Size-up is one of the most important aspects of our initial operations. Determining the incident’s critical factors plays a large part in developing an incident action plan. The critical factors fall under eight broad categories, including building. The more we know about the structures in our community, and the more we know about how they were built, the safer our incident operations will be. Use the building-construction alphabet in this article to further your department’s general knowledge. The construction definitions and processes described here should be known by all firefighters. The collapse or failure of a construction element can create dangerous—even deadly—event.

A
Arch—A curved masonry structure used as a support over an open space. Removing or destroying any part of an arch will cause the entire arch to collapse.

B
Balloon construction—One of the three basic wood-frame residential construction methods (braced-frame and platform are the other two). A balloon-frame building’s exterior walls have studs extending continuously from the structure’s foundation sill to the top plate near the attic. The concealed space between these studs can allow fire, smoke and heat to spread from the cellar area and the intermediate floors to the attic space. If a non-bearing wall collapses during a fire, the continuous studs will cause the wall to fall outward in one section at a 90-degree angle. If a bearing wall within one of these structures fails, it can cause a second collapse of the floors it supports.

Braced-Frame Construction—One of the three basic wood-frame residential
construction methods (balloon and platform are the other methods). Sometimes called post-and-girt construction because vertical timbers, called posts, reinforce each of the structure’s four corners, and horizontal timbers, called girts, reinforce each floor level. Mortise-and-tendon joints (described later in this article) connect the posts and girts. During a fire, a braced-frame building’s wall often fails in an inward/outward collapse. The wall breaks apart, with the top part collapsing inward on top of the pancaked floors, and the bottom part collapsing outward onto the street.

**Collapse**—The failure of any portion of a structure during a fire. A section of falling plaster ceiling, a broken fire-escape step, a falling coping stone and the collapse of several tons of brick wall are all structural failures and should be classified as structural collapse. The following are types of collapse:

*Curtain-Fall Wall Collapse*—One of the three types of masonry wall collapse, this occurs when an exterior masonry wall drops like a curtain cut loose at the top. The collapse of a brick veneer, brick cavity or masonry-backed stone wall often occurs in a curtain-fall manner. When an aerial platform’s master stream strikes a veneer wall at close range, it can trigger a curtain-fall collapse of bricks.

*Inward/Outward Collapse*—The collapse of an exterior wall that breaks apart horizontally. The top collapses inward, back on top of the structure; the bottom collapses outward toward the street. Wood-braced, frame-constructed buildings collapse in this manner, and a timber-truss roof collapse can cause a secondary collapse of a front wall in this way.

*Lean-Over Collapse*—A type of wood-frame-building collapse indicated when the burning structure slowly begins to tilt or lean to one side.

*Lean-To Floor Collapse*—A floor collapse in which one end of the floor beams remains partially supported by the bearing wall, and the other end of the floor beams collapses toward the floor below or collapses but remains unsupported. A lean-to collapse can be classified as supported or unsupported, depending upon the position of the collapsed beam ends. A simple supported beam is supported at both ends. If the deflection at the center of such a beam becomes excessive, a collapse may occur. A simple supported beam is more stable under fire conditions than a cantilever beam, but less stable than a continuous supported beam. A cantilever beam is a beam supported at only one end. A continuous support beam is a beam supported at both ends and in the center.

*Ninety-Degree-Angle Wall Collapse*—A type of burning-building wall collapse. The wall falls straight out in a monolithic piece at a 90-degree angle, similar to a falling tree. The top of the falling wall strikes the ground at a distance from the base of the wall that is equal to the height of the falling section. Bricks or steel lintels may bounce or roll out beyond this distance.

*Pancake Floor Collapse*—The collapse of one floor section down upon the floor below in a flat, pancake-like configuration. When floor beams pull loose or collapse at both ends, a pancake collapse occurs.

The more we know about the structures in our community, the safer our operations will be.
Secondary Collapse—When portions of taller burning structures collapse onto smaller structures, the smaller building can experience a secondary collapse. On Dec. 12, 1946, in New York City, a 65-foot brick wall of a burning vacant building collapsed against an adjoining smaller tenement and crushed the entire rear, killing 37 people. Large buildings collapsing on top of smaller buildings cause the smaller buildings to collapse.

Tent Floor Collapse—A floor collapse in the shape of a tent. When a floor collapses and an interior partition or wall holds up the center of the fallen floor, a tent floor collapse occurs. If the interior partition were not present, the structure would experience a pancake collapse.

V-Shape Floor Collapse—The collapse of a floor at the center of the floor beams. The broken center of the floor section collapses down upon the floor below, and both ends of the floor section remain partially supported or rest upon the outer bearing walls.

Deck—A horizontal surface-covering supported by a floor or a roof beam. When an arsonist spills an accelerant on a floor or roof to start a fire, the deck area inside the spill is charred and weakened. Firefighters searching or advancing hoselines in such a building often plunge through collapsing decks. Floor beams prevent firefighters from falling into the fire or the area below. However, if a firefighter cannot escape quickly from the collapsing deck, and fire is burning below, they will suffer severe and disabling foot, leg and groin burns. It is very difficult for them to remove their foot from a hole in a plywood deck because the splintered edges of the hole trap it.

Deflection—A bend, twist or curve of a structural element under a load. All structures deflect slightly when supporting a load, but a structural element is designed to withstand a load without showing signs of deflection. When a firefighter notices the deflection of a column, beam or wall, they should know this condition indicates structural overload or failure, and they should report it to the officer in command immediately.

Façade—The front or face of a building. The portion of a façade that extends above roof level is called a parapet wall. The façade’s parapet is often a free-standing, decorative wall, which frequently collapses during a fire. Parapet walls with decorative stone corbel copings are among the most unstable walls a firefighter will encounter; the slightest shift of the supports below the parapet will create a collapse danger. Even without fire conditions, these walls are prone to collapse. In areas where earthquakes occur frequently, the law limits a parapet wall’s height and ornamentation.

Fire-Cut Beam—A gravity-support beam designed to self-release from a masonry wall during a collapse. The end of the wooden beam, where it rests within the cavity of a masonry wall, is cut at an angle. It is designed this way to save the expensive masonry wall during a fire and resulting collapse. An
unintended, indirect advantage of fire-cut beams is that the floor collapse will not topple the bearing walls outward on top of firefighters operating outside the building near the enclosing walls. However, firefighters operating inside a burning building with these fire-cut beams may encounter early floor collapse.

Fire Load—The measure of maximum heat released when all combustible material in a given fire area burns. The content and structure of a building contribute to its fire load. Structural collapse during a fire is directly proportional to the fire load. The greater the fire load, the greater the possibility of structural collapse during a fire. It takes the extreme heat produced by large fire loads to weaken unprotected steel, spall concrete or destroy wooden structural members.

Force—The cause of a motion, change in motion or a stoppage of motion. Forces can be external or internal. An external force is a load, such as a dead load, a live load, a wind load or an impact load. An internal force is a stress, such as a compressive stress, a tension stress or a shear stress. External or internal force can collapse a structure.

Gusset Plate—A metal fastener in the form of a flat plate used to connect structural members. Example: a steel plate with steel bolts and nuts is a gusset-plate connection. An inferior type of gusset plate, a sheet-metal surface fastener, is used on lightweight wood trusses. This ¼-inch-thick piece of sheet metal has many small, triangular holes punched through it with a stamping machine. These hole-punches create V-shaped points that substitute for the old gusset plates’ steel bolts and nuts. The points, which act as nails, measure only ½ inch long; they penetrate the wood trusses only a fraction of an inch. During a fire, the sheet-metal surface fasteners quickly fall off the structure; heat warps and bends the sheet-metal connectors, and surface charring weakens the nailing surface. These connectors also may be knocked loose from the wood trusses during shipping and unloading at the construction site. From a fire-protection point of view, a sheet-metal surface fastener is an inferior, dangerous connector.

Header Beam—A support used to reinforce an opening in the floor of an ordinary, wood-frame or heavy-timber building. A header beam (sometimes doubled for increased strength) is placed perpendicularly between two trimmer beams and supports the shorter, cut-off beams, called tail beams. The header and trimmer beams encircle an opening in the floor. If a firefighter cuts through or pulls down a header beam, the tail beams and floor deck can collapse.

Hierarchy of Building Elements—A building’s horizontal and vertical structural elements arranged in a collapse hierarchy. The collapse of certain structural elements is more dangerous than the collapse of other structural elements, depending upon where they fit in the hierarchy.
I-Beam—A horizontal structural element with a middle section, called a web, and top and bottom sections, called flanges. A wooden I-beam is a lightweight, engineered-wood floor system that can suffer early collapse.

Joist—A joist is piece of lumber used as a floor or roof beam. The terms joist, beam and rafter are used interchangeably. A joist supports a roof or floor deck and is often supported by a girder.

Kip—One kip equals a thousand pounds. When measurements expressed in pounds become large and unwieldy, kips are used to simplify the figures. The term kips is used most often when stating the strength of steel, e.g. kips per square inch = KSI.

Loads—Forces acting upon a structure. The loads that can cause a collapse during a fire are dead loads, live loads, impact loads and fire loads.

Axial Load—One of the three ways a load can be imposed upon a supporting structural element (eccentric and torsional loads are the other two methods). An axial load passes through the center of a structure and is the most efficient way a load can be transmitted through a structural support, such as a column or a bearing wall. A structural element can withstand the greatest load—and is less likely to collapse—when the load is axial. When flames are destroying a building, structural elements become deformed and shift slightly because of heat and flame. As a result, axial loads become eccentric (off centered) or torsional (twisting) loads. Structural collapse can occur during a fire when a dead load transmitted through a column or bearing wall becomes an eccentric or torsional load.

Concentrated Load—A load applied to a structure at one point or within a limited area. A concentration of heavy cast-iron fixtures inside a small bathroom is a concentrated load. When weakened by fire, the bathroom...
A load distributed over a large area creates less strain on a supporting structure during a fire than does a load in a small area.

Dead Load—One of the five major loads that must be considered when designing a building (live, wind, impact and seismic loads are the others). A dead load is a static or fixed load created by the structure itself and all permanent equipment within. Walls, floors, columns and girders contribute to a structure’s dead load. Air-conditioning machinery, fire escapes, suspended ceilings, rooftop water-storage tanks and advertising signs are part of the equipment dead load. Firefighters have been killed by dead-load collapse.

Eccentric Load—A load transmitted off center or unevenly through a structural member. During a fire, an axial load can slowly become an eccentric load when steel columns or girders expand, timber surfaces char, or concrete spalls and exposes reinforcement steel. When load transmission slowly changes during a fire from axial to eccentric, the structure’s strength is seriously diminished. When floors collapse inside a burning brick-and-joist building, the load on the bearing walls shifts violently from a vertical axial load to a lateral eccentric load. This shift often makes the walls collapse.

Impact Load—A load applied to a structure suddenly, such as a shock wave or a vibration. An impact load can cause a structure to collapse more readily than a slow, steady, evenly applied load. Examples include explosions, or directing a master stream at a structure in a whipping or pulsating manner.

Lateral Load—Any type of load applied to an upright structure from a direction parallel to the ground. Examples: wind loads, ladder tips placed against structures, horizontal explosion shock waves and hose streams. Most upright structures are not designed to withstand lateral loads. A structure capable of withstanding great vertical loads may collapse under slight lateral loads.

Live Load—A transient or movable load, such as a building’s contents, the occupants, the weight of firefighters, the weight of fire equipment, and the water discharge from hose streams.

Static Load—A load that remains constant, applied slowly. A structure may support a greater amount of static load than impact load. Example: the contents of a floor used for storage. A firefighter who slowly and softly applies his weight along a roof deck above a fire or on a fire-escape step is demonstrating the principle of static loading.

Torsional Load—A load that creates a twisting stress on a structural member. When a large steel girder collapses at one end, the other end experiences a torsional or twisting stress.
Wind Load—A lateral load imposed by wind. A wind load may tear off a structure’s roof or collapse a free-standing parapet wall or chimney.

Mortise—A structural connection often used in braced wood-frame construction, a mortise is a hole cut into a piece of wood/timber in order to receive a tenon. A tenon is a projection at the end of a piece of timber that is inserted into the mortise of another timber. Mortise-and-tenon connections are used in braced wood-frame residential construction. Because of its reduced size, the tenon connection is the timber’s weakest portion; it can be destroyed by fire and decomposed when exposed to moisture. The mortise reduces the thickness of the timber and reduces its load-carrying capability at this point. When the timber-braced framework fails during a fire, it often breaks apart at the mortise-and-tenon connection, which has become weakened by flames and decomposition.

Noncombustible Construction—Construction material that will not fuel fire and will therefore not spread fire. It is important to note that noncombustible construction will not resist fire. Fire-resistive construction will resist fire.

Open-web steel-bar joists—A lightweight steel truss used as a floor or roof beam. It is made from a steel bar, bent at 90-degree angles and welded between angle irons at the top and bottom bar bends. This open-web bar joist is used for floor and roof beams in non-combustible buildings. An unprotected open-web steel-bar joist can collapse after 5 to 10 minutes of fire exposure.

Platform Wood-Frame Construction—One of the three methods of wood-frame residential building construction (the others are balloon and braced frame). The platform-construction method builds a structure one level at a time. One complete level of 2 x 4 enclosing walls is raised and nailed together; the floor beams and deck for the next level are constructed on top of these walls. The next level of 2 x 4 enclosing walls is then constructed on top of the first completed level. From a fire-protection standpoint, platform construction is superior to balloon and braced-frame construction because no concealed exterior wall voids extend beyond one floor level. Lightweight wood HVAC systems and other “fixed” elements are considered dead loads.
construction, using small wood trusses for floors and roofs, may replace platform construction in the future, but from a fire-protection and a collapse point of view, lightweight wood construction is inferior and dangerous to firefighters.

Q
Q-Deck Floor System—A lightweight floor system made of corrugated steel forms with 2 inches of concrete top surface. This lightweight floor system was used in the World Trade Center buildings that collapsed on Sept. 11, 2001.

R
Ridgepole—A horizontal timber that frames the highest point of a peak roof. Roof rafters are fastened to the ridgepole.

Roof—The sheltering structure of a building that protects the interior spaces from natural elements. It is designed to support dead loads, such as the roof deck, roof shingles, suspended ceilings and suspended lights, and live loads, such as snow. A roof is not designed to support the weight of firefighters and their equipment.

S
Safety Factor—The quotient of the load that will cause a structure to collapse divided by the load a structure is designed to support. If a floor beam is designed to support a load of 100 pounds per square foot, and the floor has been tested and found to collapse at 200 pounds per square foot, the safety factor of the floor is 2 (200÷100). Most structural elements are designed with a safety factor of two or more. A safety factor provides the structural engineer and the designer with a cushion or a margin for error in case there is an unknown factor in a structural element's load-bearing capability. Years ago, little was known about failure points and accurate strength testing of structural materials; to compensate, built-in safety factors were large. Today, with improved testing techniques and computers to calculate precise collapse points, the built-in safety factor is being reduced or eliminated. Lightweight building construction is one result of the reduction of safety factors.

Suspended Ceiling—Sometimes called a hanging or dropped ceiling, a suspended ceiling is built several inches or feet below the supporting roof or floor beams above. The concealed space above the ceiling is sometimes called a cockloft. The suspended ceiling is attached to beams above via vertical wood, wire or steel straps. The ceiling is held up by the collective strength of all the hanger straps. If several ceiling-hanger straps are destroyed by fire or removed during overhauling, the remaining straps may not be able to support the ceiling. A progressive total collapse of an entire stucco or cement ceiling can occur when the support of several hanger straps is eliminated.

T
Terrazzo—A polished floor covering made of small marble chips set in several inches of cement. A terrazzo floor is a collapse hazard; it adds weight to floor beams, conceals the heat of a serious fire below, and, because it is water-tight, allows water to accumulate in dangerous proportions. In New York City in 1966, a fire burning in a cellar below a terrazzo floor burned away the floor beams, although little heat and smoke penetrated the floor itself. The floor suddenly collapsed, killing 12 firefighters.

Truss—A braced arrangement of steel or wood framework made with triangular
connecting members. The truss presents several dangers to firefighters. It suffers early collapse during a fire because its exposed surface area is greater than the exposed surface area of a solid beam spanning the same distance. Also, there are a greater number of connections in a truss and, if any one fails during a fire, it can trigger the entire truss to collapse. Truss roof beams are spaced farther apart than solid beams, creating larger areas of unsupported roof deck. When the truss collapses, large areas of roof deck collapse. Consider a 100-foot x 100-foot roof: The failure of one wooden truss among a number of trusses spaced 20 feet apart can collapse 4,000 square feet of roof deck. A bowstring or peak-timber-truss roof creates a concave space on the underside of the roof, where great quantities of heat and flame can accumulate. A firefighter walking upright in a fire area where heat and flame have accumulated high above their head can miscalculate the amount of fire inside an occupancy.

U
Unrestrained Beam End—A beam end resting on a support and held in place only by gravity. During a fire, an unrestrained beam end will collapse more readily than a restrained or fixed beam end. Examples of unrestrained beam ends include a fire-cut beam, a beam resting on a corbel ledge or a beam resting on a girder.

V
Veneer Wall—An exterior masonry (stone or brick) surface finish attached to an unfinished wooden, steel or masonry backing support wall.

W
Walls—Firefighters should be familiar with the following types of walls:

Area Wall—A free-standing masonry wall surrounding or partly surrounding an area (for example, a masonry fence).

Bearing Wall—An interior or exterior wall that supports a load in addition to its own weight. Part of the skeletal framework of a structure, it most often supports the building’s floors and roof. The collapse of a bearing wall is more serious than the collapse of a column, a floor or roof beam, a floor or a roof deck, or a non-bearing wall.

Firewall—A non-bearing, self-supporting wall designed to prevent the passage of fire from one side to another. Any door or window built into a firewall must be designed to prevent fire spread. The firewall must be independent of the roof structures on either side and must be designed to withstand the complete collapse of a structure on either side. Party walls with parapets extending above a roof aren’t true firewalls. Often featuring penetrating openings that are not equipped with fire-rated doors or windows, party walls collapse if the interconnected wall or roof fails during a fire.

Free-Standing Wall—A wall exposed to the elements on both sides
and the top, such as a parapet wall, a property-enclosing wall, an area wall, and a newly constructed exterior wall left standing without roof beams or floors. Of the three types of walls—free-standing, non-bearing and bearing—the free-standing wall is the most unstable and likely to collapse at a fire because it has fewer supports.

Parapet Wall—The continuation of a party wall, an exterior wall or a firewall above the roofline. Parapet walls are considered free-standing walls and are less stable during fire conditions than non-bearing or bearing walls. The parapet of an ornamental stone-front wall in a one-story commercial building that has large display windows beneath it is collapse-prone during a fire. One-story shopping centers with large show windows often have parapet walls resting on steel lintels. The steel lintel spans the large show windows and supports the wall above. A parapet wall supported by such a lintel can become unstable and collapse if the steel shifts or warps when exposed to the heat of a fire. The impact of a master stream can also collapse a free-standing wall.

Party Wall—A bearing wall that supports two buildings’ floors and roofs. The collapse or demolition of one of the buildings served by a party wall may affect the stability of the adjoining structure. Although it does act as a fire barrier, a party wall is not designed to be a firewall; fire can spread through a party wall that has wood beams embedded in brick cavities.

Spandrel Wall—The portion of an exterior wall between the top of one window opening and the bottom of another. If elements that support the spandrel wall (e.g. a brick arch or a wooden, concrete or steel lintel) are weakened by fire, blasted with a master stream, or removed during overhauling, the spandrel wall can collapse.

Veneer Wall—A finished or facing brick or stone wall used on the outside of a building. A veneer wall is fastened to a backing wall by sheet-metal ties or cement. The sheet-metal ties or cement bindings are sometimes omitted, defective or improperly installed, creating an unstable veneer wall. A veneer wall will collapse in a curtain-fall fashion during a fire. X—A symbol that identifies a vacant building in New York City.

Yard Hydrant System—A privately owned water distribution system designed to provide firefighting water to several buildings in a large area of private property.
Z
Zone of Danger—Two types of hazardous areas, defined as follows:

*Horizontal Collapse Zone*—The horizontal measurement of the wall. When establishing a collapse zone, firefighters should estimate this measurement in addition to the outward area that the wall may cover if it falls. A miscalculation of the potential horizontal length of a wall collapse could be just as deadly as a miscalculation of the outward area a falling wall will cover with masonry.

*Vertical/Collapse Zone*—The expected ground area that a falling wall will cover when it collapses. It is generally equal to the height of the wall or one and a half or two times the height of the unstable wall.

*Click here! Questions or comments for Vincent Dunn? Join the discussion at his blog.*

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