but human error is usually the principal underlying cause.

10. The "buck stops" with the engineer of record who stamps a project's design drawings.

11. Learning from past mistakes is essential to minimizing future mistakes.

12. While the investigative reports of federal agencies like the NTSB are not admissible in evidence in a civil action for damages, such reports more likely than not will form the basis for the settlement of such actions.

13. The avoidance of errors that can result in construction defects and failures is the responsibility of everyone working in the construction and engineering industry. If you see something that doesn't look right, speak up. Don't assume that someone else has or will handle the issue. After all, it is better to be safe than sorry.

While it is inevitable that there will be future construction defects and failures, **Chapter Five** will discuss strategies for reducing their occurrence.

III. Forensic Engineering and the Expert Witness

A. *The Trial Lawyer and the Expert Witness*

The legal, construction and engineering professions perhaps intersect the most when the trial lawyer and the forensic engineer are preparing for and presenting expert testimony before a judge, jury or panel of arbitrators. Generally speaking, it is critical for the expert witness to come on board the trial team as soon as possible. Evidence must be preserved and guidance from the expert witness may be crucial in determining what physical evidence needs to be collected, photographed and retained. It is important for the expert to visit the project site in order to observe the defect or failure, to record his impressions and to establish credibility later with the judge, jury or arbitration panel.

The role of a forensic engineer has been described as follows:

> A forensic engineer relies mostly upon the actual physical evidence found at the scene, verifiable facts related to the matter, and well-proven scientific principles. The forensic engineer then applies accepted scientific methodologies and principles to interpret the physical evidence and facts.[70]

The forensic process is characterized as the scientific "ruling in or out" of theories of causation for the defect or failure based on all of the observable evidence:

> The objective of the process is to identify the cause of failure, and the process is driven by ruling in and out a failure hypothesis on the basis of specific evidence and generally accepted principles, rather than simplifying assumptions.[71]

When viewed from this perspective, the forensic engineer's guiding light is "follow where the evidence leads." This is the same guiding principle for the lawyer. Both the forensic engineer and the lawyer must be guided by the evidence, not assumptions, which can be quickly blown up on cross-examination.

There are a host of characteristics that are important to consider in the selection of the expert. One of the most important is the matching of the expert's experience and education to the technical issues of the case. Too often an expert is selected at the outset only to discover later that her background is not on target with the technical issues in dispute. Many cases will dictate the selection of more than one expert to match the many technical facets of a defect or failure case.

Most of us are familiar with the process of discovery where documents are collected, exchanged and reviewed and depositions of witnesses and others are taken as part of the trial preparation process. The expert witness will play an important role in developing the discovery plan and its implementation, including assisting in the preparation of discovery requests, assisting in the preparation of witness for depositions and the taking of witness depositions and the review of documents.

As part of the trial process, the expert will testify during the trial or evidentiary hearings concerning her professional opinions on such issues as causation. The expert must be able to communicate those opinions in a clear and cogent manner often simplifying complex scientific concepts for her lay audience using common everyday metaphors. The expert must be careful not to cross the line of expert opinion into that of an advocate. If she does, she may be viewed simply as a hired gun and not as an objective expert in her field. It is equally as important for the expert to educate the trial lawyer on the technical issues so that she can explain them to the trier of fact. There will be many times before and during the evidentiary hearings when the lawyer will need to explain and summarize the expert's opinions. If the lawyer does not have an excellent command of the technical issues, she risks losing credibility with her audience.

Before the hearings begin, the expert witness will be required to set forth her opinions in a written report. The report must be well written and easily understandable. Generally, the expert's trial testimony will be restricted to the scope of her report.

A construction defect or failure may not always result in legal liability. In the event of a defect or failure, the parties may employ a forensic engineer or other expert witness to determine the cause of the condition, which may in turn help determine which parties (if any) may be legally liable for the defect or failure. Once causation is determined, expert testimony may be needed to determine whether the design professional deviated from the applicable standard of care.[72] Also, the settlement or resolution of a legal dispute may depend on an expert's solution to resolve the issue.[73] In selecting an expert to investigate a defect or failure, it is important to select an expert who has a forensic background.[74] A good design professional may not make a good forensic expert, because the design professional is trained to manage assumptions related to factors such as loads, structural behavior, and capacity of materials, but is not trained to investigate these factors.[75] The forensic process is inherently different because determining the cause of a failure "is a process of analysis, rather than synthesis."[76]

B. *Rules Applicable to the Admissibility of Expert Testimony*

Rule 702 of the Pennsylvania Rules of Evidence controls the admissibility of expert testimony in Pennsylvania state courts and provides:

> If scientific, technical or other specialized knowledge beyond that possessed by a layperson will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training or education may testify thereto in the form of an opinion or otherwise.

The *Frye* test, first described by *Frye v. United States*, 293 F. 1013 (D.C. Cir. 1923), and adopted by the Pennsylvania Supreme Court in *Commonwealth v. Topa*, 471 Pa. 223 (1977) is part of Rule 702.[77] According to the *Frye* test, "novel scientific evidence is admissible if the methodology that underlies the evidence has general acceptance in the relevant scientific community."[78] In other words, the party offering expert evidence must prove that the methodology that the expert used in reaching his conclusion is generally accepted by experts working in his field.

Federal courts use a different standard. In the landmark case of *Daubert v. Merrell Dow Pharmaceutical, Inc.*, 509 U.S. 579, 113 S. Ct. 2786, 125 L.Ed.2d 469 (1993), the United States Supreme Court set forth the framework for admissibility of expert testimony in federal courts, which was memorialized in Federal Rule of Evidence 702:

> If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

The Court of Appeals for the Third Circuit and federal district courts in Pennsylvania have repeatedly interpreted Rule 702 to require three thresholds for the admissibility of expert testimony: (1) the expert must be qualified, (2) the expert's opinion must be reliable; and (3) the expert's opinion must "fit," or be relevant to the dispute.[79]

The *Daubert* standard is different from the *Frye* test. Under *Daubert*, the trial judge must determine whether the offered expert evidence is reliable and scientifically valid, and if it will assist the court or jury in making a determination.[80] Additionally, the *Daubert* standard does not require *Frye's* criteria of general acceptance.[81] Instead, it is one of several factors a court evaluates in deciding whether to admit expert testimony.[82] Other factors in the *Daubert* standard that a court considers to determine whether an expert's testimony is reliable and should be admitted include: (1) whether a method consists of a testable hypothesis; (2) whether the method has been subject to peer review; (3) the known or potential rate of error; (4) the existence and maintenance of standards controlling the technique's operation; (5) whether the method is generally accepted; (6) the relationship of the technique to methods which have been established to be reliable; (7) the qualifications of the expert witness testifying based on the methodology; and (8) the non-judicial uses to which the method has been put.[83]

C. *Types of Expert Testimony*

A party may retain two types of experts, a consulting expert or a testifying expert. Both may offer an opinion regarding causation. However, the main difference between them under the applicable federal rules is that, in addition to having to testify at trial, the party must produce all information considered or relied upon by a testifying expert. Under most circumstances, a party may not discover facts known to or opinions held by a consulting expert.[84] A consulting expert may be particularly useful in early case assessment and formulating case strategy because their opinions and work product are protected from disclosure to the other party.

IV. Conclusion

Defects and failures cannot be defined in a vacuum. They can only be defined by reference to applicable standards, contract provisions and causes of the defect and failure. What appears to be clear, however, is that whether based on express or implied warranties, the owner is entitled to a project that is **"free of defects."** The identification of the cause of a defect or failure will normally require expert testimony from a forensic engineer. Once the root or technical reason for the defect or failure is established, legal liability will be assessed based on an evaluation of whether the participants in the design and construction performed consistent with the standards of care applicable to their profession. In other words, for a design professional, the question is did she perform consistent with the standard of reasonable care applicable to others in the profession. For a contractor, the question is did she perform in a workmanlike manner. Again, expert testimony will be required to determine if these standards were breached.

In the case of defects and failures resulting in the loss of human life, the legal paradigm may change in order to hold those responsible accountable. New laws may be enacted, old laws may be changed and criminal charges may be levied or threatened. The privilege of holding a professional license may be revoked and reputations may be destroyed. Lawsuits are inevitable where personal injury or loss of life is involved.

The severity of the consequences of a catastrophic failure dictate that everyone involved in the design and construction industry must be ever vigilant to avoid the errors that may lead to the occurrence of defects and failures. Those professionals must not succumb to the pressures of time and money at the expense of safety and diligence. Lastly, we must learn from the mistakes of our predecessors and colleagues through the study of past failures.

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[1] CONSTRUCTION DEFECTS, 21-22 (Roland Nikles, Stephen H. Reisman, Suzanne M. McSorely, Richard J. Tyler, eds.) (American Bar Association 2012) (hereinafter "CONSTRUCTION DEFECTS").

[2] www.merriam-webster.com/dictionary/defect

[3] www.merriam-webster.com/dictionary/failure

[4] CONSTRUCTION DEFECTS, 21 n.1 (noting that a Colorado court defined a construction defect as "an irregularity in the surface or a structure that spoils the appearance or causes weakness or failure; [a] a fault; [a] flaw; [or a] want or absence of something necessary for completeness, perfection, or adequacy in form or function" and a California court appeared to "accept plaintiffs' definition of construction defects as 'deviations from the applicable building codes or industry standards'") (citations omitted).

[5] CONSTRUCTION DEFECTS, 23.

[6] *Id.*

[7] Jacob Feld and Kenneth L. Carper, CONSTRUCTION FAILURE § 1.1 (2d ed. 1997) (*quoting* from Leonards, G., (1982). "Investigation of Failures," *Journal of the Geotechnical Engineering Division,* American Society of Civil Engineers, New York (February) (hereinafter "CONSTRUCTION FAILURE").

[8] *Id.*

[9] Lopez, R., Love, P.E.D., Edward, D.J., and David, P.R. (July/August 2010), "Design Error Classification, Causation, and Prevention in Construction Engineering." *J. Perf. Constr. Fac.*, ASCE, 399.

[10] *Black's Law Dictionary* 1581 (7th ed. 1999).
[11] *Id.*
[12] "GAEP" or "Generally Accepted Engineering Practice" was defined in this contract to mean "those practices, methods, techniques and standards in effect in the process chemical industry at the time of performance of the Work, that are commonly used in prudent engineering and construction to design projects of similar size and type as the Project."
[13] *Pittsburgh Nat'l Bank v. Welton Becket Assocs.*, 601 F. Supp. 887, 890-92 (W.D. Pa. 1985).
[14] *Id.*
[15] *Ecksel v. Orleans Constr. Co.*, 360 Pa. Super. 119, 129 (Pa. Super. Ct. 1987), *citing Elderkin v. Gaster*, 447 Pa. 118, 128-29, 288 A.2d 771, 776 (1972).
[16] 6 Summ. Pa. Jur. 2d Property § 8:103 (2d ed.).
[17] R. Harper Heckman, "Drafting the 'Perfect' One-Year Warranty", The Construction Lawyer, Summer 2007 at 5.
[18] *Reflection Builders Enterprise, Inc. v. Basile*, 2012 WL 2115694 (May 21, 2012 Pa. Com. Pl).
[19] *Id.*; *Moyer v. White*, 48 Pa. D & C. 3d 487, 494-95 (Pa. Ct. Com. Pl.).
[20] *Dep't of Transp. v. Bethlehem Steel Corp.*, 368 A.2d 888, 897 (Pa. Commw. Ct. 1977); *Pittsburgh Nat'l Bank*, 601 F. Supp. at 890-92 (W.D. Pa. 1985).
[21] *Pittsburgh Nat'l Bank*, 601 F. Supp. at 888, 891.
[22] *Tyus v. Resta*, 476 A.2d 427, 432 (Pa. Super. Ct. 1982) (emphasis omitted); 6 Summ. Pa. Jur. 2d Property § 8:106 (2d ed.).
[23] *Tyus*, 476 A.2d at 432.
[24] *Id.*
[25] www.merriam-webster.com/dictionary/defect
[26] CONSTRUCTION FAILURE § 1.1.
[27] National Bureau of Standards, Building Science Series 143 (May 1982), *Investigation of the Kansas City Hyatt Regency Walkways Collapse.*
[28] *Id.*, Abstract at iii.
[29] *Id*. at 49.
[30] Luth, G.P., (May 2000), "Chronology and Context of the Hyatt Regency Collapse." *J. Perf. Constr. Fac.*, ASCE, 51, 56, 59.
[31] *Duncan v. Missouri Bd. for Architects, Professional Engineers and Land Surveyors*, 744 S.W.2d, 524, 533 (1988).
[32] *Id.* at 537
[33] *Id*.
[34] Moncarz, P. D., and Taylor, R. K., (May 2000) "Engineering Process Failure – Hyatt Walkway Collapse." *J. Perf. Constr. Fac.*, ASCE, 46-47.

[35] Luth, G.P., (May 2000), "Chronology and Context of the Hyatt Regency Collapse." *J. Perf. Constr. Fac.*, ASCE, 51, 57.
[36] Pfatteicher, S. K. A., (May 2000), "'The Hyatt Horror': Failure and Responsibility in American Engineering." *J. Perf. Constr. Fac.*, ASCE, 62, 65.
[37] Luth, G.P., (May 2000), "Chronology and Context of the Hyatt Regency Collapse." *J. Perf. Constr. Fac.*, ASCE, 51, 57.
[38] *Id*. at 59.
[39] Office of the Inspector General, Commonwealth of Massachusetts, *A Review of the Central Artery/Tunnel Cost Recovery Program*, 6 (December 2000) (citation omitted).
[40] *Id*. at 9.
[41] *Id*. at 11-16, 33.
[42] 2003 Mass. Legis. Serv. Ch. 4, Sect. 83 (S.B. 1949) (WEST).
[43] Crowley, B., *Deconstructing the "Big Dig": An Analysis of the Role of the Attorney General in the Central Artery/Tunnel Project Probe* (May 2005), 20.
[44] *Id*. at 21, 23.
[45] National Transportation Safety Board, Accident Report (July 10, 2007), *Ceiling Collapse in the Interstate 90 Connector Tunnel, Boston, Massachusetts*, 1.
[46] *Id*. at107.
[47] *Id*. at107-08.
[48] *Id*. at 85.
[49] *Id*. at 30.
[50] *Id*. at 33.
[51] *Id*. at 30-36.
[52] *Id*. at 36.
[53] *Id*.
[54] *Id*. at 42-49.
[55] *Id*. at 47.
[56] *Id*.
[57] National Transportation Safety Board, Accident Report (November 14, 2008), *Collapse of I-35W Highway Bridge, Minneapolis, Minnesota*, Executive Summary, xiii.
[58] *Id*. at 152.
[59] *Id*. at 129-30.
[60] *Id*. at 107-08.
[61] *Id*. at 102-06, 131.
[62] *Id*. at 131.
[63] 42 Pa. C.S.A. § 5525 (8) (2012); *S.T. Hudson Engineers, Inc. v. Camden Hotel Development Assocs.*, 747 A.2d 931 (Pa. Super. 2000).

[64] 42 Pa. C.S.A. § 5524 (2012); *Wachovia Bank, N.A. v. Ferretti*, 935 A.2d 565, 572-74 (Pa. Super. 2007).
[65] 42 Pa. C.S.A. §5536 (2012).
[66] *In re Individual 35W Bridge Litigation*, 806 N.W.2d 824, 825 (2011).
[67] *Id.* at 828-29.
[68] *Id.* at 833.
[69] Brief of *Amici Curiae* filed in *Jacobs Engineering Group Inc. v. State of Minnesota*, On Petition for a Writ of Certiorari to the Minnesota Supreme Court, No. 11-11074, April 2012 (Denied May 29, 2012).
[70] Brady, S.P., (January/February 2012), "Role of the Forensic process in Investigating Structural Failure." *J. Perf. Constr. Fac.*, ASCE, 3 (citation omitted).
[71] *Id*. at 2.
[72] *Id*.
[73] *Id.*
[74] *Id.*
[75] *Id.*
[76] *Id.* at 3.
[77] *Grady v. Frito-Lay, Inc.*, 839 A.2d 1038, 1043-44 (Pa. 2003).
[78] *Id.*
[79] *See, e.g. Pritchard v. Dow Agro Sciences*, 705 F.Supp.2d 471, 476 (W.D. Pa. 2010).
[80] *Grady*, at 1044.
[81] *Id.*
[82] *Id.*
[83] *Pritchard*, 705 F. Supp.2d at 483.
[84] Pa. R. Civ. P. 4003.5; Fed. R. Civ. P. 26.