Summit Anchor Co.®

Safety From the Top Down

Dropped Forged Steel Anchor Eye

vs.

Stainless Steel Ubars Anchor Eyes

Why Summit's Dropped Forged Steel Anchor Eye is Superior to Stainless Steel ubars anchor eyes.

Material Strength Properties of Summit's Forged Eye Vs a Stainless u-bar:

- 304 stainless steel u-bar 304, Min.: 42.1 ksi
- 1030 grade steel, quenched and tempered eye is a Min.: 72 ksi (see Fig 4, pg. 4)

Other Supporting Rationale to Replace Stainless Steel U Bar Anchors with Forged eyes:·

- Many specifications call out a stainless u-bar of not less than 3/4" diameter (see Fig 1,page 2) in comparison, Summit's Forged Eye maintains a 1-1/2" width dimension at thebase of the eye. This larger section size provides needed strength to arrest a fall (see Fig 2, page 2).
- Stainless steel u-bars are tightly bent into a u shape from a straight round bar (see Fig 3, page 2). The plastic deformation required to bend the u-bar into shape causes strains that can possibly cause the material to strain-harden. Strain-hardening can change the material's mechanical properties. The top of a u-bar is most susceptible to strains
- In contrast Summit's trademarked eye is drop forged then quenched and tempered. The tremendous compressive forces involved in drop forging along with the careful heattreating and cooling process results in an anchor that is stronger than a non-forged Stainless u-bar*. *Per the Forging Industry Association: "Forgings have grain oriented to shape for greater strength. Machined bar and plate may be susceptible to fatigue and stress corrosion because machining cuts material grain pattern. In most cases, forging yields a grain structure oriented to the part, resulting in optimum strength, ductility, and resistance to impact and fatigue.".
- The additional quench-and-tempering process of Summit's forged anchor eye ensures consistent performance of all our anchors. The heat treatment and cooling process capitalizes on the properties of the steel to create anchor eyes with reduced risk of catastrophic failure due to brittleness. When a worker's life is on the line, Summit's forged eye will withstand the dynamic loads imposed to keep workers safe.
- Stainless steel 3/4" u-bars generally *cannot* be tested to 5,000 lb. at bend of the u-bar without permanent deformation to the u-bar. See WJE article: "Certifying That...Anchorages Comply with Federal OSHA Reequipments" for why this is an important consideration.
- In contrast Summit 1030 steel eye *can be* tested to 5,000 lb. and beyond without permanent deflection. See FIG 5, page 3 for Summit's Forged eye tested to 10,000 lb.with minimal deflection. See FIG 6, page 4 for 5,000 lbs. requirement per, OSHAs,Subpart D – Walking and Surfaces, (b) Rope Descent Systems (i) Anchorages.
- In areas where an all stainless anchor is warranted such as in a highly corrosive environment such as near sea water, Summit can produce an 100% stainless anchor. Because of the increased cost of all stainless anchor coupled with the reduced strength properties inherent to stainless steel, such an anchor should only be selected when necessary. In the case where a 100% stainless anchor is required, Summit's dropped forged stainless eye has superior strength properties than a stainless u-bar.

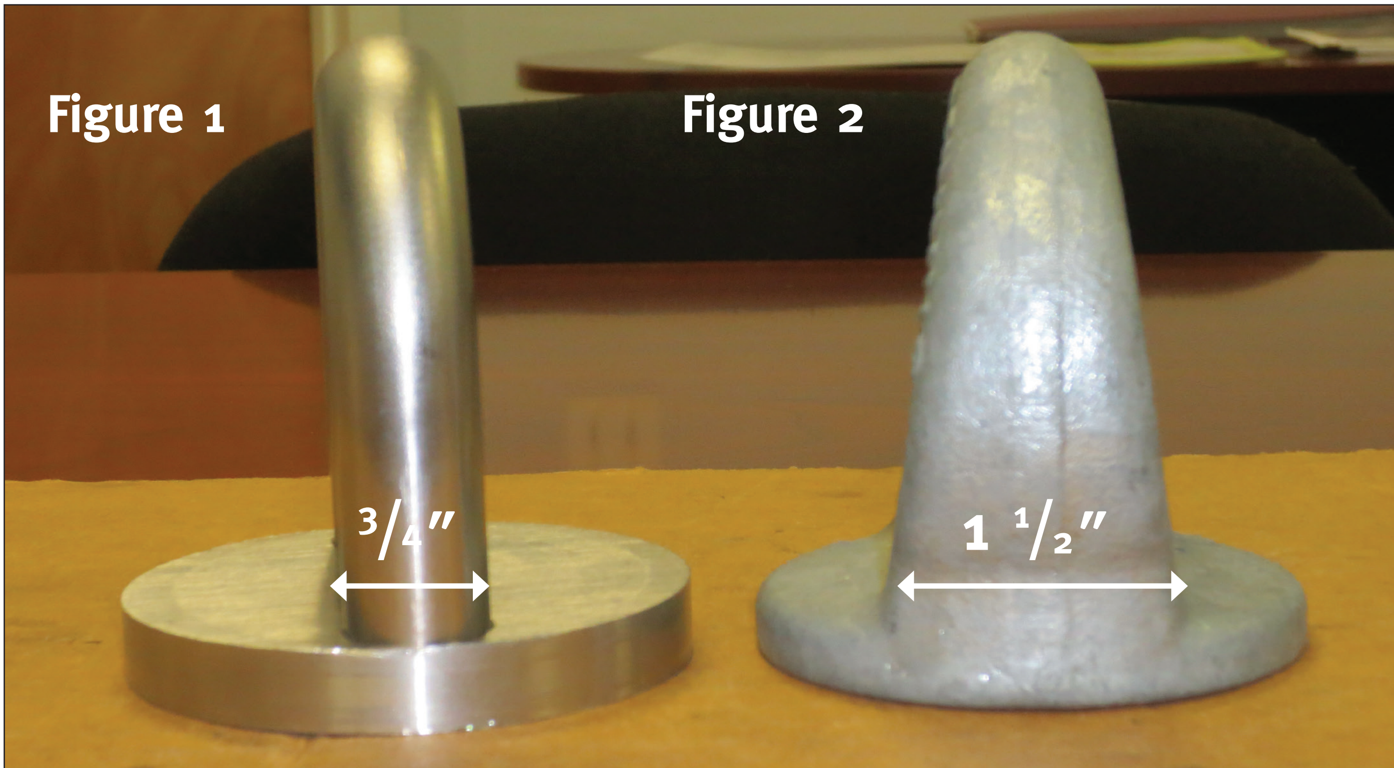

Fig. 1. & 2. *Summit's forged eye Vs u-bar*

Fig. 3. *Summit's forged eye Vs bent u-bar*

Fig. 5. *Testing Summit's Forged Eye to 10,000 lbs.*

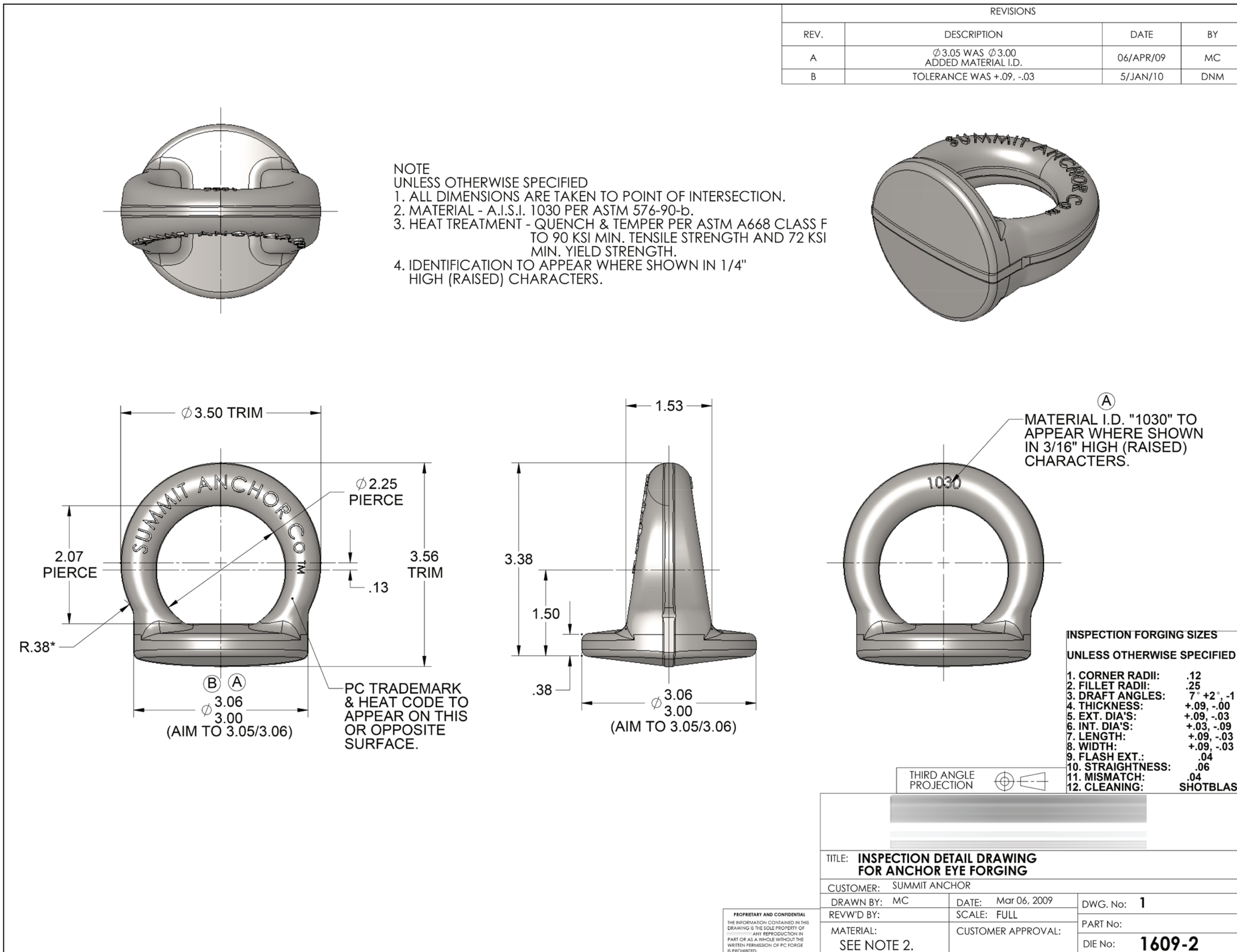

Fig. 4. *Summit's forged eye material strength*

(b) Rope descent systems--(1) Anchorages. (i) Before any rope descent system is used, the building owner must inform the employer, in writing that the building owner has identified, tested, certified, and maintained each anchorage so it is capable of supporting at least 5,000 pounds (268 kg), in any direction, for each employee attached. The information must be based on an annual inspection by a qualified person and certification of each anchorage by a qualified person, as necessary, and at least every 10 years.

Fig. 6. *Excerpt OSHA Subpart D*

Dynamic Drop Test

Date Tested: 06/22/2018

Test: Dynamic drop testing with a 6-foot steel cable attached to a 300-lb. weight connected to one end and the other end connected to the anchor eye. Anchor mounted to I-beam test frame. The pictures below show the results of that test.

Material List for Summit Anchor Model: SM-1-8-12-12 (Fig. 7)

Eye:	Summit's Forged Quenched & Tempered Steel
Base Plate:	½” x 8 x 8
Tube:	½” O.D. x 12” long Sch. 40 pipe
Bolts:	Stainless B8 Class I

Click here to see Summit Forged Eye Anchor drop test

Material List for U-Bar Anchor (Fig. 7)

Eye:	304 Stainless Steel U-Bar, ¾” Diameter, Welded to 3/8” Disk
Base Plate:	5/8” x 8 x 8
Tube:	3½” O.D. x 12” long Sch. 40 pipe
Bolts:	Stainless B8 Class I

Click here to see U-Bar drop test

Fig. 7. *U-Bar Tested Anchor*

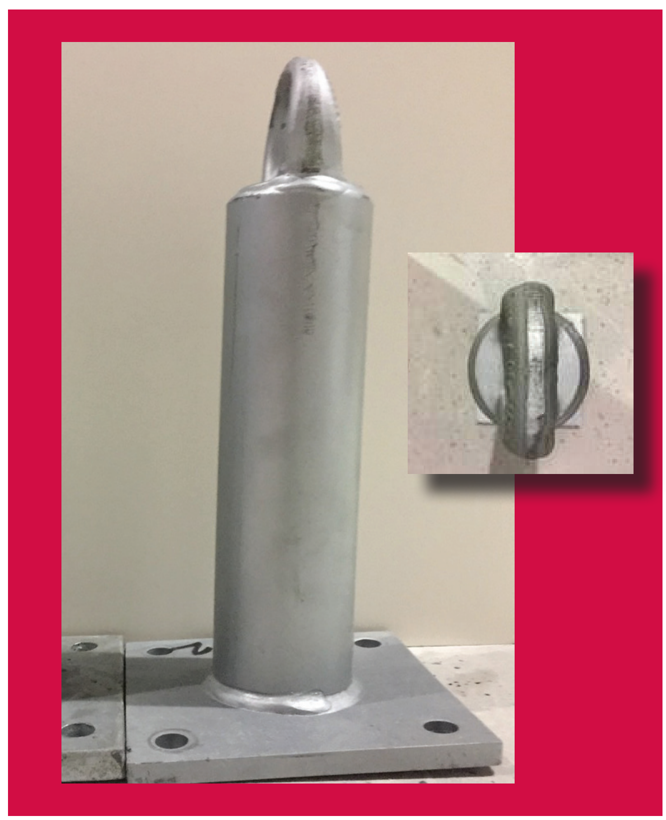

Fig. 7. *Summit's Tested Anchor*

Certifying That Existing Suspended Scaffold Structural Support Elements and Lifeline Anchorages Comply with Federal OSHA Requirements

Howard J. Hill[1]; Gary R. Searer[2]; Richard A. Dethlefs[3]; Jonathan E. Lewis, M.ASCE[4]; and Terry F. Paret, M.ASCE[5]

Abstract: The Federal Occupational Safety and Health Administration (OSHA) maintains standards (Standards) that define structural requirements for elements that support suspended scaffolds and fall arrest lanyards when this equipment is used to access facades and other elevated portions of buildings. The Standards are available online at www.osha.gov. Ensuring that applicable requirements are met is the responsibility of a qualified person—typically a professional engineer. However, navigating and applying the OSHA structural provisions can be difficult primarily because relevant requirements are not located in a single document, structural requirements vary for different uses, and structural requirements are not always written in a manner consistent with typical structural engineering practice. The rational application of key OSHA structural provisions when designing suspended scaffold support elements and lifeline anchorages is the subject of a companion paper, "Designing Suspended Scaffold Structural Support Elements and Lifeline Anchorages in Conformance with Federal OSHA Requirements," which is included in this publication. The objective of this paper is to promote the rational application of sound engineering principles when certifying the adequacy of existing elements and their compliance with OSHA Standards. Unfortunately, certain trends and recent developments in the facade access equipment industry have made proper certification more difficult than it needs to be; irrational approaches and conclusions are, at times, actually encouraged by industry groups.

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Introduction

The Federal Occupational Safety and Health (OSHA) structural provisions that apply to facade access equipment are contained primarily in Parts 1910 and 1926 of the Standards. According to OSHA, owners of buildings with facade access equipment must provide written assurance to users of the equipment that it satisfies all applicable OSHA provisions [1910.66(c)(3)]. Periodically, circumstances conspire to undermine an owner's basis for providing this assurance. For example, years of use and environmental exposure can adversely affect structural integrity. Thus, the mere passage of time can create questions about the adequacy of once adequate support elements. Otherwise, a new owner may find documentation regarding the capacities of some elements, or the elements themselves, to be lacking. In cases like these and others, a legitimate basis for providing the assurances required by the Standards must be reestablished.

Verifying the adequacy of facade access support elements should not be a particularly challenging task for a competent structural engineer. Given a proper understanding of the requirements, basic analysis tools and/or relatively simple testing capabilities are typically all that are needed to verify compliance. Unfortunately, the facade access industry has fallen prey to some rather unusual thinking and practices that have done it a disservice and have made it much more difficult for responsible engineers and owners to achieve the desired outcome; those certified systems actually satisfy OSHA requirements and provide the mandated level of safety.

Structural Analysis

While properly executed analytical verifications of in-service elements are valid, they can, under some circumstances, be very difficult and costly to implement. To be valid, an analysis must be based on reliable (or at least clearly conservative) estimates of existing material properties, element geometry, and element conditions. However, information in one or more of these areas is frequently lacking and can be difficult to obtain. For example, key components of roof-mounted davit bases and anchorages are often buried within roofing system components such that adequate documentation of current conditions would require re-

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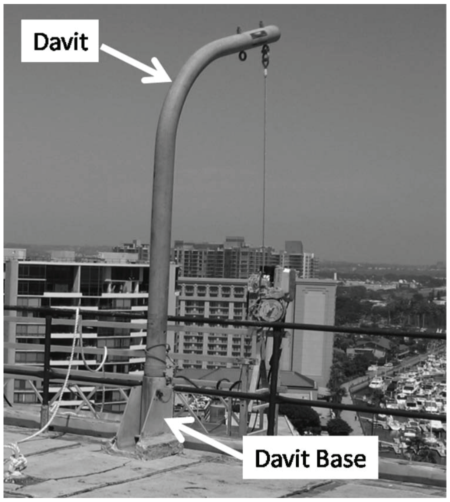

Fig. 1. Typical davit and davit base

moval of roofing and/or roof deck. Determination of the material properties for certain structural members and related hardware might require testing of samples (particularly aluminum, for which a wide range of alloys has seen common usage). In the absence of such testing, conservative estimates of material properties might result in apparent deficiencies that are not real or restrictions on use that are not necessary.

Consider the components shown in Fig. 1. Most of the davit base, including its connection to the supporting structure, is obscured from view. Neither the davit nor the davit base has any load rating tag or documentation of its construction (e.g., material specification). In this case, providing reliable estimates of component strengths via structural analysis would require destructive material testing and excavation of the roofing around each davit base to assess existing conditions. Even if conservative assumptions regarding material properties suggest adequate *as-designed* capacity, the conditions at the base of each davit base would still need to be assessed to determine in situ capacity. When adequate documentation is obtained, element capacities can be reliably established as discussed in the companion paper related to design. When adequate documentation is very difficult to obtain, proof testing may provide a more cost-effective means of verifying in situ capacities.

Proof Testing

Basic Issues

The notion of proving via testing that something has a certain capacity is older than the structural engineering profession. Today, proof testing is commonly used (and accepted by building departments nationwide) to verify the ability of structural elements to sustain particular demands by applying the required demands and observing the elements' response. Criteria are typically established beforehand to differentiate between successful and unsuccessful performances during the test. For structural elements, stability is the most basic criterion, while additional benchmarks might include limits on deformation or other performance metrics. When proof testing is performed on elements that are intended to remain in service after the test, impairment of structural capacity and serviceability are clearly important issues to consider. In subsequent discussion, this type of testing will be called nondestructive proof testing (NDPT). Elements that need to respond inelastically to each application of the target demand (e.g., structural systems designed to absorb the effects of impulsive or impact demands via ductile deformations) are not good subjects for NDPT since testing to the level required to verify capacity would likely cause significant damage. In contrast, NDPT is often an excellent way to verify the adequacy of elements that were proportioned to sustain target demands without damage. Given the often onerous requirements for performing valid analytical evaluations of some facade access support elements, NDPT represents an attractive alternative. When the required loads can be applied with simple equipment, it is usually much easier (and more reliable) to verify adequacy using NDPT methods.

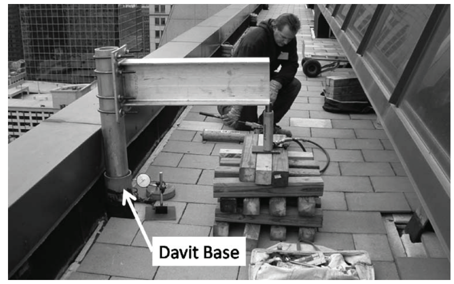

Fig. 2. Davit base testing

Another limitation of NDPT relates to the ability to make statistical inferences from the test data. Since a series of successful NDPT tests provides no direct indication of actual element capacities and capacity variation as compared to destructive testing, NDPT provides little information regarding elements of the population that have not been tested. For this reason, NDPT results are usually applicable only to the actual test specimens. While NDPT can be used to make statistical inferences, designing a test program to provide the desired level of confidence that the population has the appropriate degree of reliability can be challenging since doing so would require assumptions to be made regarding population variability. Furthermore, when using NDPT, unless the test load is much greater than the required strength, the number of tests needed to prove that population reliability is sufficient with the required degree of confidence is often greater than the number of specimens in the population.

Visual examples of equipment being proof testing are provided in Figs. 2–7. In Fig. 2, a lever and a hydraulic jack are being used to load a davit base with the type of moment it would see when supporting an in-service davit. In this case, a moment consistent with minimum OSHA requirements for davits was applied. Response was considered acceptable if the davit base could sustain this demand in a stable fashion and without excessive permanent deformation. Stability was verified by measuring deformation under load, including deformation, while the required design load was sustained and deformation under multiple applications of the design load. In situations like that shown in Fig. 2, it is usually inappropriate to require purely elastic response to the test load. During a proof test involving minimum OSHA loads, it is quite

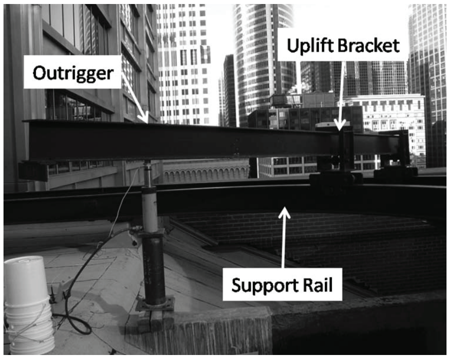

Fig. 3. Testing of outrigger support bracket and rail

likely that demands will be at an all-time high. In this case, small nonrecoverable deformations due to many possible effects such as seating of anchor bolts, minor "crushing" of concrete at the edge of an anchor plate, bolt slip, or similar effects might occur as the element achieves equilibrium under historically high loads. Such deformations are expected and have no impact on the specimen's ability to sustain future applications of the design load.

In Fig. 3, the inboard (uplift) anchor bracket and support rail for a movable outrigger are being tested. In Fig. 4, uplift loads are being applied to the inboard rail support for a movable carriage system. Fig. 5 shows testing of an element that can be used as either a tie back or a lifeline anchorage. Examples of davit testing are illustrated in Figs. 6 and 7. In all cases, the purpose of the testing was to verify conformance with OSHA provisions, which means loads consistent with OSHA minimum strength requirements were applied.

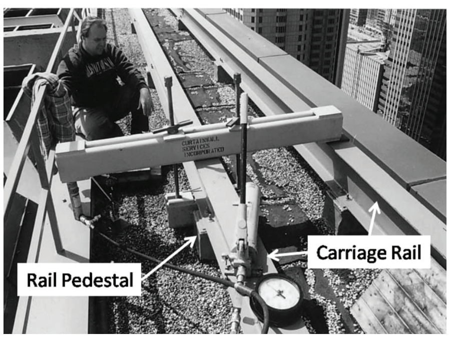

Fig. 4. Testing of carriage support rail pedestal

Fig. 5. Anchorage testing

Fig. 6. Field davit testing

Industry Problems

Few structural engineering concepts are as simple and straightforward as proof testing. In the context of verifying the strength of a structural element of questionable composition and/or condition, formal education is not required to appreciate the following proof testing axioms:

- An element that sustains a particular demand without being damaged can sustain the same demand again.
- An element's ability to sustain a particular demand says nothing about its ability to sustain significantly greater demands.

Unfortunately, it has become standard practice among certain members of the facade access equipment industry to violate the second of these axioms when asked to certify compliance with minimum OSHA structural requirements. In fact, such violations are so commonplace and widely accepted in this industry that standard-writing bodies want to "standardize" them. Section 8 of International Window Cleaning Association (IWCA) (2008) limits postinstallation testing of equipment to one-half of the minimum OSHA strength requirements. Even more surprising is that California's state OSHA body (Cal/OSHA) has been persuaded to try to prohibit valid proof testing. Section 3296(b)(4) of the *Cal/OSHA General Industry Safety Orders* (available online at http://www.dir.ca.gov/title8/sub7.html) limits testing of scaffold support equipment to one-half of the corresponding minimum Cal/OSHA strength requirements. This section of the Cal/OSHA standards is troublesome because of its inconsistency with other Cal/OSHA requirements and because it violates the axioms noted above.

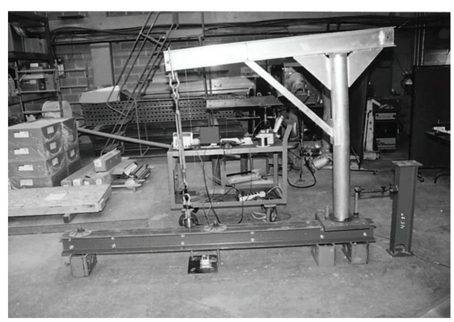

Fig. 7. Laboratory davit testing

Taken as a whole, the Cal/OSHA standards require owners to maintain certification that their equipment meets Cal/OSHA structural requirements, yet they simultaneously restrict proof testing (the most efficient tool for justifying the required certification) to a level where it has no use. Also troublesome is the implication that Cal/OSHA has the authority to limit the loading an owner can apply to a component of their building during a controlled test.

A critical concern created by this promulgation of half-load proof testing is the likely inappropriate certification of facade access support elements (platform and lifeline support structures) that have been in service for some time, elements for which the ability to carry OSHA-mandated loads is in question and which may be structurally inadequate. There are many circumstances in which the structural capacity of an in-service element may be questionable. Concerns about deterioration due to environmental exposure or reports of damage during reproofing operations may call into question the capacities of once adequate elements (i.e., previous documentation such as design documents and/or previous test reports—if they even exist—may no longer represent actual conditions). In some cases, a new owner may find relevant documentation to be inadequate or nonexistent. In these and other circumstances, a building owner must verify the adequacy of the building's facade access support elements before allowing them to be used.

As previously discussed, NDPT is often the most efficient way to verify the ability of a facade access structural component to carry OSHA minimum loads, especially when the condition of the element is not fully documented, and obtaining sufficient documentation would be more costly than performing an appropriate test (e.g., a davit base whose lower extremities and connection to the supporting structure are concealed by roofing and roof deck). If NDPT is used to verify OSHA compliance of elements whose capacities are in question, the test load obviously needs to be at least equal to the OSHA-specified minimum acceptable strength. In spite of this obvious fact:

- Several engineering firms have certified the adequacy of anchorages and platform support elements based on load testing that was limited to only *one-half* of the corresponding OSHA-specified minimum acceptable strengths.
- Cal/OSHA provisions prohibit questionable elements to be tested beyond one-half of their minimum strength requirements when testing is used to verify strength.
- The proposed updated version of the IWCA I-14.1 standard promotes in situ testing to one-half of the applicable OSHA minimum strength as a means of verifying the ability to carry the required load.

The fallacy of testing an element whose condition and strength are not confidently known (otherwise, there would be no need to test) to a particular load and then using that test to certify that the element can sustain twice the test load should be patently obvious to any competent engineer. Efforts by the writers to understand the source of this faulty logic and why engineers continue to employ it have included the following:

- Discussions with several proponents of the half-load approach;
- Formal appeals (written and in person) to the Cal/OSHA board; and
- Extensive written communications with the IWCA I-14.1 committee in the form of recommendations for improving the standard.

In the course of these activities, various arguments—either illogical or irrelevant—have been tendered in support of half-load testing. Some of the more notable examples are summarized below in bold italics, followed by a brief rebuttal.

Irrelevant Claim: Other Industries Use Proof Loads That Are Less Than Required Strength

This claim is certainly true and a likely source of the half-load testing mindset that is common in the facade access industry. Unfortunately, it is irrelevant. While the rigging industry may decide to require new rigging elements (e.g., cable assemblies or chains) to be loaded to half the required breaking strengths, this testing does not prove that the breaking strengths are adequate. If the crane industry requires a crane to be tested using loads equal to 125% of its rated capacity, such testing does not verify conformance with the ultimate strength requirements of the applicable crane design standards. If an engineer is required to certify that a crane boom has the required strength, a 125% load test would not suffice. Similarly, if an engineer needs to certify that a facade access support component has the required strength, a test to half of the required value is insufficient no matter how common such testing may be.

Irrelevant Claim: Testing to the Full Required Strength Could Damage the Surrounding Roofing

In California's Occupational Safety and Health Administration (Cal/OSHA) (2008), Cal/OSHA staff wrote the following with respect to applying test loads consistent with OSHA requirements, "Temporary deflection in the building's frame structure creates enough movement to damage roofing and weatherproofing." While the potential for damaging roofing should be considered when weighing the relative costs of performing NDPT and developing a test plan, the notion that roofing fragility should in any way dictate what constitutes an appropriate test load is patently absurd, and the fact that engineers responsible for shaping and enforcing related safety provisions can support such a notion is alarming.

In the paragraph following the one that included the quotation referenced above, California's Occupational Safety and Health Administration (Cal/OSHA) (2008) states the following, "Manufacturers contacted indicated that they support proof load testing to verify calculations and the full design capacity of suspension equipment prior to installation. However, they did not support this type of load testing for postinstallation for the same concerns expressed… in the preceding paragraph." First, equipment manufacturer feelings about roofing fragility are hardly relevant. Second, preinstallation testing cannot address concerns related to in situ conditions after years of use and environmental exposure (and cannot speak at all to the connection of the equipment to the roof framing). In short, this comment and the associated manufacturers' concerns have no relevance at all to the issue at hand.

On a practical note, the writers tested hundreds of roof-mounted structural components to the full OSHA-specified loading without causing any roofing damage. In contrast, where valid NDPT is not a viable option and component certification must be accomplished through analytical means, roofing must be completely removed in the area surrounding most roof-mounted components simply to establish existing conditions sufficiently to perform a valid computational evaluation.

Illogical Claim: Factor of Safety of Two Is "Good Enough"

This argument has several problems. First, it implies that the OSHA provisions provide a factor of safety of four with respect to critical structural demands. In no case this is true. As discussed in the companion paper related to design, the universal requirement that hoist support elements must be able to carry at least four times the rated load of the hoist provides a "factor of safety" of only 1.33 with respect to the stall loading permitted by OSHA and all related standards (i.e., a capacity of four times the rated load divided by the permitted stall demand of three times the rated load equals 1.33). In hang-up-and-fall situations, peak support loads can easily exceed two times the hoist rating. Clearly, in the case of stall conditions, half-load testing does not even provide a factor of safety of one. As for fall arrest anchorages, it was shown in the companion paper that OSHA-compliant fall arrest systems can generate up to 2,520 lbs of force. Since OSHA requires fall arrest anchorages to have a capacity of at least 5,000 lbs/lifeline, half-load testing would essentially prove only that the test subject can provide a factor of safety of one with respect to service level loads. The ability to handle anything greater than a code compliant fall situation would be left unproven. The online OSHA Federal Register provides information related to actual factors of safety provided by OSHA minimum strength requirements (e.g., document 1996-08/30/1996—Safety Standards for Scaffolds Used in the Construction Industry; final rule 61:46025-46075).

Regarding the fact that half-load testing does not even provide a factor of safety of one relative to OSHA permitted hoist stall loading, Cal/OSHA provided the following justification: "the hoist's stall load is an unusual event that is normally controlled by overload limiting devices on the hoist upper travel limit switches or obstruction bars to shut off the hoist motor" (Cal/OSHA 2008). Apparently, Cal/OSHA staff members do not feel it is necessary to maintain the strength required to sustain permitted loads simply because the permitted load is "unusual." In fact, almost all minimum structural design loads are extremely rare. Model building code provisions applicable to structures that sustain wind loads and most live loads require consideration of factored loads that occur, on average, only once every several hundred years. In general, the probability of a noncoastal building experiencing wind forces consistent with factored 90-mph wind demands (i.e., the current International Building Code requirement for most of the United States) is extremely low. The probability that the upper deck of a baseball stadium will ever experience the minimum code factored live loads is almost nil. Yet, in all of these cases, verification of adequate strength requires consideration of many very unlikely loads and load combinations.

Also related to stall loading, Cal/OSHA claimed, "Additionally, the ASME A120.1-2001 consensus standard for powered platform safety, Sec. 3.6.8(c), requires that overload protection be provided in the hoisting and suspension system…. Consequently, overload protection devices may be set as low as 1.25% [sic] of the rated load in order to stop the hoist motor in the event of an overloading or stalling situation" (Cal/OSHA 2008). While all of this is correct, it is both incomplete and irrelevant. The Cal/OSHA staff failed to mention the upper limit of the ASME A120.1-2001 overload protection requirements (i.e., the loading that would govern a legitimate design or evaluation process). Section 3.6.8(c) in its entirety says, "Overload protection. Overload protection shall be provided in the hoisting or suspension system to protect against the equipment operating in the up direction with a load in excess of the capacity of the hoist braking systems." In Sec. 3.6.8(e), ASME A120.1-2001 permits braking loads to be as high as "75% of the system's stability," which is three times the rated load and which is also the maximum hoist stall load. In other words, while overload protection devices "may" be set as low as 1.25 times the rated load of the hoist, the upper limit on overload protection load is far greater. The Cal/OSHA (2008) also fail to mention that ASME A120.1-2001

- Permits hoists to have stall loads of up to *three times* the corresponding rated load;
- Requires the capacity of the primary brakes to at least equal the maximum lifting capacity of the hoist (i.e., the stall load which can be up to three times the rated load); and
- Requires platform support devices to be able to carry a minimum of *four times* the rated load.

Clearly, verification of compliance with the ASME A120.1-2001 standard would require the same level of testing as verification of compliance with OSHA. Furthermore, even if the ASME provisions were modified to be less stringent, conformance with OSHA is still required.

On the subject of fall arrest anchorages and the fact that OSHA allows the use of systems that create up to 2,520 lbs of force, Cal/OSHA staff members had this to say, "However, these are maximum fall arrest forces permitted. Information from companies that manufacture and provide personal fall protection equipment indicate that actual fall arrest forces when one person is attached to an anchor with an appropriate shock absorbing lanyard are well below 900 lbs of fall arrest force" (Cal/OSHA 2008). Again, the implication is that it is unnecessary to maintain capacity consistent with permitted loads simply because lower loads are more likely or at least possible. The point missed by the Cal/OSHA staff members is that OSHA *does not* require the use of shock absorbing lanyards that limit fall arrest forces to 900 lbs—to the contrary, the OSHA limit is 2,520 lbs. Therefore, the Cal/OSHA testing protocol would not even provide a factor of safety of one in certain OSHA-compliant fall protection situations. On a practical note, the writers' firm is a major user of fall protection equipment, is familiar with many related products and associated manufacturer's claims, and has conducted tests using an instrumented mannequin to measure arrest forces associated with various fall conditions and equipment types. In this testing, we have measured fall arrest forces far greater than 900 lbs even when shock absorbing lanyards were used.

In Cal/OSHA (2008), the Cal/OSHA staff use consistency with International Window Cleaning Association (IWCA) (2001) as further justification for half-load testing. In the writers' opinion, this was a poor decision. The referenced standard is the inaugural edition that contains many errors and inconsistencies that have been the subject of extensive communication between the writers and the IWCA I-14.1 committee. Furthermore, when it comes to the subject of load testing and verifying compliance with applicable structural requirements, IWCA I-14.1 is hardly the most credible established reference available. Much more substantive information related to load testing is available in other documents, such as the American Institute of Steel Construction (AISC) (2005) and American Concrete Institute (ACI) (2008).

One of the most significant issues the Cal/OSHA staff misses in its California's Occupational Safety and Health Administration (Cal/OSHA) (2008) discussions is that half-load testing is inconsistent with owner needs. Since an owner must be able to assure users of a building's equipment that it meets applicable OSHA provisions (not *half* of the OSHA provisions), an engineer's certification of the equipment to the owner must provide the same assurance. So, even if for some reason an engineer feels that half the OSHA capacity is "enough," he/she cannot validly certify OSHA compliance on the basis of half-load testing. The only alternative explanation is that the Cal/OSHA staff considers passing a half-load test sufficient basis for certifying compliance with standards that require twice the strength. While common sense alone should provide a sufficient basis for rejecting this notion, California Professional Engineering practice law rejects it as well. Section (c)(7) of the California Board for Professional Engineers and Land Surveyors Board Rule 475 states, "A licensee shall only express professional opinions that have a basis in fact or experience or accepted engineering principles." Section (c)(11) states, "A licensee shall not misrepresent data and/or its relative significance in any professional engineering report." In short, there are no facts, experiences, or accepted engineering principles that support the opinion that testing an element to a particular load proves the ability of that element to carry twice that load. Moreover, using half-load test data to certify the ability to carry twice the test load clearly misrepresents the data's significance.

In California's Occupational Safety and Health Administration (Cal/OSHA) (2008), Cal/OSHA staff provided the following response to the writers' concerns that half-load testing would leave a number of deficient elements (i.e., those that would fail between 51 and 100% of the required minimum loads) in service, "However, there are no statistics, means, or methods to know how many installations may be compromised to the various deterioration levels described by the petitioners that would adversely affect the suitability of suspension equipment devices." It is difficult to fathom the purpose of such a statement other than to argue that ignorance regarding the extent of a known problem justifies ignoring it. The fact remains that Cal/OSHA half-load testing will leave an unknown number of deficient elements in service. Furthermore, assuming it is of interest to someone, testing to at least 100% of the minimum required strength will provide information regarding the extent to which Cal/OSHA testing would leave deficient items in service (i.e., the deficient items that would have passed the flawed Cal/OSHA testing protocol will be identified so that applicable statistics could be compiled). Most important appropriate testing would ensure that deficient items would not go undetected by the test program.

Illogical Claim: Testing to the OSHA-Specified Capacity Will Damage the Specimen

This notion has merit only when the test specimen must sustain substantial inelastic deformation in the course of mobilizing the needed capacity. Examples where such deformation may be acceptable are generally limited to anchorages where deformation does not preclude proper performance; although once deformed, such anchorages would typically need to be replaced. If there is reason to believe that an anchorage falls into this category (e.g., original design documentation or analysis of elements that are exposed to inspection), then NDPT is probably not a viable certification option, and analytical verification (and all that it entails) would be required. Since being "untestable" by virtue of unacceptable magnitudes of inelastic deformation is clearly a drawback, facade access structural components should be designed to support the required loading elastically, as discussed in the companion paper, whenever possible. In contrast, significant yielding of platform support elements such as davits or davit bases is typically not an acceptable type of behavior as it would create additional demands as the platform rope attachment point moves outward, a potentially unstable condition. In these situations, damage caused by full-load testing is a good thing in that it indicates a deficiency and eliminates what had been a potentially dangerous situation.

Requiring elastic response to specified loading is one rational change Cal/OSHA recently made to their provisions. The pending revisions to the IWCA I-14.1 standard also require components to remain elastic up to the required strength levels. This represents a change that the writers of this paper recommended to the IWCA I-14.1 committee in 2006. Unfortunately, promoting half-load testing undermines most of the value associated with requiring elastic performance at design loads.

Notwithstanding the above, in most of cases, this notion of preventing damage is a classic example of circular thinking. If the ultimate capacity of an element is known to be greater than the test load (i.e., if it is known that the test will cause no damage), then there is no need to do the test. For example, if there is concern about an anchorage that is required to have a capacity of at least 5,000 lbs but no doubt that it can carry 2,500 lbs, there is no need to test it to 2,500 lbs. Otherwise, if the anchorage's ability to carry 2,500 lbs is in doubt, then there is no assurance that testing to 2,500 lbs would not cause damage. To put it another way, testing only has value if there is a possibility that damage may occur during the test. The fact remains that only way to find out via testing that an item has the minimum required strength is to apply a load equal to or greater than the required strength.

In written commentary accompanying their provisions limiting test loads to half the required strength (Initial Statement of Reasons, California Code of Regulations, Title 8, Chap. 4, Subchapter 7, Article 5, Sec. 3291 and Article 6, Secs. 3,292, 3,295 and 3,296 of the General Industry Safety Orders), Cal/OSHA staff wrote, "The proposed amendment (to limit testing to half the required strength) is necessary so that these devices are tested sufficiently to ensure their structural integrity but not tested to the extent the devices or building structures sustain damage." However again, if it is already *known* that the test load would not damage the specimen, why test it? More important, if an element is incapable of carrying the minimum required load, the goal of a proper load test is to *reveal* the inadequacy by forcing a premature failure (i.e., by causing damage) under controlled circumstances. Finally, testing to half the required load will not "ensure structural integrity." To the contrary, it will permit deficient elements to avoid detection and remain in service.

The writers' experience includes a wide array of structural testing, including proof tests on hundreds of facade access components. Out of these many tests that were used to verify compliance of used facade access components, only a very small fraction of the test specimens were unable to carry the minimum required OSHA loading in a satisfactory manner. Furthermore, in the few cases where damage occurred, the specimen was typically able to carry half of the required loading but was unable to carry the required loading, which means the testing appropriately identified a deficient element that would not have been identified via half-load testing. Had half-load testing been done, very few of these deficient elements would have been detected and instead most would have remained in service.

Illogical Claim: Elements Tested to the Required Capacity Cannot Be Reused

In one of the more revealing moments of a Cal/OSHA hearing attended by one of the writers, a supporter of half-load testing and a member of the IWCA I-14.1 standard committee said, "Well, if you ask every manufacturer of window cleaning equipment in North American if they agree with having their davits load-tested in the field to 4,000 lbs for a 1,000-lbs capacity davit, they would say, 'Absolutely not. Take that out. It's been destroyed.'" In fact, however, there is no rational basis for rejecting an element that sustains, without damage, any particular load. If a structural element could carry a sustained load in a stable manner, with no signs of damage, and yet be unable to sustain a subsequent application of the same load, then proof testing in general would be invalid no matter what load is used. Ironically, an element that sustains the required load without damage would certainly pass a subsequent half-load test, which means the proponents of half-load testing would have no choice but to accept its reuse.

Proof Testing Summary

For reasons that are not completely clear, much of the facade access industry has come to accept, promote, and in some cases even require proof testing methods that fall far short of providing owners with the information they need concerning the safety of their facade access equipment and compliance with OSHA Standards. While testing to some level below the minimum required by OSHA is not a problem per se, it becomes a serious problem when engineers use such testing incorrectly (e.g., to certify conformance with OSHA requirements). Fortunately, nowhere outside the State of California are responsible engineers precluded from performing structurally appropriate tests. Unfortunately, responsible engineers certifying facade access components in California are being encouraged to rely solely on analytical verifications. Given that Cal/OSHA recognizes that testing can be useful when evaluating unknown conditions [Sec. 3296(b)(3)] and at the same time prohibits testing to the level needed to verify adequate capacity, it seems very likely that certifications in California are being based on half-load testing with some regularity. As common sense—and California Professional Engineering practice law—requires professional engineers to base their opinions on rational engineering principles, certifications of this type constitute a very serious problem.

Summary

OSHA requires owners to assure users of their facade access equipment that it satisfies applicable structural requirements. Over time, the basis for providing such assurances may become invalid, and the ability to perform as intended must be reevaluated. When evaluating equipment whose adequacy is in question, analytical methods consistent with appropriate design approaches can be employed. However, reliable analyses require detailed information concerning in situ conditions that can be difficult and/or costly to obtain. In such cases, proof testing often represents an efficient alternative, provided of course that the test proves what needs to be proven.

If compliance with OSHA minimum strength requirements is what needs to be established, then proof loads consistent with those requirements must be applied. Unfortunately, it has become commonplace in the facade access industry to base evaluations on testing to half of the required load. While such testing proves something (i.e., that the test specimen is at least half as strong as it needs to be), it does not prove conformance with OSHA standards, and it can lead to deficient elements being kept in service. The fact that Cal/OSHA adopted provisions in an attempt to prohibit proof load testing beyond half of the required strength (and in conflict with California Professional Engineering practice law) is remarkable and their documented reasons for doing so are alarming. Similar provisions being promulgated by other standard-writing bodies [International Window Cleaning Association (IWCA) (2001)] are also concerning. Fortunately, in most circumstances, there is nothing to prevent responsible engineers from performing appropriate tests.

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