17

COLLAPSE CAUSED BY MASTER STREAM OPERATIONS

"Say, Chief, how can you justify pulling us out of that burning vacant building last night, having us pour tons of water on the floors with master streams, and ordering us back inside the building to overhaul?" a firefighter asks at an informal critique of a fire, held in the firehouse kitchen. The other firefighters stop talking and turn toward the chief, waiting for his answer.

"I thought about that last night, also," answers the chief. "And here is how I justify it. First of all, the five-story building was vacant. If it was occupied, I would have continued with the interior hoseline attack. But I knew it was vacant because there have been several fires there in the past month. Also, the building stood alone. There were empty lots on all four sides, so there was no exposure problem. It was an ideal situation for using master streams.

"There are advantages and disadvantages to every fireground decision. The disadvantage of using master streams for long periods of time is that the volume of water can cause the building to collapse in the latter stages of the fire. The advantage, of course, is that firefighters will be safe during the initial and most dangerous stages of a vacant building fire. For example, last night, because we used master streams, none of you had to run through the dark interior of the vacant building when flames were spreading rapidly and visibility was zero. And none of you was exposed to the hazards presented by the dilapidated structure; cracked stair treads, holes in the floors, missing stair landings, broken fire escape steps and/or cracked and loose parapet walls. Preoccupied with searching, venting, stretching hose, and avoiding the dangers of the fire and smoke, any one of you could have been seriously injured by the hazards of the dark, vacant structure. So that's how I justified ordering you out of the building and using outside master streams.

"Now, here's how I justified sending you back inside to overhaul the smoldering fire after pouring tons of water into the building. It's a fact that there is always a danger of sudden building collapse after firefighters have used heavy-caliber outside streams on a serious fire for a long time. But there are precautions that a chief can take to reduce that danger and I took those precautions last night. First, I had you shut down the master streams and, for several minutes, I allowed no one to enter the building. This delay gave the structure time to settle after the shock of being hammered by high-pressure water streams. Next, I had the safety chief go inside the structure and survey each floor for signs of collapse. He looked for water accumulations that could overload a floor and structural weakness caused by the powerful, high-pressure master streams, such as columns out of plumb, sagging floors, and bulging walls. He also looked for leftover stock or material that could absorb large quantities of water and cause a floor overload.

"None of these warning signs was present. If any of these hazards had been reported by the safety chief, I wouldn't have allowed anyone to reenter the building. Instead, we would've set up an all-night watch and continued to drown the building with master streams to prevent a rekindle. Eventually, the water would have seeped down and quenched the deep-seated, smoldering fire. After the safety survey, I ordered only one company to reenter and overhaul. I restricted the number of firefighters operating in the danger area to one officer and four firefighters, instead of sending in 25 firefighters from the first-alarm assignment. This time when you entered the building, there was no danger from spreading flame and smoke and there was no great urgency. Portable lights pinpointed the weakened stair sections.

"Personal safety was now the number one priority and the fire—or what was left of it—was downgraded to the number two priority. Even after all these precautions were taken, a tragedy could have occurred—the building could have collapsed—but it did not. And that's why the decisions to go with master streams and then reenter to overhaul proved correct at this fire."

The Aerial Platform Large-Caliber Master Stream

The aerial platform large-caliber master stream is an extremely effective weapon in the arsenal of firefighting equipment. Its large-caliber stream has saved many firefighters. Instead of operating many hand lines inside a dangerous burning building for long periods, incident commanders can withdraw firefighters and quickly set up outside streams. When improperly used, however, the aerial platform stream can result in the death of or injury to firefighters and the destruction of property.

The large-caliber ground and aerial stream is a dangerous fireground machine if firefighters have not been trained to position apparatus correctly, control the supply of water to the apparatus, and properly direct the powerful stream. Three or four tons of water speeding through a nozzle at 100 feet per second is a tremendously destructive force. When improperly directed, streams delivered from ground or aerial appliances have caused ceilings to collapse, overloaded floors, knocked over brick walls and chimneys, lifted roofs off buildings, and made large roof sections of slate shingles explode into the air.

What exactly is a large-caliber stream? A fire department large-caliber stream (master stream) is a ground-based or aerial device with a fog or solid stream, capable of delivering more than 300 gallons per minute (gpm) to a fire. A typical master stream delivers 500 to 1,000 gpm. At this delivery rate, handheld nozzles attached directly to a hoseline are too difficult to control and direct, so mechanical, electrical, or hydraulic assists are required.

Fog streams with a delivery rate of more than 300 gpm and solid-stream nozzles of 1½-inches or more in diameter are considered large-caliber stream nozzles. Ground-based master streams include deck guns mounted permanently on top of apparatus and portable deluge nozzles that can be operated from atop an apparatus or removed from the apparatus and positioned closer to a fire. Aerial-mounted large-caliber streams are ladder pipes affixed to the rungs of ladder, snorkel, and aerial platform nozzles.

Three changes in the design and use of large-caliber streams over the years have increased their effectiveness:

- The hose diameter supplying water to large-caliber streams has increased.
- Radio communications and mutual-aid agreements have improved, enabling fireground commanders to quickly order and put into operation large numbers of large-caliber streams.
- Most importantly, the large-caliber stream no longer is restricted to the ground, but has been elevated 50 to 100 feet above street level. At serious fires 30 years ago, firefighters would operate more deck guns and portable deluge nozzles than aerial streams. Today, firefighters use more aerial streams.

Stream Destruction

While these changes have increased the large-caliber stream's effectiveness, they also have increased the destructive capability of its high-pressure, large-volume stream. The destructive pressure of a large-caliber stream is greatest in the area where water leaves the nozzle. When the nozzle of a high-pressure, aerial large-caliber stream is maneuvered close to parapet walls, chimney tops, coping stones, cornices, and roof dormers, it can blast sections of these structures away from the building and cause a partial collapse. Firefighters working near a burning building where an aerial stream is operating can be struck by building fragments knocked loose by the powerful stream.

The most serious collapse danger of a large-caliber stream, however, is caused by the large volume of water it discharges into a burning building. One gallon of water weighs a bit more than eight pounds. The average stream delivers 500 gpm into a burning building, which equals two tons of water or 4,000 pounds a minute (fig. 17–1). When an aerial ladder stream has been operating for 10 minutes, it has discharged 20 tons or 40,000 pounds of water weight into the building. Three streams delivering this water into a burning building will introduce 60 tons or 120,000 pounds.

Some of the water will be vaporized by the heat of combustion; most of it will flow through cracks, beneath doors, down the stairs, and back into the street. However, an undetermined quantity of water from the stream will be absorbed into plaster ceilings and walls, dried-out wooden floors, and the porous paper and cloth contents of the building. It is this absorbed water weight that can cause a collapse.

Water from streams also can become trapped inside a watertight, sealed floor area and quickly build up to dangerous proportions—sometimes as high as windowsill level. At one fire, water from stream accumulations was seen spilling over windowsills and running down the front of a fire building seconds before all interior floors suddenly collapsed. Firefighters operating on floors below the fire were buried in the collapse.

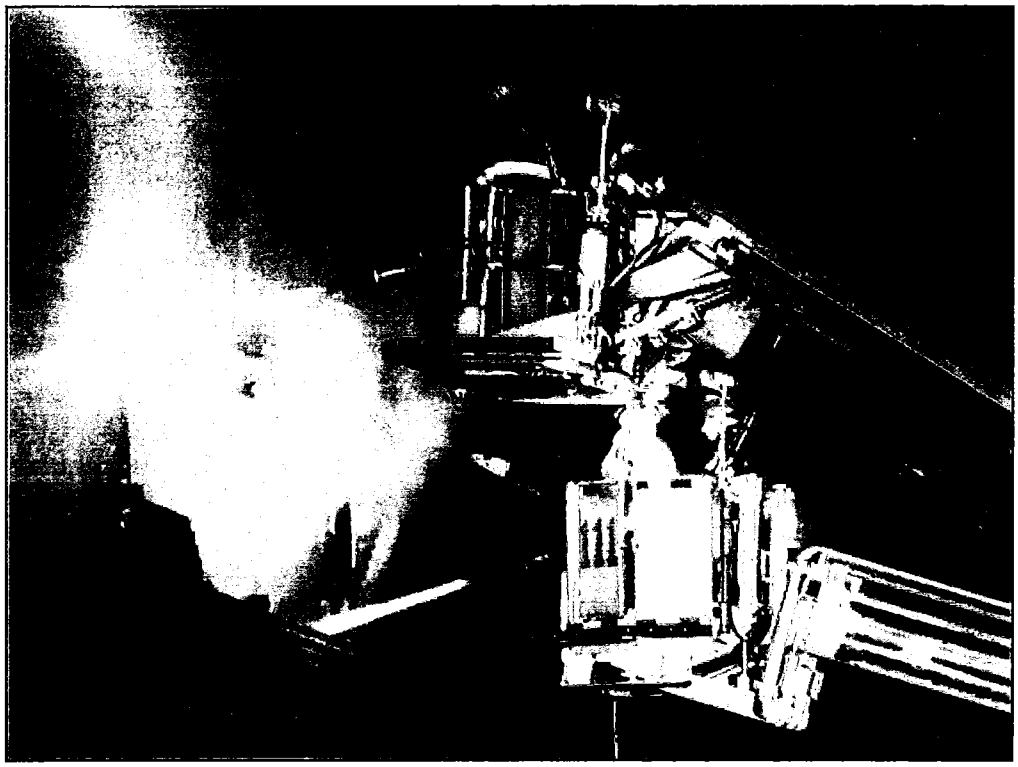

Fig. 17–1. Two tons of water delivered by master streams can cause a building collapse.

A firefighter who has used only small, handheld attack streams during his or her career may not be aware of the destructive power of a large-caliber nozzle or the collapse danger presented by improperly using a large-caliber stream. Firefighters should understand the following principles of control and direction of large-caliber streams:

- ***Weight of water.*** Firefighters directing a large-caliber stream should realize the nozzle is pouring two to four tons of water a minute into the building. When they extinguish the fire in one window, they should move the stream to another window, never directing it at smoke. Firefighters should notify the officer in command when visible fire is darkened down and suggest a possible shutdown or repositioning of the stream.
- ***Dangers of the upper portion of building.*** The upper portion of old structures, such as chimney tops, parapet walls and cornices, may be structurally unsound and present a collapse danger even before a fire occurs. Exposed to the elements of wind and rain on more surface areas than other parts of the building, the upper portion deteriorates more rapidly and its maintenance is expensive and often neglected. When a deck gun or an aerial stream sweeps the upper portions of a burning structure at close range, it can knock over a section of a chimney or collapse a side or rear parapet wall or loose coping stones. Firefighters operating in the vicinity of the master stream can be struck by building parts blown off the building by the force of the stream.

A large-caliber stream delivers 500 gpm into or onto a burning building. This equals two tons of water or 4,000 pounds a minute. This destructive force is shooting from the nozzle at 100 psi (pounds per square inch) around 100 feet per minute.

Stream Direction

Today, inexperienced firefighters must be trained to operate master stream nozzles. An inexperienced firefighter who has used only small, handheld streams during his career may not be aware of the difficulty of directing the powerful master stream. This problem was highlighted when a firefighter was ordered to operate a deck gun into a window of a tenement to protect people trapped by flame on a fire escape. The first attack hoseline inside had suffered a burst length. Flame coming out a window prevented the people from descending the fire escape. The chief urgently ordered a quick knockdown of the fire in the window as the burst hose was being changed. He ordered the pumper repositioned in front of the fire building and the booster tank water to supply the deck gun atop the truck. The booster tank had 500 gallons of water. It provided only about two minutes of deck gun use. The order from the chief was a quick knockdown, to drive the flames back into the window below the people on the fire escape.

When water came out of the nozzle, the young firefighter, unfamiliar with the difficulty of maneuvering a large master stream, directed the water stream up the face of the wall along side the flaming window. Then he moved it across the top of the wall above the flaming window and finally down the side of the wall next to the flaming window and ran out of water. Then the water supply ended. He completely missed the flaming window. Needless to say, the chief was upset. Fortunately, the interior hose stream was restarted and extinguished the fire coming out the window and the people were safely removed from the fire escape. All firefighters should be trained in the control and direction of large-caliber aerial and ground stream nozzles.

Water Accumulations

With a greater overall view of the fire scene than personnel working on the ground, firefighters operating elevated streams high above street level are usually the first to detect hazards, such as water buildup on a floor or roof. They should notify the incident commander immediately of any water accumulations.

Roofs surrounded by parapet walls on the four sides of the building are especially prone to water buildup. If drains are clogged and several ground-level, large-caliber streams are operating, a roof area may fill up with water quickly and collapse on firefighters inside the building.

The hollow area inside a marquee or canopy attached to a building is another place where water accumulates. The weight of the water built up inside the void of a marquee where drains are clogged can make the marquee collapse and also bring down the front facade wall to which it is fastened.

Stone or Brick Veneer Wall Collapse

When a large-caliber stream is redirected from window to window on a burning masonry building, it strikes the brick wall between openings at close range. If the cement bonding between the finished stone or brick veneer and the back wall to which it is attached has lost its adhesive qualities over the years, the impact of the stream can cause large sections of stone or brick veneer to collapse into the street below. A large-caliber stream continuously directed at a brick or wood shingle wall at close range can blast away the wall and throw fragments of the wall into the air.

Sounds of a Large-Caliber Stream

At a fire where smoke reduces visibility to zero in the street, firefighters must rely on the sound of the large-caliber stream striking objects to determine its effectiveness. For example, when a large-caliber stream strikes a brick wall in smoke, a "splattering" sound is made by the stream striking the wall. When it strikes the side wall of a wooden building, a "drum" sound is made by the stream striking the wall. When it enters a window, the sound of the large-caliber stream is reduced and only a distant rumble is heard.

Collapse Zone for Aerial Streams

In the past, some chief and company officers used a dangerous firefighting strategy when operating large-caliber streams at major fires. When the wall of a building was in danger of collapse, all firefighters working at ground level were ordered to withdraw from the perimeter of the building and a collapse danger zone was established. Then, firefighters operating tower ladder streams were ordered to begin operations, with the elevated stream operating close to the perimeter of the building and within the collapse danger zone. This no longer is the strategy (fig. 17–2).

When chiefs establish a collapse zone for firefighters operating in the street, they now take a similar safety precaution for firefighters operating aerial large-caliber streams. This is imperative because, in recent years, an increasing number of building collapses have seriously injured firefighters operating aerial master streams. The collapse zone for an aerial stream will vary slightly because of the height of the nozzle above ground level. The tip of the aerial ladder or platform basket should be kept away from a weakened wall a distance greater than the height of the wall above the bucket floor.

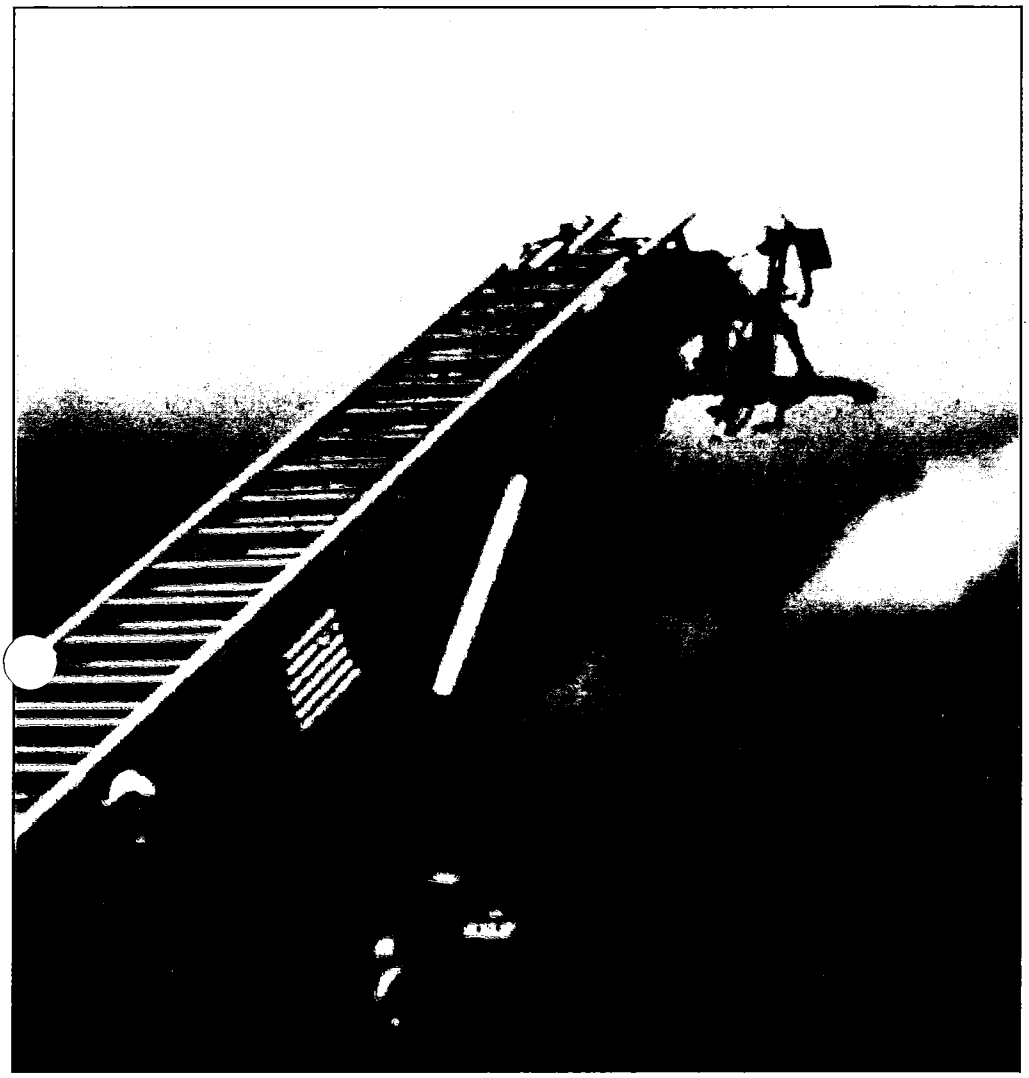

Fig. 17–2. This aerial master stream was operating in the collapse danger zone.

Master Stream Close Approach in Windows

When an aerial master stream is to be used for a quick knockdown, the master stream nozzle is most effective when placed close to the window of the building. This close-up position can give the stream deep penetration and its widest horizontal range inside the floor area. A large, burning open-floor area of a supermarket or factory floor sometimes can be quickly extinguished when the master stream is positioned near the window opening and the stream sweeps the floor. However, this close approach should not be ordered if the wall over the window is in danger of collapse. When there is a danger of structural collapse, no part of the aerial stream bucket and/or nozzle should be positioned where it could be struck by a falling wall. There have been instances when this fireground precaution was not heeded, resulting in firefighters

in the bucket of an aerial platform being buried with falling bricks, the tower ladder bucket being torn from the apparatus boom, or the ladder being tipped over on its side by the weight of a collapsing wall.

At one recent fire in a row of stores in the Bronx, New York, a parapet wall collapsed on firefighters in a tower ladder bucket. Everyone at the scene was notified by the safety chief of a dangerous parapet wall leaning out over the burning stores. It was a five-foot-high, 75-year-old brick parapet. A collapse zone was ordered. Some time later, the ladder was ordered to reposition for use of the aerial master stream in front of the building and so the apparatus was moved in front of the fire building. The chauffeur safely positioned the ladder truck outside the collapse zone, away from the dangerously leaning parapet wall. Supply lines were being connected.

However, to enable two firefighters to climb into the bucket for operations before raising, the chauffeur raised the boom and bucket from the bed and lowered it onto the sidewalk inside the collapse zone. As the firefighters walked in the collapse zone and opened the gate to step into the bucket, the parapet wall came crashing down on top of them. One firefighter suffered a concussion; the other a broken collar bone and a dislocated shoulder. The lesson learned here is when a wall is in danger of collapse, the fire apparatus and the tip of the tower ladder must remain out of the collapse zone. The priorities of positioning apparatus are life safety first, which includes the lives of firefighters; fire containment is the second priority. That rule never changes.

- ***Renovated Buildings***. Renovated brick buildings being gutted have all interior partitions removed, with only the four brick walls and wooden floors remaining in place. An aerial large-caliber stream is particularly effective when there are no interior partition walls to obstruct the stream reach, as it can penetrate through the entire depth of the burning floor. However, when a fire occurs in a renovated building that does not have great floor depth from front to rear wall, the powerful large-caliber stream directed through a front window can travel through the burning floor area and strike the inside of the rear wall with sufficient impact to collapse it into the rear yard. Firefighters operating a hoseline in the rear yard can be buried under the tons of falling brick that are collapsed by the stream.
- ***Flanking a Building***. When there is a danger that a wall will collapse outward with explosive force and be driven beyond the normal collapse zone, firefighters should operate streams from a flanking position. If a portable deluge nozzle or an aerial platform is placed on one side of a weakened wall of a building in front of an adjoining building, the stream range operated on an angle into a window or doorway of the burning building may be limited. However, the firefighter will be protected from the collapse (fig. 17–3).

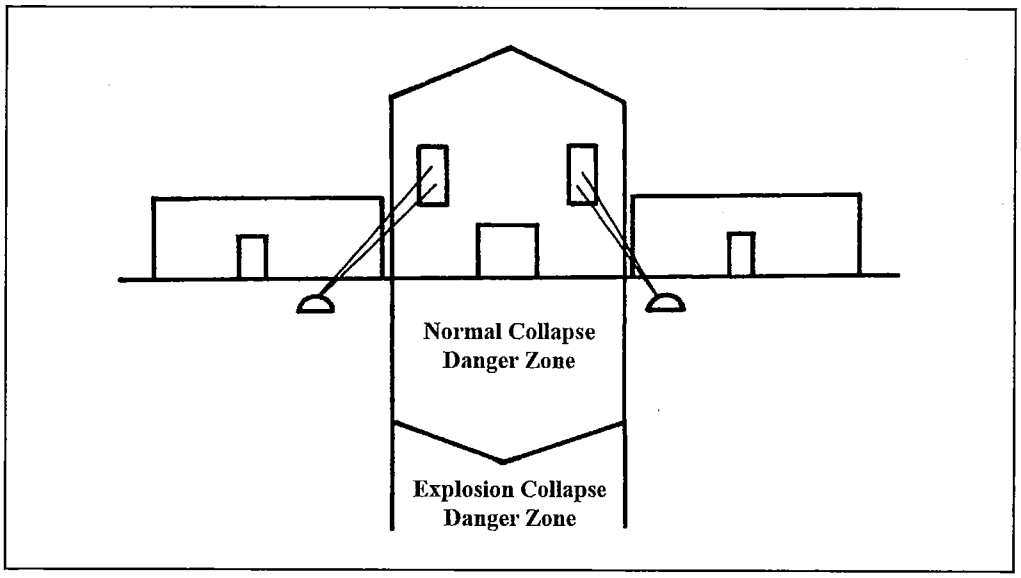

Fig. 17–3. Master streams must often be positioned in a flanking position to avoid a possible wall collapse.

Aerial streams operated by firefighters above the roof of a burning building will also be less effective, but they will be safely above the collapse zone of a weakened wall. Again, when there is no danger of wall collapse and aerial master streams are needed because of the size of the fire, firefighters may operate the aerial nozzle close to the flaming window of the building for effective penetration of the master stream. But before this tactic is used, the incident commander must size up the wall above the windows. If the wall appears unstable, this tactic should not be used. Instead, withdraw the tower ladder bucket back out of the collapse zone of the unstable wall and use the reach of the stream from a safe distance to penetrate the flaming window, or operate the bucket of the aerial master stream above and attack the fire at roof level.

Ceiling Collapse

Firefighters often use large-caliber streams when fire spreads through concealed spaces above suspended ceilings in supermarkets and rows of stores. These streams are effective when they are directed from below the ceiling. This works well in large, open areas. If part of the suspended ceiling has fallen or burned away the concealed space above, the area can be swept with a large-caliber stream. In other instances, the force of a large-caliber stream directed from below can break through a ceiling and expose flame above. This can be accomplished effectively when firefighters operate large-caliber streams near the front of a store or supermarket where they previously have removed a large open display window to vent the fire. When an interior partition or the absence of large windows prevents this strategy, firefighters must operate aerial large-caliber streams from above, through a burning roof, where the fire is beyond the control of an inside hoseline attack.

When either of these strategies is used, water from large-caliber streams may become trapped in pools above a watertight suspended ceiling or absorbed into sound- or heat-insulating material in or above the suspended ceiling. If the water weight becomes excessive, a large section of the ceiling can collapse suddenly. This is one reason why it is unsafe to direct outside large-caliber streams into burning buildings while firefighters are inside the structure. Even after they have shut down and reentered a building with a suspended ceiling, firefighters should examine the space above the ceiling for water accumulation or absorption.

Strategies for Master Streams

There are two strategies for master stream use. One is using a master stream for a "temporary knockdown" of a large body of flame. In this strategy, firefighters inside the burning building are withdrawn and then reenter to conduct interior firefighting when the master stream is shut down. During this strategy, a temporary knockdown, the incident commander must confirm that all firefighters have withdrawn to a safe position before the master stream is used. Interior forces must retreat to the floor below or out of the building before the large-caliber stream is directed into the burning building.

The second strategy is an exterior master stream attack used for final extinguishment. When this defensive strategy is used, no firefighter should remain inside the burning building during the master stream attack.

When master streams are put into operation for total extinguishment of a fire, the force of the high-pressure streams, the weight of the water absorbed into the building and the fire destruction over a long period of time can weaken the structure. The incident commander must prepare for collapse of the building. The chief must withdraw all firefighters operating inside the building, as well as order those working around the perimeter of the building to move beyond a collapse zone. A collapse zone is the distance away from the wall equal to one, one and a half, or two times the height of the unstable wall.

Overhauling Master Stream Strategy

After master streams have been used to extinguish a fire, overhauling becomes a dangerous strategy because of collapse danger. Several deadly building collapses have occurred after master streams were used and firefighters returned into the building to extinguish spot fires and prevent rekindle. Collapse happens during overhaul because the building has been destroyed by flame, the impact of the master streams has pounded the building, and tons of water have been absorbed by the plaster, wood, and concrete of the structure.

After a long-duration master stream operation is completed and the main body of fire has been extinguished, the incident commander should order master streams shut down. The large-diameter streams used for total extinguishment have accomplished

their task. Now, before any firefighter is ordered to reenter the burned-out, smoldering, water-soaked structure to overhaul, the following safety actions should be taken. The building should be allowed to drain. Next, the incident commander must order a safety officer to conduct a safety survey.

The safety chief should determine if it is safe to allow firefighters to enter and overhaul. During this inspection, the safety chief looks for the following warning signs: broken stair treads and cracks in marble intermediate landings; floor and ceiling sagging due to the weight of water; fire damage to steel columns and girders that are twisted, warped, bent, or elongated. The presence of trusses and/or lightweight steel bar joist or wood I-beam construction must be reported to the incident commander. Water accumulations and heavy machinery are warning signs that could trigger floor failure. Water-absorbing content, such as paper bales, baled rags, or plumbing supplies, are heavy loads that could cause collapse during overhauling.

If the safety officer decides that the structure is safe, the incident commander may start overhauling, but limit the number of firefighters who reenter to extinguish spot fires. However, if the safety officer decides the structure is unsafe, no firefighter should reenter the structure. Instead, the incident commander should order *defensive overhauling*. Defensive overhauling is a strategy of using a master stream or several handlines directed from outside the burning building and outside the collapse zone, to the burning structure for several hours or days, if necessary. Firefighters may be rotated each tour. Defensive overhauling—sometimes called a "watch line"—is continued for however long it takes until the smoldering fire is quenched.

Lessons Learned

Chief and company officers have a personal responsibility to safeguard firefighters when large-caliber streams are put into operation at major fires. Even though firefighters direct and control the large-caliber streams, chiefs and company officers constantly must monitor and evaluate their effectiveness and safe use. The incident commandeer also must confirm that all firefighters have withdrawn to a safe position before allowing them to use a large-caliber master steam. It is not enough to simply order all companies to withdraw. The chief must wait for the officer directing operations inside the building to confirm the safe withdrawal. Over the years, firefighters retreating from a fire building have been burned and scalded with steam created by the outside master streams directed into the building. They were not given sufficient time to leave.

The safe transition from interior to exterior attack of a structural fire requires four elements:

- Effective communication between interior and exterior sector commanders
- An interior sector who has effective command and control over the firefighters
- A pump operator who waits for the order to start water from the incident commander and does not prematurely start water to the master stream

- An incident commander who understands the priorities of fireground safety—protection of life first, including firefighters; fire containment second; and property protection last

When master streams are put into operation, not for a quick knockdown, but for total extinguishment, the force of the high-pressure streams and the weight of the tons of water poured into the building will weaken the structure. The officer in command must prepare for eventual collapse of the building. The incident commander must withdraw firefighters operating inside the building, as well as order those working around the perimeter of the building to move beyond a collapse zone.

Finally, the officer in command should order the master stream shut down as soon as they have accomplished their task. Then, before any firefighter is ordered to reenter the burned-out, smoking, water-soaked structure to overhaul, a safety chief first should inspect the structure for stability. If this officer decides that the structure is unsafe, no firefighter should reenter the structure. Instead, the incident commander should implement a defensive overhauling strategy using master streams. A watch line should be established.

19

SAFETY PRECAUTIONS PRIOR TO COLLAPSE

Around midnight, an engine and a ladder company respond to a fire in a shopping center. Street lights reveal large volumes of smoke drifting from several stores near the center of a one-story building. The engine officer radios communications headquarters: "Engine 8 to Communications Center. We have a working fire in a shopping center at King and 3rd Streets. Request a full assignment of companies to respond. Smoke is showing from a one-story, 200×50-foot, brick-and-joist structure containing nine stores. Ladder 6 and Engine 8 are arriving on the scene."

"Communications Center to Engine Company 8, ten-four."

Driving into the deserted parking area, the pumper stops at a hydrant, leaves one firefighter, and lays a supply line to the front of the stores. In front of the fire building, two firefighters pull 200 feet of 1¾ inch hose off the transverse hose bed. They remove the kinks and lay the hoseline out in folds to allow a quick advance on the fire. The pump operator disconnects the 5-inch supply line, connects it to a gated inlet, opens the intake gate, and signals the hydrant man to start the supply water flowing. Then he looks around and sees the hoseline stretched and unkinked. The officer orders the hoseline charged; the discharge gate is opened, and the pump pressure increased.

Meanwhile, the ladder chauffeur parks the aerial ladder away from the one-story structure. Two firefighters unlock a 20-foot portable ladder from the truck, carry it to the front of the stores, raise it, and place it against the building. Carrying a power saw, an axe, and a pike pole between them, the two firefighters climb the ladder to the roof to begin ventilation. A ladder company officer and two other firefighters with forcible entry tools run to the front of the middle three stores, spread out, and quickly examine the interior of the stores through the glass display windows. They pinpoint the fire inside the center store, a bank and check-cashing establishment.

First, after feeling the blackened, stained, glass panel door for heat, the forcible entry team verifies that the door is locked. They quickly force the door with a rabbit tool. As the door is chocked open, a burglar alarm sounds. The officer and forcible entry team crawl inside the bank to search for maintenance workers, but heat forces them back to the entrance. The firefighters with the charged hoseline enter the store doorway and disappear into the smoke. For deeper penetration, the mask-equipped firefighter on the hoseline opens the fog nozzle to the solid stream position.

The captain of the hose team coaxes the firefighter to crawl several feet into the heat and smoke. "Come on, that's it," he says. "You're getting it." In the pitch-black smoke there is no visible fire, but the crackle and roar of flame can be heard from the back of the store. The firefighters temporarily redirect the hose stream at the ceiling to cool down the heated convection currents over their heads, and scalding hot water cascades back down over their helmets and shoulders.

The radio blares: "Ladder 6 to roof team, go ahead."

"Lieutenant, we're having trouble cutting a vent opening in the roof. The roof deck is covered with steel, burglar-proof plating sheets. We can't vent the rear of the building from the roof, either. There are no windows or doors."

"Ten-four, Ladder 6 roof team," replies the truck officer, who then shouts to his men over the din, "Take out those glass display windows!"

Glass shatters as a firefighter smashes the top part of the smoke-blackened glass with a pike pole. He uses just enough force to break the window top without showering the firefighters inside with pieces of broken glass. He breaks the middle and lower portion of the window next, but smoke does not flow out of the opening. He thinks, "There must be a partition behind the window," and attempts to pull a display sign and curtains out of the window opening with a pike pole.

Sirens of responding apparatus are wailing in the distance, when suddenly the interior of the bank erupts into a huge red ball of fire. The smoke flowing out of the door and window openings instantly turns to flame. Two hose team members, followed by the captain, stumble, fall, and crawl out of the blazing store. The chief arriving on the scene runs over to the firefighters on the sidewalk. "Are all of the men out of the store, Captain?" he asks and the captain nods his head.

"Transmit a second alarm!" shouts the chief to his aide.

Firefighters set up a defensive exterior hoseline operation. The fire has spread throughout the entire nine-store structure via the concealed roof space that extends over the ceilings of the stores. Several fire companies are operating hoselines from the sidewalk around the perimeter of the burning structure. The captain of the first-arriving engine and his men are still operating a hoseline—this time from a safe distance, back from a cracked exterior masonry wall of the first building. The young firefighter directing the hose remarks to his officer: "Captain, if we move the hoseline closer to the building, we can hit more fire and get back to the firehouse."

"I don't like the look of that wall," replies the officer. "We already had one close call—let's not press our luck."

"Captain, I have never seen one of these walls collapse in all my time on the job," says the young man. "I don't think that wall will collapse on us if we move closer and get a better shot at the fire with this hoseline. Besides, the chief would know if that wall looked like it would collapse. He did not warn us to stay back."

"Let me tell you something," replies the captain. "You can't predict if that wall will collapse, I can't predict if that wall will collapse, and the chief can't predict if that wall will collapse. That wall will probably stay up for the entire fire operation, but it could also collapse the second we step under it. Relax and stay where you are!"

Collapse Precautions

There is a saying in the fire service. It goes like this, "If you see something, say something." Lives have been lost because firefighters did not report firefighting dangers to the chief in command. However, there is a second half to this saying,"If they say something, you must do something!" When a danger is reported to the command post, the incident commander must do something. The chief must take action when

receiving reports of danger from firefighters: order increase supervision, establish safety equipment to the danger area, or withdraw firefighters from the danger area. If we tell our firefighters to report dangers, we must tell incident commander what to do.

What actions should a commanding officer take when a danger is reported? The response must be balanced. The response must match the severity of the danger reported. A response by an incident commander can not be too extreme, or too restrained. The response must equal the danger reported. The degree of danger reported at a fire will vary, and so must the commander's response. The response to a reported danger may depend upon several factors: who transmits the danger; the seriousness of the warning; the firefighters available to respond to the crises, and the urgency of rescue operations being carried out at the time of the report. A response to a reported danger transmitted to the command post may range from a simple verbal acknowledgment, to an emergency evacuation of all firefighters from the building. There may be several responses by the incident commander to a single reported danger. As the danger becomes more severe or less severe, as resources become available, and the rescue effort is resolved, the responses of the incident commander may increase and/or decrease to reflect the changes.

We train firefighters to report all dangers observed, so we must train incident commanders in the various safety precautions that may be taken in response to a reported danger. The following is a list of safety actions an incident commander may consider when receiving a reported danger. These safety actions progress from a simple acknowledgment to extreme emergency evacuation of all firefighters from the burning building.

1. Acknowledge the report and take no immediate action.
2. Light up the danger area.
3. Assign an experienced officer or chief to investigate (fig. 19–1).
4. Increase supervision.
5. Alert a rapid intervention team to respond.
6. Evaluate an unstable structure with a telescopic lens.
7. Rope or tape off a danger area.
8. Establish a collapse safety zone around a danger area.
9. Evacuate people and firefighters near a reported danger area.
10. Order a partial withdrawal of firefighters from a section of a building.
11. Change strategy from offensive to defensive by withdrawing firefighters from a fire building.
12. Order an immediate emergency evacuation of all firefighters.

Fig. 19–1. The incident commander can direct a supervisor to investigate a reported collapse danger.

Acknowledge receipt of the reported danger by radio

A chief in command of a fire can simply acknowledge a report received of a danger and take no action. This situation may occur when receiving what is considered a known minor danger report, such as smoke seeping through an exterior brick wall during the early stages of a firefighting operation. If it is known there is only a content fire and not a structure burning and the crack in the mortar between bricks is not due to fire-weakening of the interior structure, but to improper foundation settling prior to the fire this action may be taken. If the fire is not extinguished by the initial hoseline and, instead, grows and involves the structure, the incident commander may reconsider the reported structural defect and take additional precautions. All reports of danger must be acknowledged by the incident commander.

Light up the reported danger area

During a night fire, if a danger is reported, the incident commander may order increased lighting to be placed near the area (fig. 19–2). A spotlight could be directed on a cracked wall or partly collapsed cornice; a floodlight could be ordered to illuminate the entire area in front of a burning building where a structural defect has been discovered. This action is often taken during an initial stage of a nighttime fire when a chimney or advertising sign has become unstable or partially collapsed and is hanging down on one side.

Fig. 19–2. Lighting is an important safety precaution at a fire operation.

Because of the need for a search-and-rescue effort, and initial hoseline placement, this initial action may be taken when there are no available firefighters at the scene to secure or remove the dangerous structure. When all available firefighters are preoccupied with other duties, having a rapid intervention team illuminate the danger can bring the hazard to most everyone's attention. As soon as the life hazard is controlled and the rescue effort completed, the incident commander may order increased safety measures when additional firefighters are available. The chief may order the dangerously hanging cornice or sign to be secured with ropes or cut and removed.

Investigate the danger area

An incident commander may order a chief or experienced company officer to investigate a reported danger. This officer would investigate the condition and advise whether to continue or discontinue firefighting in the vicinity of the danger. This action might be taken during overhauling when the stability of a floor is in question.

For example, if the floor is reported to be "springy" or bounce when walked upon, this action can be taken. In some older buildings, the floors vibrate when walked upon. This effect may be caused by the absence of cross-bracing or bridging between the joists, or be due to overloading with firefighters or stock. Also, after a serious fire, the charred floor joists may be reduced in thickness.

A frequent type of structural investigation directed at fires in badly damaged buildings is to have a safety chief inspect the building's interior after a fire where master streams are used. Before overhauling is started, a safety chief can be directed to inspect the building's structural interior stability to determine the destructive effects of the fire damage, the powerful master streams, and the water accumulations. No one would be inside the structure but the safety officer and a team member. This safety officer would note floors containing storage or heavy machinery, look for excessive vibration of floors, rope off charred and weakened floor decks that could disintegrate when stepped upon, observe the condition of stair treads and landings, and estimate the weight of water accumulations absorbed into broken and burned plaster that had fallen to the floor, in addition to water that had been absorbed into storage materials. Based upon these factors and other safety conditions, the safety officer would recommend to the incident commander whether to have firefighters reenter for overhauling. If the investigating officer finds the structure unstable, the incident commander could increase the safety precautions taken and order firefighters not to conduct overhauling. Command could order them to remain outside the smoldering building and outside the collapse zone, and direct master streams into the damaged building for several hours or days.

Increase supervision in the reported danger area

At serious fires, an incident commander may assign a battalion chief or veteran officer to operate in a danger area to increase the supervision of firefighters from a position close to the operations (fig. 19-3). This supervising officer would bring a safety-conscious attitude of a commander, to balance the aggressive attack attitude of a company officer. A supervising officer's priorities at this situation would be life safety of firefighters over fire containment and property protection.

The chief, or veteran officer, assigned to supervise a dangerous firefighting operation, has the advantage of being close to the danger. This officer would keep the incident commander informed firsthand of conditions by frequent radio communications. This assigned chief or company officer has the authority to withdraw the firefighters from the danger area, whenever the danger becomes too great. The assignment of a chief to supervise a danger area is often directed when the continuation of a rescue or firefighting effort is critically important to the overall operation. There are several operations in burning buildings where dangers are always present and where the assignment of a chief is often directed. These dangers include: cellar fires, operating on the floor above a fire, roof venting, top floor fires, and hoseline advancement at a rapidly spreading fire.

Fig. 19–3. The incident commander may assign another chief officer to direct operations in a danger area.

Alert the rapid intervention team (RIT) of the reported danger

Whenever there is a danger reported to the command post, this information should be relayed to the rapid intervention team (RIT). Based on the reported danger, the incident commander might alert the RIT officer of the need to obtain

additional equipment preparing for a potential trapped firefighter. There should be a RIT standing by at every working fire. They should be put on alert when a danger is reported but only respond to rescue trapped firefighters. They may raise ladders in front of the building, reposition an aerial ladder for rescue, and set up lights in front of the building, and remove hoseline kinks in front of the building. However the RIT team should not enter the building or wander from the command post. They must be ready for quick response to a trapped firefighter. If, for some extreme reason other than firefighter rescue, a RIT team is used, the dispatcher should be notified and another company sent to replace the team.

Assign a monitor

At most building explosions and collapses, there is a danger of secondary collapse due to a cracked or leaning wall, unsupported lean-to floor, or unsupported content sliding out of the broken building. When it seems that a secondary collapse could occur, yet the firefighters must continue to rescue surface victims and operate in the secondary collapse danger area, the incident commander should order an officer or firefighter to observe the structural defect continually. This monitor must warn the incident commander of any change in the unstable wall, floor, or content. This safety precaution is often directed during an explosion or collapse where firefighters are searching the rubble for live, buried, or partially buried victims.

A transit—a telescopic surveyor's tool that can see small movements of a building, undetectable by the human eye—is now carried on many rescue companies. A transit is more effective than a firefighter when a monitor is needed. A firefighter must continually monitor the transit by looking through the sight glass anytime firefighters are operating in a secondary collapse danger area. The firefighter must have a radio to notify the incident commander of any movement of a monitored wall, floor or roof.

Cordon off the reported danger area

Another action often directed when a danger is reported to the command post is to cordon off the reported danger area. A utility rope or police tape is placed around the danger to restrict entry into the area. The rope or tape could be used to restrict entry into an area near a leaning masonry chimney or a section of loose bricks on a parapet wall. This action can be taken when the danger area beneath the unstable structure is small. Firefighters would estimate the ground area that would be covered by the falling structure and then cordon off the area with a utility rope or orange marking tape. The rope or tape is tied to parts of apparatus, building parts, or utility poles and should be waist to chest high above the ground. Incident commanders should be aware, even after an area is cordoned off, that continuous monitoring is required to ensure the roped-off area is not entered by pedestrians and fire personnel.

Establish a collapse zone around the danger area

When a large part of a building is in danger of collapse and requires more than a small area to be roped off, a collapse danger zone should be established by the incident commander (fig. 19–4). This collapse zone is directed to keep all firefighters out of the area where the building could fall and cover a large area of ground with bricks and steel. The collapse zone area should be an area equal to one, one and one half,

or two times the height of the wall, depending on the incident commander's orders. A wall collapse danger from a truss roof failure with hip rafters or a mansard roof with hip rafters can be greater than just the height of the falling wall. The force of the collapsing hip rafters of the truss or mansard roof could kick out a wall farther than normal. A collapse area distance should be specified in every fire department's standard operating procedure (SOP) and firefighters trained to comply with the order to establish a collapse zone.

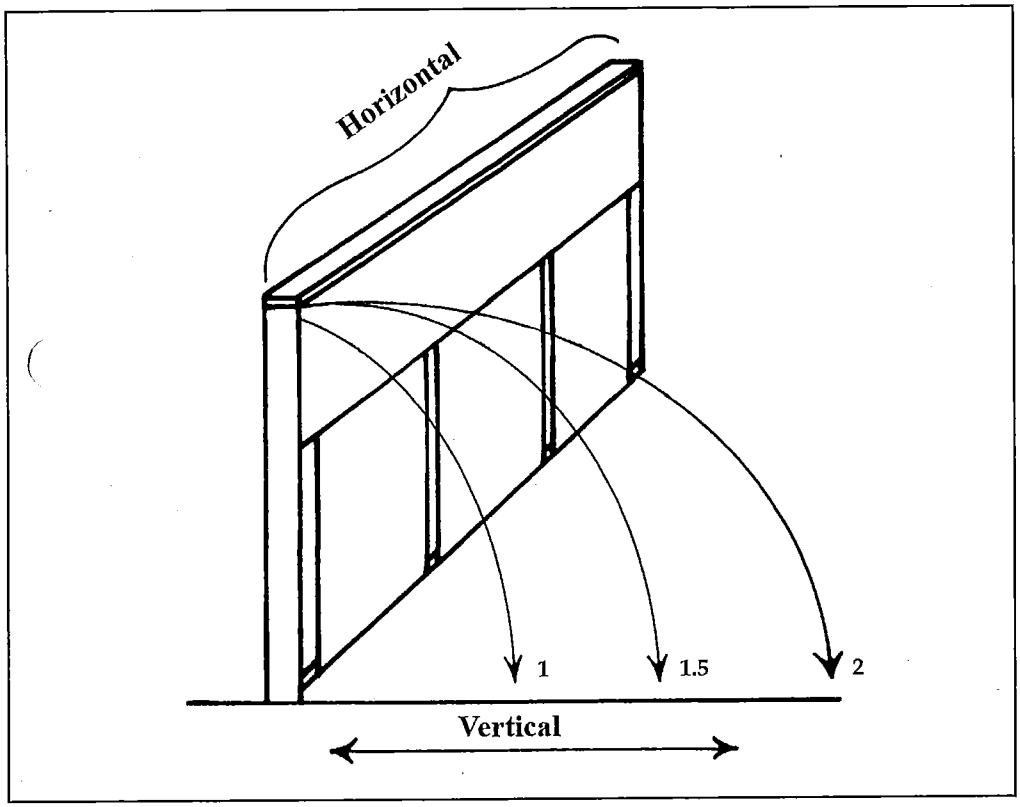

Fig. 19–4. Zones of danger must be considered when operating near the walls of burning buildings.

Some times after a collapse zone has been ordered, freelancing firefighters try to enter a danger zone to obtain better hose stream penetration. Company officer supervision is required in addition a collapse danger zone. When a collapse zone is ordered by the incident commander, responsibility to ensure firefighters comply with the order rests with the company officers and the sector, or division officer, in command of the area. An incident commander must also considered the horizontal frontage of the wall which could collapse. In addition to the outward distance that the wall may fall, an incident commander must estimate the horizontal danger.

A parapet wall is a section of wall that extends above a roofline. The incident commander must estimate whether just the unstable portion will collapse, or will the unstable portion drag down the 50 or 100 feet of wall on either side with it? The most dangerous type parapet wall is an ornamental cast stone wall. This is because a hollow ornamental cast stone wall is tied together by reinforcement bars and angle

irons. When an ornamental cast stone parapet appears unstable, bulging or leaning outward, assume the horizontal collapse zone to be the entire parapet wall length. Miscalculation of the potential horizontal length of wall collapse could be just as deadly as miscalculation of the outward area of a wall collapse.

Evacuate occupants and firefighters from buildings adjacent to the danger building

An incident commander should consider many factors when analyzing a potential building collapse. One important consideration is the possibility that the falling structure could cause the failure of a smaller structure nearby. If a three-story structure falls on an adjoining one-story building, it will collapse the one-story building. Even the failure of a rooftop parapet wall can collapse the roof of a small structure nearby if tons of bricks crash down on top of it. At one incident where FDNY Lieutenant Robert Dolney died, an exterior wall of a three-story building collapsed, fell on the roof of a one-story building, and collapsed the roof. When the roof collapsed, it pushed out the front wall that killed the officer and injured a firefighter. The post-fire analysis revealed the original building collapse caused a second roof collapse, and the falling roof caused a third wall collapse. When analyzing a potential collapse, look beyond the initial danger. Try to determine if the falling building could trigger a series of subsequent structure failures. You might have to consider the collapse danger zone for the structures surrounding the original weakened building.

Partial Withdrawal of Firefighters

When firefighters inside a burning building report a collapse danger, the chief may order withdrawal of firefighters from a portion of the building. A partial withdrawal of firefighters to a safe location inside the building may allow interior firefighting to be continued. This practice can be followed only when the construction of the building is known in detail, and partial collapse will not cause the entire structure to fail. For example, when a ceiling collapse is possible, the building has a stairway enclosed by masonry walls, and the stair landings are independent of the floor landings, firefighters can be withdrawn to the safety of the stair enclosure before the ceiling collapse occurs. Also, some structures are divided into building sections, which are separated by fire walls and have separate roofs and floors. A party wall where roof beams from both sections are supported by the wall is not a true fire division. Collapse of the roof on one side could cause the party wall to collapse on the other side.

According to a fire protection design standards, a true fire wall, separating two sections of a building, has an independent foundation and is designed to allow collapse of the roof and floors of one section without affecting the integrity or stability of the fire wall and other section of the building. A fire wall where roof and floor beams run parallel with the wall can be considered a fire division. In this situation, a fire company could be safely withdrawn from one section of the burning structure and continue interior firefighting from a horizontal opening in a fire wall from a safe section of the structure. Attached two-family houses with a plaster board or masonry fire wall between the houses must be considered one structure. When one

half of the attached structure becomes unstable and in danger of collapse during a fire, the entire structure is in danger. Occupants and firefighters must be withdrawn from both sections.

Complete Withdrawal of Firefighters

An incident commander may direct complete withdrawal of firefighters from a fire building and its surroundings any time a serious structural defect is reported by a firefighter. When this happens, an offensive strategy is changed to a defensive strategy. Firefighters are withdrawn and outside master streams are put into operation—this is a common strategy change. An incident commander may order an orderly withdrawal and an exterior defensive attack on a burning building whenever a fire is too large for the resources at the scene or when a structural defect is reported to the command post. Some structural hazards or warning signs that would justify this action are:

- An expanding crack in a masonry wall
- Bricks falling out of a wall
- Walls separating at the corners where exterior walls meet
- A structure leaning to one side
- Large volumes of runoff water from exterior hose streams through mortar joints or over tops of windowsills
- Roofs from which joists have fallen or which are extremely bouncy when walked upon
- Floors and roofs that give the sensation of swaying or moving with supporting walls
- Floor or roof joists that appear to be pulling away from masonry wall supporting enclosures
- Vibrating floors that are lower at the center because of deflection or overload
- Steel columns or girders that are out of plumb, warped, sagging, twisted, or fallen
- A building that has sustained any interior collapse
- Severe cracking and slanting of plaster interior walls or ceilings, which may indicate a shifting of structural framework behind the sheathing
- Creaking, rumbling, or cracking sounds coming from a structure
- Any fire where steel bar joist, timber or lightweight truss construction is exposed
- A large body of fire on several floors in an old building

This last warning sign is the most frequent event that causes incident commanders to withdraw firefighters from a burning building. Any large rapidly spreading fire throughout a structure is a danger to firefighters because of the possibility of structural collapse. A large, uncontrolled body of fire in an old building of combustible structure must be considered a warning sign. In many older cities and towns, fire

chiefs have developed informal guidelines as to when to withdraw firefighters from certain collapse-prone old structures. These guidelines, usually passed down from veterans to newer chiefs and company officers, have been developed after years of experience—sometimes years of tragic experiences. are: "Firefighter may be withdrawn from a burning building when there is a prolonged burning of a serious fire on one or more floors." The age of a structure, large combustible content, large structural fuel load, undivided open floor spaces, use of unprotected cast-iron columns, lightweight steel and wood trusses, and long span roof and floor systems are additional factors that cause an incident commander to withdraw firefighters and order a defensive outside firefighting strategy.

Emergency Exit Evacuation

There is a difference between changing from offensive to defensive strategy by withdrawing firefighters from a burning, and ordering an immediate emergency exit evacuation of all firefighters. The less urgent withdrawal strategy change is ordered when fire is beyond extinguishment or when a possible collapse is anticipated. The more urgent emergency evacuation is ordered when there is imminent danger discovered or reported, such as an explosion, collapse, terrorist event, or hazardous material incident threatening to overtake firefighters and trap them. In an emergency exit evacuation, unlike a withdrawal, a special evacuation signal is sounded, fire department tools and hoselines are left behind, all firefighters report to a predesignated area, a roll call or a head count is conducted, and the results reported to the incident commander. An emergency exit evacuation is a rare occurrence in the fire service, and, because of this, there is usually confusion and delay when it is ordered. Fire departments should train members for such an emergency exit evacuation. There should be a specific signal used only for an emergency exit evacuation, firefighters should exit the building upon the receipt of this prearranged signal, leaving behind tools and equipment. The should report to a prearranged area for roll call by their immediate supervisor, and the results of the roll call are reported to the incident commander.

Exit strategy training

Over the years, I often told firefighters how to enter burning buildings. I never once told them how to get out of a burning building. I never explained to firefighters how they may have to quickly exit a burning building in case of a possible sudden collapse, explosion, terrorist "dirty" bomb residue, or a hazmat release. Neither did any other fire chiefs I know. The words *retreat, withdraw, fall back, evacuate, escape,* and *draw back* are rarely mentioned in the fire service. There's no exit strategy training in the fire service. There is a firefighting strategy, a search-and-rescue strategy that explains how firefighters should enter into a burning building, but there is no exit strategy, no plan describing how firefighters should quickly withdraw from a burning building. There is no standard operating procedure that explains exactly how firefighters should evacuate a burning building.

This omission was evident on 9/11 at the World Trade Center fire and collapse. When Fire Chief Joseph Callan, at the lobby command post, Tower 1, ordered everyone to evacuate the building, even before the first collapse of Tower 2, some firefighters

did leave, and some did not. No one knows why. One theory is some firefighters did not hear the message to withdraw because the radio signal was blocked by the steel and concrete in the high-rise building. Another theory is some firefighters heard the message, but chose not to leave, and instead continued to search for victims. If the latter theory is true or not, the fire service must do a better job of training firefighters, how and when to leave a burning building.

The fire service must develop an emergency exit strategy, and train firefighters how to withdraw from a building when there is an imminent danger of collapse, explosion, gas release, or fire spread (fig. 19–5). The fire service must develop a standard operating procedure for emergency evacuation, and enforce its compliance, just as vigorously as it does an aggressive firefighting attack and rescue strategy.

Fig. 19–5. The fire service must have an exit strategy and train firefighters how to evacuate a burning building.

This emergency exit plan must instruct firefighters how and when to leave a burning building. There must be a universal, specific signal to alert firefighters to evacuate a building immediately, no questions asked. The fire service exit strategy must specify what tools and equipment are left behind. After leaving a building, the exit strategy must designate an assembly point where firefighters go to conduct a head count. The results of the head count are relayed to the incident commander at the command post by radio message.

Evacuation signal

A fire department must have a specific signal to alert firefighters to start an immediate evacuation of the building. Upon transmission of this exit signal all firefighters should withdraw from the building in a disciplined manner and report to the assembly area where a roll call is conducted. This signal must effectively reach and be heard by all firefighters. For example, in a low rise building a continuous air horn sounding could be heard by all firefighters at a scene. In a high rise building this would not be effective. In a high rise building a piercing tone signal transmitted over the portable radio by the officer in command should be considered, or any other type signal that would reach all officers, and most importantly, all firefighters operating out of sight or sound of a supervisor. A tone signal rather than a radio voice message would lessen the chance of misunderstanding. The Mayday announcement does not effectively cause firefighter to leave a building. There are too many reasons to use the Mayday signal today. The Mayday signal is used for firefighters trapped, when victims are found, and many other emergencies. Because the Mayday signal is frequently used and has other meanings, it should not be used as an emergency evacuation signal. If a radio tone signal is used to order a quick evacuation of a burning building it should be used for no other purpose. If the radio signal is used, it is imperative all firefighters who operate out of sight or sound of a supervisors be equipped with a radio to hear this evacuation tone signal. Firefighters working in proximity with the officer will be aware of the signal transmission, but firefighters assigned to operate alone, such as roof operation or outside venting, must have a radio to ensure they receive an emergency exit signal. The evacuation signal should never be used for any other reason except ordering a firefighter evacuation.

Tools and equipment

When the evacuation signal is given, all tools that could slow down a firefighter's exit should be left behind. The location a piece of equipment is left should be noted for future retrieval. Hose should be left. Power saws and heavy forcible entry tools should be left. Self-contained breathing equipment also left behind if it would slow a 10- or 20-story descent. This is an option as long as the exit path is smoke free. Anything that would slow down a quick, orderly, safe exit from a building should be left behind.

Assembly point

During fire prevention week, the fire service advises citizens when conducting a family fire drill in the home to identify an assembly area where the family meets after leaving the house during a fire or a family escape plan drill. The fire service should

require the same. After an emergency evacuation signal is transmitted and firefighters exit a building, they too should have an assembly point. This assembly point should not be in the front of the building and it should not be at the command post. These assembly areas could be near the fire apparatus parked in the staging area, or in the street away from the building. At this assembly area the company officer should conduct a roll call and report the result to the officer in command.

Time of evacuation

The fire service does not have a clue how long it would take to get all the firefighters of a second- or third-alarm assignment out of a building during an emergency. The one or two times I have ordered an evacuation of a burning building, it took much longer to get everyone out than I expected. The time of evacuation must be recorded. The exit time is the time from when the signal is transmitted until the time when all fire companies at the scene report the results of the roll call. The fire service does not know how long it takes for firefighters to exit a burning building. We know our response time, we know our "set up" time, but we do not know an exit time. Knowing how long it would take for all firefighters on a working all-hands fire, a second-alarm assignment, a third-alarm assignment, a fourth-alarm assignment, and a fifth-alarm assignment to quickly leave a burning building would assist the incident commander's strategy. This knowledge of exit time might reduce the possibility of an incident commander's overcommitment of resources into a fire area. Overcrowding on a stairway or behind a nozzle firefighter is a problem at some fires. The more firefighters I send into a burning building, the longer it will take to get them out of the building. In this age of terrorism, IEDs, secondary devices, and "dirty" bombs, this exit strategy information is invaluable. Knowing firefighting emergency exit time might help an incident commander assess the time necessary to change strategies from offensive to defensive.

Training

A recent law change in New York City being considered as a result of 9/11 is the requirement of a full-scale evacuation drill of all high-rise office buildings once a year. The fire department must know how long it takes to evacuate all persons from a high rise office building in order to effectively decide the risk or rewards of whether to fight a fire or to evacuate the building. This information is critical when determining strategy during a fire, terrorist bomb threat, hazmat threat, or collapse danger. This law will require all occupants of a high-rise building to descend the stairs and leave the building entirely, and not just assemble near a stairway as was required for a fire drill before 9/11. The fire service must do the same. We must train firefighters for full-scale emergency evacuation of a building.

During rookie school, or during annual evaluation training exercises, fire companies should be trained in procedures for conducting an emergency evacuation. When conducting a firefighting exercise for new recruits during rookie training school or veterans during company evaluation training, an evacuation signal should be part of several training events. For example, during an exercise, of hose stretching or search-and-rescue in a training tower, the evacuation signal should be sounded. Firefighters should leave tools, and quickly, in an orderly manner, and safely leave the training tower. Then they should assemble back at the apparatus or designated area. There

a roll call should be conducted and the results transmitted by radio to the training incident commander. The exit should be timed and recorded. This timing is not to increase speed of evacuation. The time recordings should be to show the fire officers and fire chiefs how long it will take for an emergency evacuation to take place.

A strategy for exiting a building should not be left to chance. Firefighters must be trained how and when to leave a burning building during an impending sudden danger. If we do not train, it will not be carried out during a fire or emergency.

Lessons Learned

We ask firefighters to "say something when they see something," so we better know how to "do something when they say something."

23

Early Floor Collapse

An engine company is advancing the first attack hoseline 10 feet inside the first floor of a burning two and half-story wood frame dwelling. The firefighter directs a stream "over his head and all around," breaking up heat waves and driving flames back. Moving forward, smoke is banked down. The floor feels hot. There is zero visibility. The nozzle firefighter backed up by a captain and second firefighter move forward. Directing the hose stream, the firefighter feels a strong backwards tug on the hose, a cracking noise, and a shout behind him. Turning; there is no one behind him. A section of floor collapsed. The officer and backup are gone—they fell through the flo Smoke and flame rise up through the floor opening. Leaping backwards over the opening and then getting up and scrambling out to the front porch, the firefighter shouts "Chief, the floor collapsed! The company is in the cellar!"

This *"through the door through the floor"* story is being repeated throughout the country. A veteran fire officer said to me, "Floor collapse seems to be happening during the early stages of a fire, too often, and at too many fires. Some one has to sound an alarm." For example, in the FDNY, Howard Carpluk, Mike Reilly, and John Clancy. Across the river in New Jersey, East Franklin Fire Department, Kevin Appuzzio. Across the nation, Brant Chesney, Forsythe County, Georgia; John Ginocchetti, Tim Lynch, Manlius County, New York; Steve Smith, Wea Township, Indiana; Arnie Wolfe, Green Bay, Wisconsin. All of them went "through the door through the floor" with collapsing first floors (fig. 23–1).

Sometimes the cause is old construction, other times bad renovations, but most of the time, it's rapid failure of preengineered floor construction or lightweight truss construction. Preengineered wood materials have long been identified by the fire service as the cause of early collapse incidents at post-fire investigations. Finally the scientific community is catching up. Underwriters Laboratories (UL) has an online presentation summarizing a research study of structural stability of engineered lumber and fire conditions (*www.ul.com/fire/structural.html*). They examine the hazards and assess risk for the life safety of building occupants and firefighters in the program. The study was funded by a Department of Homeland Security grant. The fire service now has scientific proof of claims of early collapse of structures built with lightweight, preengineered wood materials, specifically, wood trusses and wood I-beams.

Fig. 23–1. Steve Smith, Wea Township FD, was the first firefighter to die in a wood I-beam floor collapse.

A type of floor collapse that seems to occur over and over again is the first floor of a private dwelling collapsing into a cellar fire. Firefighters fall into the basement after the floor collapses and are killed by products of combustion, flame, heat, smoke, or gas.

- Question 1. What causes a first floor to collapse?
- Question 2. Why don't the firefighters size up the fire as a cellar and stay off the first floor?
- Question 3. Why is the floor collapse increasing?

The following are some answers to these questions.

Cause of Floor Collapse

Cellars are often unoccupied spaces. They contain large amounts of storage and heating units. If a fire occurs, it can quickly grow unnoticed. Cellar fires are often delayed alarm fires. There will be a delayed notification to the local fire department. Undetected fire progresses through three stages: growth stage, fully developed stage, and decay stage. An undetected cellar fire may progress from the growth stage to the fully developed stage before it is discovered and before the arrival of first responders. Flashover—full room involvement—can happen in the transition from the growth stage to the fully developed stage. Once the blaze is burning freely, it starts to attack the structure and the collapse danger begins. The collapse danger of a cellar fire is the

collapse of the first floor. A long-burning cellar fire can feed on the underside of the first floor. Upon arrival of the first responders, smoke and fire may involve the upper floors of a dwelling, hiding the real origin of the blaze down in the basement or cellar.

Most basements are unfinished. There is no cellar ceiling. The underside of the first floor is open joist construction. In a finished basement with a ceiling, the ceiling barrier can give floor supports 20 or more minutes of fire protection. Without a ceiling, any fire will quickly weaken the underside of the exposed floor joists and the first floor quickly becomes a collapse danger during a cellar fire. A first floor will collapse faster than second floor level or even attic floor if it is without ceiling protection. Even if there is a ceiling protecting the underside of a first floor, there may be panel missing or the light fixtures may not have fire-rated frames or some of the ceiling panels not be properly set in the frame, allowing cracks for fire to spread to the first floor construction. Often, unoccupied cellar areas get less maintenance than upper floors.

Why Don't Firefighters Size Up a Cellar Fire?

Why don't the first-arriving firefighters locate the origin of the fire in a cellar and use offensive firefighting tactics? The answer is the fire in a cellar may be overlooked during the initial size-up, especially when heavy smoke is pushing out the upper floors and attic. The large open stairway in a private dwelling often extends from the cellar to the second-floor bedrooms. Smoke from the cellar rises up the open stairs to the upper floor bedrooms. A private dwelling of balloon construction has concealed spaces that extend from the cellar to the attic. In balloon framing construction, unlike post and girt, or platform wood construction, the exterior wall studding has 16-inch spaces that extend from the cellar foundation sill directly up to the attic space. If you have a cellar fire in a balloon constructed building, you can have smoke and fire coming out of the attic when you actually have a cellar fire. Fire and smoke from the tightly sealed up burning cellar can enter the exterior walls spaces at the foundation sill and travel up the walls spaces of balloon construction to the attic.

The increase of "through the door, through the floor" collapse, makes initial size-up upon arrival critical for first responders. In addition to the size-up of smoke and flame from outside the building, first responders must then ask themselves "Is this a cellar fire?" When responding to a dwelling fire and smoke involves one of the upper floors, the cellar must be checked to see the blaze has not originated there. The small basement windows or double cellar doors at the side or back of the house should be checked for signs of cellar fire. At strip store fires, tragic experience over the years has taught incident commanders to order someone to check the cellar for fire origin. This is because of the danger of floor collapse. In New York City, 12 firefighters were killed when a first floor collapsed into a burning cellar. Have someone check the cellar for fire. This size-up is even more critical if you know the building is lightweight wood truss or I-beam construction (fig. 23–2).

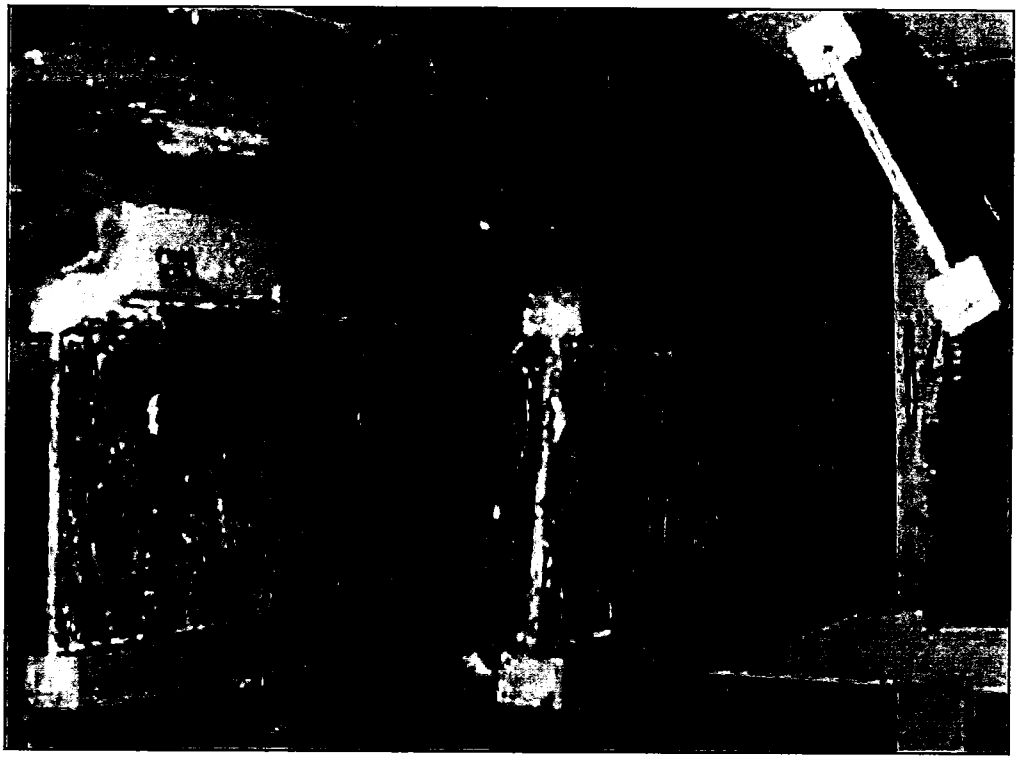

Fig 23–2. Lightweight wood I-beams have a wood web member and a 2×2 inch top and bottom flange.

If smoke is coming from a chimney and there is a fireplace in the finished basement it could be a cellar fire. If smoke is coming from the attic in a balloon frame wood building it could be a cellar fire. If fire is coming from the first or second floor and there is an open cellar stair it could be a cellar fire.

After a lecture on lightweight wood truss collapse and a slide show that names 21 firefighters who have died, I am sometimes asked, "Chief do you know anyone who has died from wood I-beam floor collapse?" My answer was no until I went to Lafayette, Indiana. The firefighters from Wea Township, Indiana, told me about Chief Steve Smith. He died in a floor collapse during a cellar fire on June 26, 2006 (fig. 23–3). Chief Smith is the first firefighter to die by the floor collapse of a wood I-beam floor failure.

The Lafayette, Indiana, building was one-story wood frame 1,200-square-foot private dwelling built in 2004. The fire started in the unfinished basement that had no ceiling. A lightning strike hit the cable TV roof antenna. The TV cable ran down through the building into the cellar and through the laminated glue-and-wood shaving web section of several wood I-beams supporting the first floor. The hot antenna wire ignited the cellar wood I-beam. Smoke showed from the first floor of the building. Chief Smith, first on the scene, entered the first floor to make a quick size-up before the first engine arrived. He entered the front door, made a left turn, and the floor collapsed. The first floor caved in less than 10 feet from the front door, and he fell into the burning basement, where he was trapped.

Fig. 23–3. The wood I-beam floor collapsed and killed Chief Steve Smith.

A post-fire investigation (NIOSH F 2006-26) and photo analysis revealed that the cellar was unfinished and there was no ceiling. The first floor was supported by wood I-beams. During the post-fire investigation, the open joist wood I-beams showed exactly how the fire burned and the floor collapsed: First the hot electric cable wiring extended through holes drilled through the web section ignited several I-beams simultaneously. Flames spread outward from the wire, consuming the web sections constructed of wood shavings and glue. When the web sections burned away completely, the top flanges of the I-beams (2×2-inch wood pieces) bowed downward at the center. The top flange compressed downward to the bottom flange and then the bottom flange broke and fell away from the burned web section and top flange (fig. 23–4). There was no beam support for a section of the floor deck. A section of floor deck and several burned wood I-beams collapsed under the weight of Chief Smith as he entered the first floor to locate the fire's origin.

Fig. 23–4. The destruction of wood I-beam floor by fire

In 1984, James Pressnall was the first firefighter to die by collapsing lightweight wood truss construction using sheet metal surface fasteners, and in 2006, Chief Steve Smith was the first firefighter to die by collapse of wood "I" joist. Because of an increase in "through the door through the floor" collapse incidents, firefighter survival tactics and rapid intervention team (RIT) rescue tactics have been developed. These tactics have been successfully used by firefighters surviving a through-the-door, through-the-floor collapse, and by firefighters in rapid intervention teams who have rescued firefighters after a collapse.

Survival Tactics for Trapped Firefighters

Transmit a Mayday. State your location to the best of your ability, state the floor, room, area or division—A, B, C, D side. You must give rapid intervention team firefighters as much information about your location as possible. Stay in radio contact with command and rescuers. Manually activate your PASS alarm and maximize sound control—this can alert nearby firefighters to your location and they can come to your aid before a rapid intervention team. Remain in place unless heat and fire forces you to move. If you have to move due to fire or smoke, search for a window or door if possible. Notify command of your movement to escape fire and indicate the direction of your movement from collapse area if possible.

Use a tool to tap metal or a hard surface to make noise for rescuers and tell rescuers of any special tools necessary to get to you. Point your flashlight beam to the ceiling to assist rescuers, and stay low. Conserve air supply in your mask by trying to control your breathing, while communicating with command and rescuers. Do not remove your facemask. If your mask runs out of air, stay low, breath into your turnout coat, or crawl to a floor pipe recess or floor corner and try obtain air from a concealed space.

Admittedly these are difficult survival procedures to accomplish in a life-and-death situation when you're caught and trapped after a floor collapse, however survivors have used these life-saving actions and recommend their use.

Rescue Tactics for Rapid Intervention Teams

RITs standing by at a cellar fire should preplan a first floor collapse with trapped firefighters in a cellar. If a first floor collapses and a firefighter falls into a cellar, consider the following rescue procedures.

Have ground ladder placed down the collapse floor opening. A firefighter can sometimes climb up a ladder through the floor collapse opening. Divert a charge hoseline and quickly direct it down through the collapse floor opening. This will cool some fire and burning material around a trapped firefighter after a collapse into a burning cellar, and immediately lets the trapped firefighter know you recognize his location and the life-threatening situation. Extra self-contained breathing masks could be dropped down the floor opening to trapped firefighters for use if their masks run out, and extra flashlights could also be dropped down a floor collapse opening to trapped firefighters.

Rescuers must use caution after a floor collapse. If the floor deck around the floor collapse opening has sloped and tilted downward, there could be a "slide effect." The edges of a floor deck tilting downward could cause rescuers to slide into the cellar though the floor collapse opening. A ground ladder over the opening or supported by firefighter at one end could be used to support rescuers approaching a floor collapse area. Immediately after a floor collapse trapping a firefighter into a cellar, simultaneous rescue should be attempted from adjacent spaces such as adjoining buildings or cellar rooms or any horizontal opening, in addition to rescue from above.

Lessons Learned

- Building using preengineered wood trusses or I-beams should be identified and preplans for defensive firefighter drawn up.
- First responders should know upon dispatch if a building has preengineered truss or wood I-beam floor or roof construction. This can be accomplished by dispatcher's relaying this information to all first responders by radio during the response. The incident commander should have detailed written preplans of any building with preengineered construction material in the auto and ready for use at a fire. Defensive

firefighting procedures should be known by all chiefs, company officer and firefighters and recorded in the preplans.

- For example a pre plan could recommend a defensive firefighting standard operating procedures (SOP) such as the following:
  - Content fire: standard firefighting procedures
  - Structure fire: remove occupants and conduct exterior firefighting procedures
- A floor deck may appear intact even after supporting wood I-beams have burned away and failed. The floor deck may then suddenly collapse without warning.
- Upon arrival at a house fire in a building with truss or wood I-beam construction, first size-up a fire and determine if the fire origin is the cellar. Check side cellar foundation windows for signs of smoke or fire. Open any cellar doors at the side or rear to check for fire or smoke.

Note: For more information on floor collapse, search the Web for: *Firefighter Fatality Investigations: NIOSH F 2006-24; F 2005-09; F 2004-05; F 2002-11; F 2001-16; F2001-26; F 97-04.*