U.S. Department
of Transportation

Federal Aviation
Administration

Advisory Circular

Subject: FRANGIBLE CONNECTIONS | **Date:** DRAFT | **AC No:** 150/5220-XX
Initiated by: AAS-100 | **Change:**

1. PURPOSE. This advisory circular (AC) contains the Federal Aviation Administration (FAA) specifications for the frangible connections used to support objects located in airfield safety areas.

2. SCOPE. This AC covers the following types of frangible connections:

a. Fuse bolts (also frangible or neck-down bolts),

b. Special material bolts (also alloy bolts),

c. Frangible couplings,

d. Tear-through fasteners (also countersunk rivets), and

e. Tear-out sections (also gusset plates).

This AC is based on the performance standards, specifications, and recommendations contained in two primary documents: the International Civil Aviation Organization (ICAO) *Aerodrome Design Manual*, Part 6, *Frangibility*, and the US Air Force (USAF) Engineering Technical Letter (ETL) 01-20: *Guidelines for Airfield Frangibility Zones*. These frangibility standards are meant to supplement, and not to conflict with, the specific testing and certification standards already in place in the various ACs produced by the Airport Engineering Division of the FAA Airports Organization. In the event of a conflict between the text of this document and the references to other ACs cited herein, those ACs take precedence. Otherwise, this document takes precedence over any other references mentioned.

3. APPLICATION. The specifications contained in this AC are recommended by the FAA in all applications involving the use of frangible connections. For airport projects receiving Federal funds under the airport grant assistance or the passenger facility charge programs, the use of these specifications is mandatory.

4. COMMENTS OR SUGGESTIONS for improvements to this AC should be sent to:

Manager, Airport Engineering Division
Federal Aviation Administration
ATTN: AAS-100
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Washington DC 20591

5. COPIES OF THIS AC. The public may obtain electronic copies of this AC by visiting the FAA home page and navigating to The Office of Airport Safety and Standards, Advisory Circular database (www.faa.gov). A printed copy of this AC and other ACs can be ordered from:

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CHAPTER 1. INTRODUCTION

1.1. GENERAL.

A fundamental goal of the FAA is to improve the safety of the runway environment at public use airports. Specific "safety areas" have therefore been established on airfields that prohibit the placement of objects that could present a hazard to operating aircraft. However, current technological limitations or operational requirements often require certain types of objects, such as navigational or visual aids, to be placed within these designated safety areas. In such cases, those objects are required to be of minimal mass and height, mounted as low as possible to the ground, and to be mounted on frangible support structures.

1.2. FRANGIBILITY CONCEPTS.

a. Flight Safety Impact. An aircraft in flight (or maneuvering on the ground) that impacts an object located on an airfield may be susceptible to the following flight safety risks: (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.1.1).

(1) The aircraft may lose momentum;

(2) The aircraft may change direction; and

(3) The aircraft may suffer structural damage.

b. Momentum Loss. The amount of momentum lost is mathematically governed by the integral of force over time. This implies that both the magnitude of the impact load and its duration presented by a frangible structure should be as minimal as possible. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.1.2)

c. Energy Components. The potential for structural damage to the aircraft is related to the amount of energy required to move the obstacle, or part of it, and must therefore be limited. This energy can be broken down into the following components: (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.1.3)

(1) Energy to activate obstacle break-away or failure mechanisms;

(2) Energy required for plastic and/or elastic deformation of the obstacle, or part of it; and

(3) Energy required to accelerate the obstacle, or part of it, up to at least the aircraft velocity.

d. Failure Mechanism. The energy required to activate break-away or failure mechanisms depends on the efficiency of their design and on the number of mechanisms to be activated. The energy absorbed by plastic or elastic deformation of the structure is strongly dependent on the choice of material: the amount will be higher for ductile materials with high-yield strengths. The (kinetic) energy required to accelerate the obstacle, or part of it, is dependent on the aircraft velocity, which is not a design variable, and on the mass to be accelerated. Therefore, the mass must be limited, for example, by using low-mass brittle materials and/or by limiting the amount of structure to be accelerated, which can be accomplished by incorporating suitably located break-away or failure mechanisms in the structure. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.1.4)

e. Impact Area. The structural damage to the aircraft is also related to the contact area between the aircraft and obstacle through which the energy transfer takes place. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.1.5)

f. Failure Mode:

(1) To meet the frangibility requirements, different failure mechanisms can be applied. For example, structures can be of modular design, which on impact "open a window" for the aircraft to pass through, or of a one-piece design, which on impact do not disintegrate but are deflected away by the aircraft. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.2.1)

(2) In the case of a modular design, the structure should contain break-away or failure mechanisms which, apart and together, require only a minimum amount of energy for their activation. This concept permits moving the least amount of mass out of the way of a colliding aircraft. The sequence of events is easier to predict as the structure behaves in a brittle way, disintegrating preferably at small deflections. The structure would fail if it wraps around or entangles an aircraft rather than disintegrating or falling to the ground. This is a difficult design goal to achieve and requires considerable testing to verify. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.2.2)

(3) In the case of a one-piece design, the frangibility must be guaranteed by a complete failure of the structure, which is achieved by the failure of structure members, instead of by failure of predetermined break-away or failure mechanisms. This implies that eventually the entire structure will be involved in the impact, resulting in a relatively high value of the kinetic energy required to move the structure out of the way. Therefore, this type of failure mechanism seems to be suitable only for lightly loaded structures, i.e. those meant to carry low-mass equipment. Moreover, due to the continuous nature of the structure, the sequence of events is difficult to predict and the tendency to "wrap around" the aircraft should be considered an additional hazard. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.2.3)

g. Impact load. The impact load is a rapidly changing dynamic load of short duration. Typical loading and response times are in milliseconds. The impact load influences the frangibility performance in two ways. First, the maximum impact load may adversely affect the structural integrity of the aircraft. Second, the integral of the impact load over the duration of the impact may lead to a change of momentum (including direction) of the aircraft. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.3)

h. Energy Transfer:

(1) During an impact, energy will be transferred from the aircraft to the obstacle. As the damage to the aircraft is proportional to the energy transferred, it should be limited. The energy required is estimated as follows: (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.4.1)

(a) The energy required to cause a break-away mechanism to fracture is determined in a laboratory on a component scale; this amount of energy must be multiplied by the number of mechanisms to be broken;

(b) The energy required for plastic and/or elastic deformation is calculated or determined by simple tests; this energy is often negligible when stiff and brittle materials are applied in a modular design; and

(c) The kinetic energy required for acceleration of the fragments, or the total structure in the case of a one-piece design, is calculated using the known mass and the representative aircraft velocity.

(2) The estimation should be done for all different scenarios of an aircraft impacting the structure. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.4.2)

1.3. DEFINITIONS.

a. Airfield Obstacles. All fixed objects located within the airfield environment that extend above any of the imaginary surfaces of the airfield or are located within the runway or taxiway safety areas. Airfield obstacles may be of either standard or nonstandard design. Obstructions are also classified as obstacles.

b. Break-away or Failure Mechanism. A device which has been designed, configured, and fabricated in a manner that it is very sensitive to one type of loading, usually resulting from a time dependent dynamic impact, but immune to the normal environmental and operational loads imposed on the mechanism during the lifetime of the structure. The "break-away mechanism" can be designed in conjunction with the joints of the structure and/or designed independent of the joints of the structure.

c. Frangibility. The ability of an object to collapse or fall over when struck by a moving vehicle.

d. Frangible Object. An object of low mass designed to break, distort, or yield on impact to present a minimal hazard to aircraft. The goal of these objects is to not impede the motion of, or radically alter the path of an aircraft, while minimizing the overall potential for damage during an incident.

e. Impact Energy. The amount of energy of a moving object imparted to an obstacle.

f. Impact Load. A sudden application of a load or force by an object moving with high velocity.

g. Low Impact Resistant Supports (LIRS). Supports designed to resist operational and environmental static loads and fail when subjected to a shock load such as that from a colliding aircraft.

h. Material Toughness. The ability of a metal to deform plastically and to absorb energy prior to failure or fracture.

i. Modulus of Toughness. The ultimate amount of energy by volume that a material will absorb. This value may be calculated as the entire area under the stress-strain curve from the origin to failure.

j. Object Free Area (OFA). An area on the ground centered on a runway, taxiway, or taxilane centerline provided to enhance the safety of aircraft operations by having the area free of objects, except for objects that need to be located in the OFA for air navigation or aircraft ground maneuvering purposes (as defined in AC 150/5300-13, *Airport Design*).

k. Runway Safety Area (RSA). A defined surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot, or excursion from the runway (as defined in AC 150/5300-13, *Airport Design*).

l. Taxiway Safety Area (TSA). A defined surface alongside the taxiway prepared or suitable for reducing the risk of damage to an airplane unintentionally departing the taxiway (as defined in AC 150/5300-13, *Airport Design*).

1.4. ACRONYMS AND TERMS.

AASHTO	American Association of State Highway and Transportation Officials
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
NCHRP	National Cooperative Highway Research Program
PVC	Polyvinyl Chloride
USAF	United States Air Force
LIR	Low-impact Resistant

1.5. APPLICABLE DOCUMENTS.

The following documents form part of this specification and are applicable to the extent specified.

a. FAA Orders, Specifications, Drawings, and Advisory Circulars (ACs):

AC 150/5340-26A	*Maintenance of Airport Visual Aid Facilities*
AC 150/5345-44H	*Specification for Taxiway and Runway Signs*
AC 150/5345-45C	*Low-impact Resistant (LIR) Structures*
AC 150/5345-46C	*Specification for Runway and Taxiway Light Fixtures*
AC 150/5345-53	*Airport Lighting Equipment Certification Program*
AC 150/5300-13	*Airport Design*
Drawing C-6046	

b. Military Publications:

U.S. Air Force (USAF) Engineering Technical Letter (ETL) 01-20: *Guidelines for Airfield Frangibility Zones*, November 2001.

c. International Civil Aviation Organization (ICAO):

Aerodrome Design Manual, Part 6, “Frangibility”, 2006.

d. American Society of State Highway and Transportation Officials (AASHTO):

LTS-4-M - *Structural Supports for Highway Signs, Luminaires and Traffic Signals,* 4th Edition, with 2002, 2003, and 2006 Interims

e. Transportation Research Board (TRB) - National Cooperative Highway Research Program (NCHRP):

Report 350	*Recommended Procedures for the Safety Performance Evaluation of Highway Features*
Report 494	*Structural Supports for Highway Signs, Luminaires, and Traffic Signals*

f. The documents listed above may be obtained from:

(1) FAA ACs may be obtained from: U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Ave., Landover, MD 20785. Telephone: (301) 322-4961, FAX: (301) 386-5394, www.faa.gov

(2) FAA Orders, Specifications, and Drawings may be obtained from: Federal Aviation Administration, ATO-W CM-NAS Documentation, Control Center, 800 Independence Avenue, SW, Washington, DC 20591. Telephone: (202) 548-5502, FAX: (202) 548-5501, www.faa.gov/cm/dcc

(3) USAF publications may be obtained from: HQ AFCESA, 139 Barnes Drive, Suite 1, Tyndall AFB, FL 32403-5319, Telephone: (888) 232-3721, www.e-publishing.af.mil/

(4) ICAO publications may be obtained from: icaodsu.openface.ca/search.ch2 (the Part 6, Frangibility document can be found in the pull-down list under the "Documents" box.)

(5) AASHTO publications may be obtained from: bookstore.transportation.org/shop_by_phone.aspx/

(6) NCHRP publications may be obtained from: books.trbbookstore.org/

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CHAPTER 2. PERFORMANCE STANDARDS

2.1. GENERAL.

The performance standards listed in this section are focused on the frangible connections used to support equipment located in airfield safety areas. A wide variety of equipment exists in airfield safety areas, each with specific performance requirements designated in ACs produced by the Airport Engineering Division. As such, general frangibility requirements are provided, while the particular requirements for different classes of airfield structures (such as elevated lights, signs, and navigational aids, etc.) are specified when applicable.

2.2. REQUIREMENTS.

a. Equipment and its supports, located in airfield safety areas (such as RSAs, TSAs, or OFAs, as specified in AC 5300-13), must be frangible to ensure that they will break, distort, or yield in the event that they are accidentally impacted by and aircraft. The design materials selected must preclude any tendency for the components, including the electrical conductors, etc., to "wrap around" the colliding aircraft or any part of it. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 3.3.1)

b. The frangible structure must include concepts such as low-mass members, brittle or low-toughness members and connections, and/or suitable break-away mechanisms. Various design concepts exist, each with its own advantages and disadvantages. Designs may incorporate one or more concepts in order to ensure frangibility. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.1) A detailed discussion of approved frangible connections is found in Chapter 3 of this AC.

c. Structural Integrity:

(1) General Requirements. Unless otherwise specified, frangible connections located in the OFA, RSA, or TSA must be designed as follows:

(a) to withstand the static and operational wind or jet blast loads with a suitable factor of safety but should break, distort, or yield readily when subjected to the sudden collision forces of a 6614 pound (lb) (3000 kg) aircraft airborne and traveling at 87 mph (140 km/h or 75 kt) or moving on the ground at 31 mph (50 km/h or 27 kt);

(b) to not impose a force on the aircraft in excess of 10,116 pounds force (lbf) (45 kN, or 10 kip). The maximum energy imparted to the aircraft as a result of the collision must not exceed 40,566 foot pounds (ft lbs) (55 kJ) over the contact period (approximately 100 milliseconds) between the aircraft and the structure. To allow the aircraft to pass, the failure mode of the structure must be one of the following: fracture, windowing, or bending. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.9.20); and

(c) to provide for a frangibility point no greater than 3 inches (76 mm) above the surrounding grade. Structural foundations (e.g. concrete blocks) must be made flush with the surrounding grade (or as close as possible if there is a need to mitigate water accumulation/ponding). (Reference AC 150/5300-13, *Airport Design*).

(2) Specific Requirements. Design standards for the following types of equipment are provided in the following ACs:

(a) Signs, Runway and Taxiway	AC 150/5345-44H (2007)
(b) Low-impact Resistant (LIR) Structures	AC 150/5345-45C (2007)
(c) Light Fixtures, Runway and Taxiway	AC 150/5345-46C (2006)
(d) PAPIs and REILs	FAA Drawing C-6046

d. Any design using frangible mechanisms has to ensure that no slippage or change in shape occurs from cyclic loading. For example, in a design using interconnecting tubes, aeroelastic flutter on a tube caused by a jet blast or wind could loosen or separate it from its counterpart. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.8)

e. Break-away or Failure Mechanisms. The location of break-away or failure mechanisms must be such that disintegration results in components of predictable mass and size, which, in case of a secondary impact, do not present a greater hazard than they present as part of the undamaged structure. It is desirable that break-away or failure mechanisms be independent of the strength required for withstanding wind loads, ice loads, and other environmental loads. In addition, the mechanism must not be subjected to premature fatigue failure. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.6)

f. Environmental. The environmental requirements for specific types of equipment can also be found in the ACs listed in paragraph 2.2.c.2. The environmental requirements for frangible connections supporting such equipment are equal to those required for the entire structure/system.

g. Material Selection:

(1) Materials and configuration for frangible structures must be suitable for the intended use and should result in the lightest structure possible. Structures can be fabricated from metallic or non-metallic materials that are not adversely affected by outdoor environmental conditions. Material selected to meet frangibility requirements must be strong, lightweight, and have a low modulus of toughness. Minimum weight is important to ensure that the least amount of energy is expended to accelerate the mass to the velocity of the impacting aircraft. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.7.1)

(2) Standard, commercially available materials provide the most cost-effective design. Non-metallic materials can be specially designed to provide excellent frangibility characteristics; however, their structural behavior may be difficult to analyze because of uncertainty about their elastic modulus or material isotropy. All material must be able to withstand or be protected against environmental effects including weathering, solar radiation, temperature fluctuation, etc., typical of an outdoor environment.

h. Electrical Components. The strength of electrical conductors incorporated in the design of frangible structures as well as the fire hazard presented by the arcing of disrupted conductors must be considered in the overall design. It is recommended that conductors be designed such that they do not rupture but break at predetermined points within the limits for frangibility of the structure. This is accomplished by the provision of connectors that require a lower tensile force to separate than that required to rupture the conductor. In addition, the connectors should be protected by a break-away boot of a size commensurate with the voltage employed in order to contain any possible arcing at disconnection. Break-away connector assemblies are commercially available. (Reference ICAO

Aerodrome Design Manual, Part 6, Section 4.8.2 and USAF ETL 01-20: *Guidelines for Airfield Frangibility Zones*, Section 5.8)

i. Maintenance Equipment Design:

(1) A frangible structure no longer meets requirements if the structure itself is used as a climbing frame or is denigrated by the addition of a fixed ladder. The total structure should be maintained either by equipment that can be easily moved into position or by lowering the structure to the ground. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 7.2.2)

(2) Portable maintenance stands are recommended to maintain airfield lighting structures. In cases where the maintenance equipment is permanently fixed and adjacent to the frangible structure, that equipment must also be mounted on frangible supports. However, if the maintenance equipment is made of material such as plastic or wood, and mounting the equipment on frangible supports would be impractical or cost-prohibitive, then alternate frangibility provisions are acceptable.

(a) If permanently fixed maintenance stands are to be used, they should be made of material no stronger than Schedule 40, 2 inch (51 mm) diameter PVC piping or pressure treated wood posts no larger than 4 x 4 inches (0.1 x 0.1 m) in size. Additionally, if wood is used, 1 inch (25 mm) diameter holes must be drilled through each face of the post, at a height no greater than 3 inches above the surrounding grade.

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CHAPTER 3. TYPES OF FRANGIBLE CONNECTIONS

3.1. GENERAL.

In a frangible connection design, frangibility is incorporated in the connection, which carries the design load but fractures at impact. The structural member is not designed to break but rather to transfer the impact force to the connection. A stiff, lightweight member provides efficient load transfer to the connection and minimizes the energy absorbed from bending and mass acceleration. The connection should break at low energy levels, as determined by impact tests. Types of frangible connections include neck-down or fuse bolts, special material or alloy bolts, countersunk rivets or tear-through fasteners, and gusset plates with tear-out sections. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.2)

3.2. FUSE BOLTS (ALSO FRANGIBLE OR NECK-DOWN BOLTS).

a. Failure of this type of connection is induced by providing a "stress raiser," due to removal of material from the bolt shank. One method used to achieve this is to machine a groove to reduce the bolt diameter or to machine flats in the sides of the bolts, making it weaker in a specific direction. Shear strength is maintained and tensile strength is reduced by machining a hole through the bolt diameter and locating it out of the shear plane. Fuse bolts must be carefully installed to ensure they are not damaged or overstressed when tightened. One disadvantage of fuse bolts is that the stress raiser may shorten the fatigue life of the bolt or may propagate under service loads and fail prematurely. Fuse bolts with machine grooves are commercially available. See Figure 1 an example of the application of such fuse bolts. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.2.a)

Figure 1. Application of Fuse Bolts

b. Common applications of fuse bolts include use as the frangible connections for localizers (typically five-eighth or 0.625 inch (15.88 mm) diameter bolts) and for approach light towers (typically three-quarter or 0.75 inch (19.1 mm) diameter bolts).

3.3. SPECIAL MATERIAL BOLTS (ALSO ALLOY BOLTS).

Use of fasteners manufactured from special materials eliminates the need for extensive machining or fabricating and allows the basic design to consist of conventional cost-effective techniques. The fasteners are sized to carry the design loads but are made from material with low-impact resistance. Materials such as steel, aluminum, and plastic should be selected based on strength and minimum elongation to failure. Because frangibility is based on material selection, it is extremely important to purchase hardware with guaranteed compliance of physical properties. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.2.b)

3.4. FRANGIBLE COUPLINGS.

a. A frangible connection for cylindrical or tubular objects is often obtained through the use of frangible couplings. Frangibility is achieved in these devices by modifications that reduce the circumference of the coupling at a given point or through the machining of holes or other elements that reduce the effective strength of the coupling at a given point.

b. Common applications of frangible couplings are found in light posts, masts, and electrical metallic tubing (EMT) supports for runway and taxiway lights (See ACs 150/5345-44, 150/5345-46, and FAA Drawing C-6046 for frangibility requirements). It is important to recognize that many types of frangible couplings are available, and only those types approved for the purpose or application originally intended should be used.

3.5. TEAR-THROUGH FASTENERS (ALSO COUNTERSUNK RIVETS).

Fasteners such as countersunk rivets can be used to sustain shear loads but tear through the base material if the impact force creates a tension load. The hole in the base material is accurately machined to grip a minimum amount of the area under the head of the fastener. The taper of the countersunk head also helps initiate the pull-through. This technique relies heavily on the manufacturing process and requires extensive quality inspection. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.2.c)

3.6. TEAR-OUT SECTIONS (ALSO GUSSET PLATES).

Connecting gusset plates can be designed with notches that will tear out with the member. In this type of connection the fastener does not break but instead is used to pull out a section of the gusset plate. Fatigue life and manufacturing quality are the primary design considerations. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.2.d)

3.7. OTHER FRANGIBLE MECHANISMS.

a. Frangibility can be incorporated into the support structure by means of a mechanism that slips (e.g. slip-bases), breaks, or folds away on impact and removes the structural integrity of the support. A frangible mechanism can be designed to withstand high wind loads but remain very sensitive to impact loads. Frangible mechanisms tend to be directional in strength, i.e. they carry high tension and bending but very low shear. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.5).

b. Friction joints used as frangible mechanisms can supply high strength normal to the sliding surface but slip when the force is applied parallel to the sliding surface. In a support structure, impact forces are predominantly horizontal. Friction joints should be designed so that the slip plane is horizontal and complete failure occurs if impacted in any direction in that plane. This is achieved by using flangetype couplings on the ends of tower legs or interconnected tubes that slide apart on impact. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.6)

c. "Swing-away" support members can also be used as frangible mechanisms. These are incorporated into the structure to provide stability but if broken away on impact, leave the structure unstable and allow it to fracture. This type of design, however, may require large amounts of mass to be moved out of the way before failure. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 4.5.7)

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CHAPTER 4. QUALIFICATION REQUIREMENTS

4.1. SELECTION, INSTALLATION, INSPECTION, AND MAINTENANCE.

a. Selection: There are two primary factors used in selecting frangible connections for supporting equipment in airfield safety areas:

(1) First, all devices must be approved according to the testing requirements outlined in Section 4.2 of this AC.

(2) Second, it must be ensured that the total rated shear strength of *all* the frangible connections do not exceed the frangibility design requirements listed in the relevant equipment ACs.

As a general example, in order to meet the impact force limits to an aircraft defined in the general structural integrity requirements (paragraph 2.2.c.1.b) of this AC, the rated shear strength of all the frangible connections used to support a structure must be less than or equal to 10 Kips. In this case, the use of 4 fuse-bolts with rated shear-strengths of 2.5 Kips each would be acceptable. Any other combination of bolts yielding a total greater than 10 Kips would be unacceptable for this example. It must be emphasized that the structure must be viewed *as a complete system* in order to determine the proper amount and type of frangible connections that are to be used.

b. Installation. Frangible structures should be installed in accordance with the recommendations of the manufacturer and the requirements of the applicable Advisory Circular. This refers to the structure, any cabling and connectors, and the base on which the structure is fitted. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 7.2.1)

(1) Firm bases are essential for any precision visual or non-visual navigational aid. The design of the base should therefore provide maximum stability. Navigational aids are commonly supported on a concrete base, which should not be an obstacle to an aircraft overrunning an installation. This objective is achieved either by depressing the base below ground level or by sloping its sides so that the aircraft comfortably rides over the base (see paragraph 2.2.e for detailed requirements). Where the base is depressed, the cavity above the base should be back-filled with appropriate material. This, together with the frangible construction of the navigational aid and its supports, ensures that no substantial damage is sustained should an airplane run over the aid. (Reference ICAO *Aerodrome Design Manual*, Part 6, Section 7.2.3 and USAF ETL 01-20: *Guidelines for Airfield Frangibility Zones*, Section 5.9)

c. Inspection and Maintenance. The inspection and maintenance of frangible structures should meet the manufacturer’s or purchaser’s requirements, whichever is more stringent. Recommendation for an inspection and maintenance program can be found in AC 150/5340-26A, *Maintenance of Airport Visual Aid Facilities*, and the ICAO *Aerodrome Design Manual*, Part 6, Section 7.3.

4.2. TESTING, CERTIFICATION, AND APPROVAL.

a. General. All frangible connections and devices must be tested for conformance to frangibility standards by an independent, third-party certification body. For equipment listed in FAA ACs, the provisions of AC 150/5345-53 must be met. Detailed testing and certification requirements are found below.

b. Testing:

(1) There are two primary categories of frangibility testing considered in this AC. The first category is that which is undertaken to determine the frangibility performance of an entire airfield structure. Within this category, a number of frangibility testing requirements apply, including:

(a) Signs, Runway and Taxiway	AC 150/5345-44H (2007)
(b) Low-impact Resistant (LIR) Structures	AC 150/5345-45C (2007)
(c) Light Fixtures, Runway and Taxiway	AC 150/5345-46C (2006)
(d) Other Airfield Equipment	ICAO *Aerodrome Design Manual*, Part 6, Chapter 5, "Testing for Frangibility"

(2) The second category of frangibility testing applies only to the frangible connections used to support airfield structures. The testing procedures used by the Federal Highways Administration (FHWA) to determine the performance of frangible connections found in highway infrastructure provide a reasonable indication of how those same objects might perform in the airfield environment. It is the intent of this AC to build upon and adopt the substantial testing program of the FHWA regarding frangible connections.

(a) In testing frangible connections, the FHWA requires that testing procedures are performed in accordance with the National Cooperative Highway Research Program (NCHRP) Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*. The requirements for breakaway supports used in that testing are based on the American Association of State Highway and Transportation Officials' (AASHTO) *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.

(b) Results of this testing are submitted to the FHWA for approval, whereupon acceptance letters are written to manufacturers of frangible connection devices (or breakaway support systems) acknowledging that the devices tested successfully according to the required parameters and performed satisfactorily. Typically, the acceptance letters describe the device tested and include a drawing of the device, test results, and information on limitations on use of the device, such as the weight of the system tested or the soil in which it is acceptable. The acceptance letters are also posted online, and can be found at the following URL for the FHWA:
http://safety.fhwa.dot.gov/roadway_dept/road_hardware/breakaway.htm

(3) The third party certification body will determine if any software simulations are acceptable to supplement frangible device performance. General guidance on these methods can be found in the ICAO *Aerodrome Design Manual*, Part 6, Chapter 6.

c. Certification and Approval:

(1) Manufacturer's wishing to obtain certification and/or approval of their equipment for use in airports must follow the procedures of AC 150/5345-53, using the requirements of equipment listed in paragraph 4.2.b.1, if applicable.

(2) For devices or equipment not applicable to the preceding paragraph, such as commonly available frangible connection devices, items that have been approved by the FHWA for use in highway applications (as described in paragraph 4.2.b.2) are similarly approved for use in airports, provided that all of the performance standards listed in Chapter 2 of this AC have been met.

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