(presented at the First Party Claims Conference, Warwick, Rhode Island, October 2016)

COSMETIC AND FUNCTIONAL DAMAGE
PART ONE

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Abstract – *In the insular world of forensic engineers, the terms "cosmetic damage" and "functional damage" were recognized as meaningful terms long before they became part of the Underwriter's standard lexicon. This paper explores the bifurcation of direct physical damage into "cosmetic" and "functional" components, why this represents a false dichotomy, the problems it poses for data collection and analysis, and the cases for and against the standardization of terms. The paper is divided into two parts. The first part studies the origin of the terms. The second part (forthcoming) deals with practical applications.*

Key Words – Cosmetic Damage, Functional Damage, Forensic Architecture, Forensic Engineering, Building Damage Assessment, Building Methodology, Direct Physical Loss, Construction Specifications Writing.

BACKGROUND

Design professionals (Architects and Engineers) and other building consultants (such as Roof Consultants) who inspect buildings for the cause of damage are generally referred to as "forensic engineers" even though the term "engineer" has specific legal meaning and alternately certain tasks performed under the rubric "forensic engineering" (such as the evaluation of water-damaged drywall and the specification of color-matched materials) have little to do with engineering practice. As I presume the reader is less concerned with the taxonomy of experts than the result of their endeavors, this paper refers to all building consultants as "forensic engineers" without prejudice to those with professional licensure.

Generally speaking, a forensic engineer (FE) is charged with finding "direct physical loss" to a building or structure, identifying the causal events associated with that loss (what, how, where, when, why), and recommending a protocol to restore the building or structure to a pre-loss condition. Although many FEs tailor their repair recommendations to the prescriptive cut of "like kind and quality", this reflects the limitations of certain insurance policies rather than the real-world requirements of model building codes. The FE's scope should always include all work necessary for planning, permitting, and lawful construction of the rebuild through the Certificate of Occupancy. Simply put, you can't "put it back the way it was before the loss" if the Local Official Having Authority (LOHA) won't let you put it back.

THE LANGUAGE PROBLEM

It is curious to hear FEs pontificate about "cosmetic" and "functional" damage when rarely do the same speakers acknowledge the broader term "direct physical loss" which (it can be assumed) is the etymological root of the neologisms they so warmly embrace. Most FEs assert "functional" damage (and by association "cosmetic" damage) as *engineering terms* yet hold "direct physical loss" taboo because it is an *insurance term-of-art* used to establish coverage. The mere utterance of "direct physical loss" by a FE can raise eyebrows among peers, let alone accusations of collusion based on the preposterous notion that FEs best serve their clients when they are ignorant of their client's workaday vocabulary.

The lack of communication is a two-way street. Consider an Insurance Adjuster who retains a FE to identify "structural damage" to a given property. The Adjuster means direct physical loss to the building's *structure* as opposed to the building's *contents*, but the FE presumes this to mean "*structural* damage" as opposed to "*non-structural*" or "*cosmetic*" damage. With her head buried in SEI/ASCE-7, the FE tediously investigates the Main Wind Force Resisting System (MWFRS) while ignoring the cracked Venetian plaster. The FE reports "*no structural damage*", the Adjuster hears "*no damage*", the claim is denied, and all Hell breaks loose. As this author previously noted:

"putting aside the broad definition of structure as "that which is built or constructed" (IRC, 2009), structural elements (framing and trusses) only represent 15.6% of new homebuilding cost (NAHB, 2009). What insurance engineers often trivialize as "aesthetic damage" to

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architectural components can nevertheless entail serious economic consequence for the homeowner" (Hall, 2012).

This author has heard more than a few FEs snidely remark "engineers don't do pretty". This is the ignorance of a forensic investigator who has never worn a hard-hat, swung a hammer or worked a construction job. FEs familiar with the trades know and understand that crown molding costs more per linear foot than the framing studs, and conduct their investigations accordingly.

DIRECT PHYSICAL LOSS

Whether writing reports or giving testimony, FEs walk a linguistic tightrope. On the one hand, FEs must not create engineering jargon out of whole cloth. The invention and inappropriate use of ambiguous or poorly defined terms is no substitute for standard terminology and will likely lead to miscommunication, confusion, conflict and litigation. On the other hand, unless terms like "direct physical loss" are plainly defined, the FE must fashion his own meaning or (at the risk of "practicing law without a license") turn to jurisprudence. As a single example, one court has held that a direct physical loss:

"contemplates an actual change in insured property then in a satisfactory state, occasioned by accident or other fortuitous event directly upon the property causing it to become unsatisfactory for future use or requiring that repairs be made to make it so" (AFLAC v. Chubb, 2003).

Even this seemingly explicit definition is problematic: unsatisfactory to whom and by what standard? As experts in building performance, it is incumbent on FEs to have the answer.

PERFORMANCE, FUNCTIONALITY & SERVICEABILITY

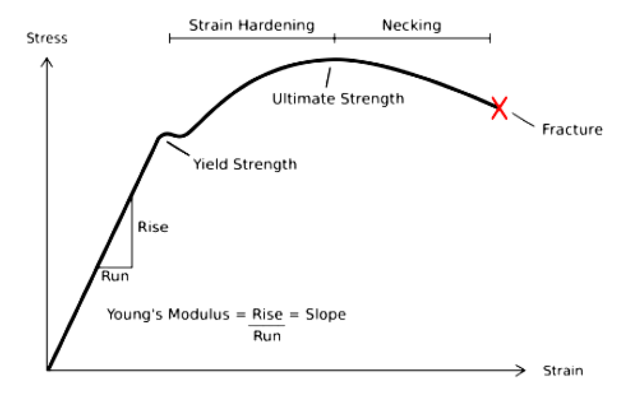
Building performance can be defined as the in-service functioning of a building for a specified use (ASTM E1480-92). A building's performance state is reflected by two different indicators: the physical condition state and the functionality state. Functionality states include human comfort, structural adequacy, maintainability, life safety and (hold this thought) aesthetics (ERDC, 2006).

A third concept is serviceability which refers to the conditions under which a building is still considered useful. When a building component exceeds its intended serviceability limit, its physical condition no longer supports an intended function. Consider a curtain wall component locally damaged by wind. It remains firmly attached to the building structure, but the mullions have buckled allowing rain water to penetrate the building envelope. From the perspective of the LOHA (and most FEs) the structural connection still complies with code. The component's physical condition is satisfactory for future use. However, for the building owner and users, the component has exceeded its serviceability limit and its condition is unsatisfactory for future use. The component must be repaired or replaced.

Until recently, model building codes did not address serviceability issues. The Commentary to the 1998 edition of SEI/ASCE-7 remarked:

"Serviceability limit states are conditions in which the functions of a building or other structure are impaired because of local damage, deterioration or deformation of building components or because of occupant discomfort. While safety generally is not an issue with serviceability limit states, <u>they nonetheless may have severe economic consequences</u>" (emphasis added).

More recent editions of ASCE-7 incorporate Load and Resistance Factor Design (LRFD) which in engineering practice is rapidly replacing the Allowable Stress Design (ASD) method of structural design. In a nutshell, ASD told the engineer to reduce the "yield strength" of a material by some fraction to make the allowable stress smaller than yield stress. The engineer would then compare the allowable stress (incorporating the appropriate safety factor) to the actual (or intended) loads. A quick glance at Figure 1 shows that a material's yield strength (in this example, steel) occurs at the stress point where the material begins to exhibit plastic deformation in the form of "strain hardening". Prior to that point, the material would recover from any deformation (strain) when the applied stress is removed. Such reversible deformation is called "elastic deformation". Once the yield point is passed, some fraction of strain is non-reversible. Non-reversible deformation beyond the yield point is called "plastic deformation".



Typical stress vs. strain diagram indicating the various stages of deformation.

Figure 1: Typical stress vs. stain diagram

With LRFD, instead of decreasing the allowable load using a one-size-fits-all safety factor, the engineer first increases actual design loads and decreases the nominal strength of the planned materials, and then compares the result to the ultimate strength of the material. Note that LRFD load combinations operate in the realm of plastic deformation (between yield strength and ultimate strength). In practice, the use of stronger (but not stiffer) construction materials, lighter architectural elements and the uncoupling of the nonstructural elements from the structural frame may result in building systems that are relatively flexible and lightly damped (ASCE-7-98). The inadequate performance of these components under load conditions less than ultimate strength can lead to the loss of intended functions with "severe economic consequences". LRFD accounts for this behavior by computational checks on serviceability loads as well as the ultimate load, such as designing for adequate stiffness to limit deflections and lateral drift. But not all FEs are familiar with the concept of serviceability limit states. As a result, forensic investigations – unlike computational checks – often focus on failure at ultimate strength rather than the range of damage caused by plastic deformation. This leads us to the difference between damage and failure.

DAMAGE AND FAILURE

Our discussion so far has attempted to show how the presumed ontology of "direct physical loss" is uniquely interpreted by each individual FE's education, practice and subjective judgment. Design engineers who see ASD and LRFD as Platonic Forms may cringe at my using engineering methodologies as competing metaphors for investigative thinking. Design engineers should be equally appalled by the analytical approach of FEs who measure reality on the Procrustean bed of textbook theory. Says Poincaré (1905):

"Instead of endeavoring to reconcile intuition and analysis, we are content to sacrifice one of them, and as analysis must be flawless, intuition must go to the wall".

Our previous example involved a FE who misconstrued the intended meaning of the term "structural damage" because her background gave different meaning to the word "structural". Just as likely, she may misconstrue the word "damage" itself. For an "old-school" Adjuster, "damage" meant "direct physical loss". For an FE schooled in the classic theory of strength of materials, "damage" is "the condition in which *some* plastic deformation has occurred, relative to the 'as new' condition of the component" (Matthews, 1998). Thus an "old-school" engineer has no problem recognizing damage as *any* deformation beyond the yield point, in agreement with the insurance indemnification concept of "direct physical loss". To the LRFD-trained engineer, the same yield point that ASD engineers see as the edge of the cliff is merely a bump in the road to ultimate failure. To this generation of FEs, *some* plastic deformation is little more than a useful predictor of building end-life. No wonder what some see as damage, others call "wear-and-tear".

THE ORIGIN OF FUNCTIONAL DAMAGE

The origin of the term "functional damage" is unclear. One of the first engineering papers to use the term was authored by Haag (2004), but the paper received little attention in the engineering community because the authors read the paper at a conference on meteorology. In the paper, Haag asserted that an earlier work by Greenfeld (1969) "defined failure or *functional damage* as a fracture in the coating or membrane" of built-up roof samples (italics added).

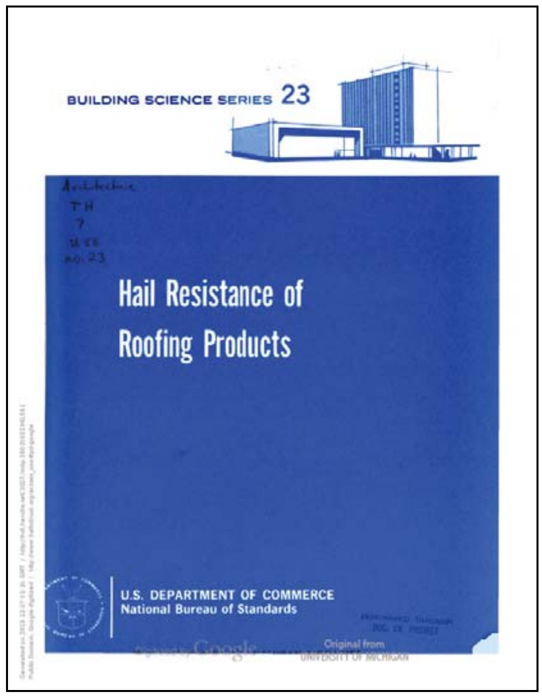


Figure 1: Greenfeld (1969)

Greenfeld was a research associate with the Asphalt Roofing Manufacturers Association (ARMA) studying hail resistance to roofing products. The National Bureau of Standards published his paper as part of a series "directed toward the manufacturing, design, and construction segments of the building industry, standards organizations, officials responsible for building codes, and scientists and engineers concerned with the properties of building materials".

Although Haag seemingly attributes the term "functional damage" to Greenfeld, Greenfeld never used the term. Greenfeld recognized two categories of damage: "(1) Severe damage, which leads to penetration of the structure by the elements and (2) Superficial damage, which affects appearance but does not materially interfere with the performance of the roofing". Severe damage permitted the penetration of liquid water "to an appreciable extent". Superficial damage affects appearance but "does not materially interfere with the performance of the roofing". Greenfeld distinguishes between severe damage where "the possible loss can exceed the replacement cost of the roofing many fold" and superficial damage which is "distracting and leads to insurance claims". Greenfeld is interested in investigating severe damage because it can result in third-party claims against ARMA members. As a scientist he recognizes superficial damage as "damage" but has no agenda-driven interest in the subject because it isn't covered by ARMA warranties. That, Greenfeld flatly informs us, is why we have insurance.

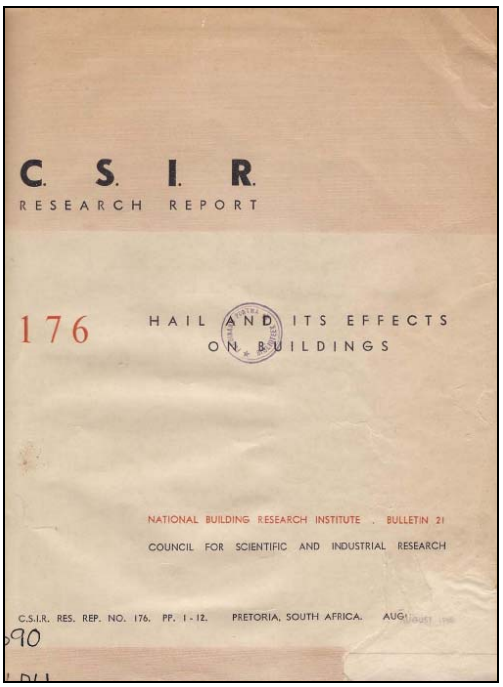


Figure 2: Laurie (1960)

Greenfeld relied heavily on an earlier paper by a South African researcher working for the National Building Research Institute (Laurie, 1960). Laurie argues that "in most cases the critical energy for a roofing material would be that at which the damage would give rise to water penetration to an appreciable extent". This aligns with Greenfeld's description of "severe damage" and Haag's description of "functional" damage". But Laurie said something else:

"It should also be noted that in some cases damage, although not sufficient to impair the functioning of the material, is nevertheless so unsightly as to necessitate replacement".

If we start with Laurie and read forward we learn that Laurie (1960) recognized the importance of cosmetic damage to the point where a building roof so impaired may require complete replacement. Greenfeld (1969) lauds Laurie's paper as "the only one in its field" but then trivializes cosmetic impairment as "superficial damage" of interest only to insurance companies. Haag (2004) cites Greenfeld but drops the relationship of "superficial damage" to insurance claims altogether. With apologies to Matt and Trey:

Figure 3: Playing the Citation Telephone Game

Although this Author cited Haag (2004) for its reference to Greenfeld (1969), the term "functional damage" earlier appeared in a Haag Engineering publication released in 1997 and cited by Timothy Marshall and Richard Herzog in a paper read at a roofing conference in Ontario, Canada (Haag, 1999a). At the same conference, Scott J. Morrison also of Haag Engineering offered this definition:

"Functional damage to any roof covering is <u>defined by Haag Engineering Co.</u> as a diminution of water-shedding capability or reduction in the expected long-term service life of the material" (Haag, 1999b, p. 30, emphasis added)

The citation suggests the term "functional damage" was first coined by Haag Engineering, certainly within their right and to their credit it is properly cited. The Morrison paper adds in specific reference to asphalt shingles, "impact-causing damage is rupture of the reinforcement *or* displacement of granules sufficient to expose underlying bitumen" (p. 31). (Note that each criterion stands alone. This author has read many FE reports that cite Morrison concerning *rupture* but ignore the equal weight he gives *granule displacement*).

Moving to the present time, the Citation Telephone Game is rampant in FE reports and even pops up in engineering papers. At an ASCE Forensic Engineering conference, three Rimkus engineers defined hail impact damage to asphalt shingles as "the loss of water-shedding capability or a reduction in the expected long term life of the roofing material" (Sharara, Jordan & Kimble, 2009, p. 186). While clearly derived from Haag, the authors simply described their assertion as "a functional definition which has industry acceptance". That may be true, but what Haag developed as a working definition, Rimkus elevated to an industry standard without citing any consensus authority.

In his comprehensive tome on forensic engineering, Petty (2013) followed suit:

"Within the roofing and insurance markets, the industry standard definition for functional damage to the roofing system of a building is defined as a reduction or diminishment of its water-shedding capabilities and/or a reduction in its expected long-term service life" (p. 41).

This may be agreeable to certain insurance companies, yet come as a surprise to organizations such as the National Roofing Contractor Association (NRCA). Petty footnotes his "industry standard definition" with references, but all three references are authored by Haag Engineering. Haag (1999a) was previously discussed. A second paper (Petty provides no date, but the paper was read at the 2002 AMS Conference on Severe Local Storms) simply provides a quote from Morrison's 1999 paper (Haag, 2002). The third paper – a 1993 Morrison paper "revised" 1995 – this author has been unable to obtain. To establish an industry consensus, certainly it should take more than three related articles from the same authors.

In fact, currently there is no engineering standard for the terms "cosmetic damage" and "functional damage", although the ASTM International E58 Technical Committee on Forensic Engineering may soon prove the exception. In what one can only assume was the sole "hit" in an internet search for examples pre-dating Haag, Petty references the U.S. Department of Defense *Dictionary of Military and Associated Terms* definition of "functional damage assessment"*:*

"The estimate of the effect of military force to degrade or destroy the functional or operational capability of the target to perform its intended mission and the level of success in achieving operational objectives established against the target".

Given the lack of industry standards, FEs have three alternatives: reference the insurance policy, use the Haag definition or invent their own. There is nothing innately wrong with using any of these alternative sources as long as authorship is properly credited.

Figure 4: Cosmetic damage or more?

THE FALSE DICHOTOMY

While the use of properly cited definitions is important, the FE working on assignment should always endeavor to "reconcile intuition and analysis", in this case meaning the ontology of damaged building components versus the false dichotomy of "cosmetic" and "functional" damage. In his seminal *"Design for the Real World"*, Victor Papanek (1985) argued:

"Should I design it to be functional, the students say, or to be aesthetically pleasing? This is the most heard, the most understandable, and the most mixed-up question in design today. Do you want it to look good, or to work? Barricades erected between what are really just two of the many aspects of function. It is all quite simple: aesthetic value is an inherent part of function" (p. 30).

Papanek's argument agrees with the traditional definition of "cosmetic damage" as "direct physical loss". This is explained by National Underwriters in a FC&S Bulletin as follows:

"The [insurance] policy doesn't exclude cosmetic damage, so direct damage, even if it is cosmetic, is covered. It's the same as if vandals had painted the side of the house purple. While cosmetic, it's damage, and is covered" (cited in Merlin, 2009).

Most readers will recognize that newer insurance policies *do* exclude "cosmetic damage" in which case the policy may offer its own definition of "cosmetic damage", often in opposition to "functional damage" (although this author has never seen the term "functional damage" actually used in an insurance policy). A discussion of how these exclusions impact FE investigations is forthcoming in Part Two of this paper.

NON-ENGINEERING STANDARDS

The dichotomy between "cosmetic" and "functional" damage is flawed not only because it rips the integrity of seamlessly designed (and insured) products, but because it suggests a duopoly of attributes when in fact dozens of important attributes must be considered. A few examples of non-engineering standards will illustrate the point.

ANSI D16.1 "Manual on Classification of Motor Vehicle Traffic Accidents" is an industry standard providing a "common language for reporters, classifers, analysts and users of traffic accident data". The Manual defines five categories of damage. "Functional damage" is "any road vehicle damage, other than disabling damage, which affects operation of the road vehicle or its parts". "Disabling damage" is defined as damage precluding "departure of the vehicle from the scene of the accident in its usual operating manner by daylight after simple repairs".

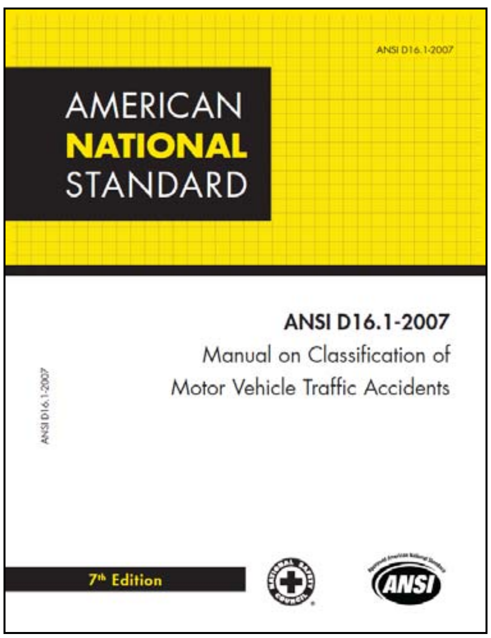


Figure 5: ANSI D16.1

Closer to home for FEs who investigate building damage, the Construction Specifications Institute (CSI) has established four attribute categories for product performance: functional, sensible, practical and safety and protection, with numerous product attributes assigned to each category. Further discussion of the CSI attribute categories is forthcoming in Part Two of this paper.

SUMMARY

Design engineers may be aghast that I reduced ASD and LRFD methodologies to metaphor; more likely many FEs rent their garments at my mention of FC&S Bulletins and insurance policies. But one should not need to be a legal expert to read plain language. In his treatsie on engineering failure investigation, Matthews (1998) tells his fellow FEs "if you want to become competent in failure investigation, you will soon run into the fact that your engineering knowledge is only part of the story".

In Part One I have endeavored to provide theoretical background for the issue of "cosmetic" and "functional" damage. In Part Two (forthcoming) I will offer practical knowledge for dealing with these same issues.

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NOTES

This version corrects spelling and other minor errors found in a previously released version.

I have listed "Haag Engineering" as the author of all publications authored by Haag engineers for continuity in the narrative. It was not my intention to slight individual authors or their individual contributions to their collected works.

DISCLOSURE

The author is a Forensic Architect and Engineer. While consulting services are available to all requesting parties, at the present time the majority of his clients are property owners as opposed to insurers.