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AVAILABLE IN ELECTRONIC FORMAT

Rooftop Emergency Heliports

William T. Sampson III
Sandra Henninger

Systems Control Technology, Inc.
1611 N. Kent Street, Suite 910
Arlington, VA 22209

Richard S. Fixler, P.E.

Hoyle Tanner & Associates
5 Commerce Park, North
Bedford, NH 03102

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Final Report

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**Federal Aviation
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800 Independence Ave., S.W.
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MAR 21 1994

Dear Colleague:

Enclosed is a copy of FAA report DOT/FAA/RD-93/2, **entitled "Rooftop Emergency Heliports"**.

In the process of developing two previous Federal Aviation Administration (FAA) documents, "Rotorcraft Use in Disaster Relief and Mass Casualty Incidents -- Case Studies ," DOT/FAA/RD-90/10, and "Guidelines For Integrating Helicopter Assets Into Emergency Planning," DOT/FAA/RD-90/11, the FAA determined that there was a need for further study of the use of rooftop heliports in emergency situations and standards for these heliports. This document is intended to be used by planners and engineers who are responsible for city, urban , aviation, and emergency response planning, and for those who participate in disaster relief.

The research for this project began with an in-depth analysis of high-rise fires in which helicopters were used. Following this effort, building codes were studied which were applicable to the construction of heliports and helistops on the roofs of high-rise buildings. After appraising this information, the FAA's "Heliport Design" Advisory Circular (AC) 150/5390-2, was reviewed to ascertain if it fully addresses the requirements of emergency rooftop heliports. This data was then used to develop recommendations for additions or changes to the AC.

Helicopters have made significant contributions to the successful outcome of high-rise fires. In the past, most high-rise rooftop rescue efforts involving helicopters were spontaneous, unplanned responses by well-intentioned helicopter operators and pilots. There is a broad divergence of opinion among fire-fighting professionals on the need for and uses of rooftop emergency heliports. This document will hopefully provide information that will assist in site specific decision making at the local level.

We welcome any comments or questions you may have. Please address your comments to:

Federal Aviation Administration
Vertical flight Program Office, ARD-30
800 Independence Avenue S.W.
Washington, DC 20591

You may also call us at (202) 267-8514 or FAX us at (202) 267-5117

Sincerely,

Richard A. Weiss, Manager
for Vertical Flight Program Office

Enclosure

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In the process of developing two previous Federal Aviation Administration (FAA) documents, "Rotorcraft Use in Disaster Relief and Mass Casualty Incidents - Case Studies" DOT/FAA/RD-90/10 and "Guidelines for Integrating Helicopter Assets into Emergency Planning" DOT/FAA/RD-90/11, it was determined that there was a need for further study regarding rooftop emergency heliports.

The research for this project included an in-depth analysis of high-rise fire incidents in which helicopters have been used. Following this effort, a survey was conducted of building codes that were applicable to the construction of heliports and helistops on the roofs of high-rise buildings. These codes were examined to determine common and uncommon elements and to identify strengths and weaknesses.

After analyzing this data, the FAA's Heliport Design Advisory Circular (AC) 150/5390-2 was reviewed. This data was then used to develop recommendations for additions or changes to the AC.

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1.0 INTRODUCTION

In the process of developing two previous Federal Aviation Administration (FAA) documents, "Rotorcraft Use in Disaster Relief and Mass Casualty Incidents - Case Studies[1]," DOT/FAA/RD-90/10, and "Guidelines For Integrating Helicopter Assets Into Emergency Planning[2]," DOT/FAA/RD-90/11, the FAA determined that there was a need for further study of the use of rooftop heliports in emergency situations, and standards for these heliports.

The research for this project began with an in-depth analysis of high-rise fires in which helicopters were used. These helicopter operations varied from evacuating occupants to the delivery of fire/rescue personnel to the roofs of burning buildings.

Following this effort, building codes were studied which were applicable to the construction of heliports and helistops on the roofs of high-rise buildings. These codes were examined to determine similar and dissimilar elements, and to identify strengths and weaknesses.

After appraising this information, the FAA's "Heliport Design" Advisory Circular (AC) 150/5390-2[3], was reviewed to ascertain if it fully addresses the requirements of emergency rooftop heliports. This data was then used to develop recommendations for additions or changes to the AC.

1.1 BACKGROUND

The primary purpose of the rooftop emergency heliport/helistop is to provide a means for the fire department to gain access to the roof and generate interior smoke relief by venting the smoke through the penthouses. A secondary purpose is to allow the occasional evacuation of people from the roof when it is not possible to remove them down past the fire floor. However, this method of evacuation is considered a last resort for saving lives. Unless extenuating circumstances prevail, as determined by the fire department, all occupants should evacuate to the ground floor. The final purpose of the rooftop emergency heliport/helistop is to safely insert and extract fire fighting personnel and equipment to fight the fire from above. However, fire departments do not readily approach fighting a high-rise fire from above the fire, because the risk to firefighters increases substantially with exposure to intense smoke and heat.

There is a broad divergence of opinion on the need for and use of rooftop emergency heliports. In certain areas, California in particular, rooftop emergency heliports are a necessary element for the construction of high-rise buildings. Alternatively, in other parts of the country, rooftop emergency heliports are not given any consideration at all. It is the opinion of these regulators that early notification and rapid evacuation of occupants down and out from a burning building is most desirable. It is further believed that the presence of a rooftop heliport encourages occupants to go to the roof.

In previous disasters, when helicopters were used to support the efforts of fire and rescue personnel, it was necessary in many cases for helicopters to operate on makeshift rooftop landing zones. Planned emergency landing areas could have resulted in safer and more effective air-support operations. However, few buildings have such landing areas and few city planners/architects consider this option during the design of buildings. They generally fear that rooftop heliports would encourage occupants who are above the fire floor to go "up" rather than "down" when trying to evacuate the building, particularly if they know a rooftop heliport exists. During these high-rise fires, it has been necessary to vent the smoke from inside the building out through the roof and, on occasion, to insert fire personnel on the roof to fight the fire from "above." Also, in some extenuating circumstances, the need has arisen to evacuate occupants from the roof.

Many California cities such as Los Angeles, Pasadena, and San Diego, incorporate emergency rooftop heliports/helistops during the design phase of all new high-rise buildings. Their experience has proven that, on occasion, there is a strong requirement to have the capability to provide safe, immediate, and effective helicopter support during high-rise fires.

These cities vary somewhat in their requirements for emergency rooftop heliports. However, because of fire department extension ladder limits, all buildings require emergency helistops when any occupancy level is higher than 75 feet above the point of fire department access. This requirement is waived in some cities if there are two avenues to vent the smoke from the interior of the building out through the roof. These avenues are referred to as smoke-proof enclosures, interior vestibule smoke towers, pressurized stair wells, and vertical ventilation. In some cities, a helistop and two vertical smoke vents are required.

The requirement for helistops on new high-rise construction is limited to California. Generally, cities in the East and South are not receptive to the installation of emergency rooftop heliport/helistops. It is generally felt in these areas of the country that early evacuation and sprinkler systems are adequate. Further, new high-rise construction in these cities often uses an architecture that does not lend itself to the installation of rooftop emergency heliports.

1.2 PURPOSE

As previously mentioned, rooftop emergency heliports/helistops are not universally accepted because of the perception that they encourage occupants of burning buildings to evacuate to the roof. This document is intended to afford city planners the opportunity to broaden their perspective in developing specific building and fire codes for their own city or municipality, and to provide additional data that will assist them in assessing their requirements for fire/rescue services.

2.0 USE OF HELICOPTERS IN HIGH-RISE FIRES

The following section presents five case studies of high-rise fires in which helicopters were used to rescue occupants or insert fire support personnel. These case studies provide a descriptive background on the high-rise fire, examine the impact of the fire, address what type of support was provided by helicopters, and summarize what was learned as a result of the disaster.

2.1 ANDRAUS BUILDING FIRE, SAO PAULO, BRAZIL, FEBRUARY 1972

> On February 24, 1972, a fire in the 31-story Andraus Building in Sao Paulo, Brazil, killed 16 people and injured over 375 others. The fire, which occurred in a reinforced-concrete department store and office building, offers an unusual example of exterior fire spread in a high-rise building. The fire developed on four floors of the department store and then spread externally up the side of the building, involving another 24 floors. Wind velocity and combustible interior finish were factors contributing to the fire spread. A heliport provided refuge for 300 persons. Two hundred others were trapped in a stairway during the height of the fire. Fire fighters rescued 100 persons from the stairway at the fifteenth story over ladders from an adjacent building. During a four-hour operation helicopters rescued 350 persons from the heliport. Others were led to safety down the stairs after the fire had been controlled.[4]
>
> When fire fighters arrived at 4:26 pm flames had engulfed the facade and were extending above the roof. The mass of fire was 130 feet wide and over 330 feet high and projected at least 50 feet into the street. Fire also spread externally through windows on the west end of the building. ...Faced with a holocaust, fire fighters immediately called for additional help. People were trapped in the burning Andraus Building and in three involved apartment buildings across Avenue Sao Joao to the north.[5]
>
> The 31-story Andraus Building completed in 1961, was of mixed occupancy. The Pirani Department Store occupied the basement and seven stories above grade. Offices for a number of business firms were located from the eighth to the twenty-seventh floor. The top four floors, the twenty-eighth to the thirty-first, were finished for offices, but they were vacant at the time. A

heliport was located on the roof - the first heliport in Sao Paulo - but the facility had been closed to traffic by government officials for failure to comply with safety regulations, including failure to install landing lights.[6]

2.1.1 Impact of the Fire

The fatalities from this fire were remarkably low. The final count was 16 dead. ...Three hundred and seventy-five others were treated at hospitals and clinics for smoke inhalation, lacerations, and broken bones. Many others were treated at an aid station established in a bank one block from the scene. ...The fire loss estimates by insurance authorities indicate a building loss of over $2 million.[7]

...At the fifth-floor level (one floor above the point of origin) the door apparently failed during initial fire development. When that failure cut off escape to the street, office employees sought refuge in the stairway or on the heliport. The stairway was tenable on the floors above the thirteenth, and, ... ladder rescues were conducted on the fifteenth- and sixteenth-floor levels. People survived in the stairway for almost four hours until either removed over ladders or led to the heliport. Windows in the stairway were either opened or broken by occupants to obtain fresh air. Some amounts of smoke seeped from doors or drifted into the stairway. At the top of the Stairway, below the closed heliport access door, frantic crowding and pushing by people attempting to reach the heliport caused many injuries. The stratification of the fire, heat, and smoke damage in the stairway coincided with the height of the adjacent 14-story office building to the south. The floors above the fourteenth-story level were tenable, as noted above, indicating that more ventilation was afforded above the roof of the adjacent building, which blocked the wind.[8]

2.1.2 Helicopter Involvement

A chief rescue officer learned that two helicopters were available for service. He and another fire fighter boarded one, located at a heliport on a nearby high-rise building. Three other fire fighters boarded the other helicopter

and proceeded to the Andraus Building. By that time (approximately 5:15 pm) the fires on various floors had consumed much of the available fuel and the massive flame front subsided. The helicopters were able to approach the building and the rescue officer attempted to land. However, the people on the heliport were so desperate to be rescued they surged toward the aircraft and attempted to pull it down, and, fearing an accident, the pilot flew off. The second helicopter with the three fire fighters hovered just above the crowd, and the fire fighters dropped to the roof. A landing site was cleared and the rescue officer landed.

The primary task for the rescue officer was to gain control of the crowd and prevent panic. This was accomplished with the aid of volunteers from the crowd. A television antenna was dismantled for use as a landing site barricade. Reassurance of rescue and the leadership of fire fighters established order and prevented further casualties.

The scene was to change again when fire fighters discovered the closed door to the stairway. When it was opened they found a mass of people below crushed up against the sliding door, many of them seriously injured by those pushing from below. Fire fighters then brought another 100 persons to the roof. Some were unconscious from smoke inhalation; others had suffered broken bones and lacerations. The most serious cases were laid out on the roof ready for evacuation.

The roof crowd began to despair again when they saw the injured brought to the heliport. They thought that the injured would be evacuated first, delaying their rescue, and some presented self-inflicted injures, hoping to be among the first. Nevertheless the fire fighters were able to maintain control and organize evacuation. The ambulatory were grouped into one area for removal by the larger helicopters, and the injured were loaded into smaller helicopters (a much slower operation). This basic method permitted more people to be airlifted in a given time. The first group was airlifted at approximately 5:30.

The helicopter operation was not preplanned. Previous planning had been conducted to use Brazilian Air Force helicopters for emergencies,

but none was available in the area the day of the fire. One helicopter was from state government, two were from the city government, and the eight others were from various business firms. Three pilots saw the fire from the air; another heard a news broadcast at home; the rest were notified by various means. Radio contact was maintained between the Fire Department communications center and the airport to control the operation. Air Force officers assisted air traffic control from the airport control tower. The Fire Department selected three landing sites, a nearby plaza and two soccer fields, one 1 1/2 miles away and the other 2 1/2 miles away, where medical personnel established first-aid stations. Ambulances transported the injured to area hospitals.

Of the 11 helicopters involved, only eight were actually engaged in rescue at any one time. The largest helicopter carried eight passengers; three helicopters, five; two helicopters, four; four helicopters, three; and one helicopter carried two passengers.

In all, 350 persons were rescued in the four-hour operation. At dusk people still on the heliport held flashlights to guide the helicopters to the darkened landing site. As previously noted, the heliport was not equipped with landing lights; power had been cut over an area of several blocks. Some time after 8:00 pm all the office workers in the stairway had been either removed over ladders or taken to the roof. On the upper floors the fire had burned out and on the lower floors fire fighters had controlled the fire. Approximately 50 persons were led down the stairway to the street floor. The injured and those who refused to go down the stairs were removed in the continuing helicopter operation.[9]

2.1.3 Summary

...The principal factors responsible for the survival of people in the Andraus Building were the location of the office stairway relative to the wind direction and the ventilation afforded to both the stairway and the heliport by the wind velocity. The fresh air supply to the stairway through exterior windows was sufficient to maintain tenable conditions above the thirteenth floor - this in spite of door failures on lower levels and on the twenty-fifth and twenty-sixth

> floors. The wind velocity also maintained adequate air supply to the heliport. Thermal columns from the flame front tended to move away from the heliport. People got far enough away from the flame front to escape the effects of the radiant heat.
>
> Efficient rescue operations by fire fighters on the heliport and the fifteenth floor level also served to minimize casualties. Their efforts prevented further panic jumping or escape attempts, and the removal from the top of the stairs to the heliport relieved a very serious condition at that point. The closure of the heliport door by unknown persons contributed to injuries to those below. If all 500 people had gone to the heliport, it would have provided a place of relative safety throughout the fire.[10]

Wind direction, a heliport, and available helicopters aided in the rescue and evacuation of people on the roof. However, helicopters were not available during the height of the fire and would have been unable to approach and land on the roof. There was a tremendous flame front that stretched from the 5th floor all the way to the top floor.

Office and department store workers fled to the roof in this case, because they could not flee down the stairs due to extreme heat and smoke at the 5th floor level. The fire started on the lower floors and the 5th floor stairway door failed. Those that were heading down the stairs to street level were turned back. After the fire had consumed the contents of the building, it essentially burned itself out. Some people who had made it to the roof were evacuated back down the stairs. Others refused to go down the stairs and waited for helicopter evacuation. Most of the injured people from the upper floor were airlifted off the heliport roof.

2.2 MGM GRAND HOTEL FIRE, LAS VEGAS, NV, NOVEMBER 1980

> A fire at the MGM Grand Hotel on November 21, 1980, resulted in the deaths of 85 guests and hotel employees. About 600 others were injured and approximately 35 fire fighters sought medical attention during and after the fire.
>
> The high-rise building, constructed in the early 1970's, consisted of twenty-one stories of guest rooms situated above a large ground-level complex comprised of a casino, showrooms, convention facilities, jai alai fronton, and mercantile complex. The hotel was partially sprinklered but major areas including the Main Casino and The Deli, the area of fire origin, were not

sprinklered. About 3,400 registered guests were in the hotel at the time of the fire.

As reported by the Clark County Fire Department, the most probable cause of the fire was heat produced by an electrical ground-fault within a combustible concealed space in a waitresses serving station of The Deli.

Following full involvement of The Deli, a flame front moved through the Casino. Smoke spread to the high-rise tower through stairways, seismic joints, elevator hoistways and air handling systems. The means of egress from the high-rise tower was impaired due to smoke spread into stairways, exit passageways and through corridors.

The high-rise tower evacuation alarm system apparently did not sound and most guests in the high-rise were alerted to the fire when they heard or saw fire apparatus, saw or smelled smoke, or heard people yelling or knocking on doors. Many occupants were able to exit unassisted down stairs. Others were turned back by smoke and sought refuge in rooms. Many broke windows to signal rescuers or to get fresh air. The fire department confined the fire to the Casino level in a little over one hour. It was approximately four hours before all guests were evacuated.

Of the 85 fatalities, 61 victims were located in the high-rise tower, and 18 were on the Casino level. Five victims were moved before their locations were documented. The 85th victim died weeks after the fire. Of the 61 victims found in the high-rise tower, 25 were located in rooms, 22 were in corridors, 9 in stairways and 5 were found in elevators. One person died when she jumped or fell from the high-rise tower.[11]

2.2.1 Impact of the Fire

Some 600 persons injured as a result of the fire were treated, transported from the scene and ultimately seen by hospital personnel. Of the 600 injured, 318 were admitted to hospitals, and 282 were treated and evaluated in hospital emergency rooms and released later the same day.[12]

The National Fire Protection Association (NFPA) conducted a survey of 1,960 of the 3,400 registered guests in the hotel. Of those responding, 78.8 percent reported exiting the building by the stairs, 6.1 percent exited by the doors, and 5.8 percent reported exiting the building by helicopter.[13] The exact number of people evacuated by helicopter was not confirmed. However, the NFPA estimated that 300 people were rescued by helicopter.[14]

> Fire damage other than smoke damage at the MGM Hotel was almost entirely limited to the Casino level and second floor office area. There was minor flame damage on one or two guest rooms on the fifth floor and heat and smoke damage on upper floors, but the major damage by fire was in the Main Casino, the lobby areas at the main and Flamingo Road entrances, the hotel registration area and the west end of the Hall of Fame.[15]

2.2.2 Helicopter Involvement

Helicopters were crucial to the evacuation of approximately 10 percent of the hotel's occupants. They were used in three primary roles: evacuation of hotel occupants, transporting rescue personnel and supplies, and providing aerial command and control to expedite operations.

Tom Mildren, a police officer with the Metro Police Department, was flying routine patrol in Air #2, a Hughes 500, and was the first to spot the smoke and notify dispatch. He also was the first to arrive at the scene and land on the roof. Officer Mildren recalls,

> It was a panic situation up there. At one time, there were about 200 people on the roof, and they all wanted to get on the helicopter at once. We were a long way from the fire, but these people didn't know that; they thought they were going to die if they didn't get into a helicopter immediately. So, I had to load the few who could fit inside, then fight back the rest, and let the helicopter take off without people hanging on. When we would try to get back onto the roof to evacuate more people, we had to try to clear enough space to land.
>
> When people are that panicked, they're not going to listen to logic; they're not going to calmly stand in line. Those people all wanted on, and they fought me like cats and dogs.[16]

Air #2 had to land with its tail rotor hanging over the edge of the roof when it made its first few landings because of the danger it posed to the panicked mass of people. The pilot of Air #2 solved part

of the problem by leaving the copilot on the roof to control the site and crowd. Those rescued from the roof were dropped off in a dusty field near the hotel. Because no police or fire personnel were present at the field and the copilot was not on board, the people had to get out of the helicopter on their own. Many did even before the aircraft landed, hanging dangerously onto the sides and undercarriage of the helicopter and some all too close to the tail rotor. Eventually ground control was established by the Metro Police Department. When three more civilian helicopters arrived, Metro #2 stopped evacuating people from the roof and started performing local air traffic control for the rescue operation. As reported by the NFPA,

> Helicopter operations were jointly coordinated by McCarran International Airport Approach Control and the Metro Police Department. A Metro police sergeant at the command post maintained communications with the Metro helicopters. All of the on-site helicopter operations were coordinated by the Metro Police Department helicopter. Metro helicopters were in the air almost continuously, coordinating the operations of all other helicopters.[17]

A race track pattern was established to control the traffic flow of the helicopters. As fast as one helicopter would be loaded, another would land. According to one report, one helicopter hovered near the roof to blow away smoke while the others landed.[18] In approximately half an hour, the roof had been cleared. At any one time, there were 9 to 12 helicopters, a mix of civilian, commercial, and military aircraft, in the air. Table 1 contains a list of the helicopter operators who responded to the scene. Air #2 kept them all informed of the location of other aircraft. One military pilot commented, "I don't think it would have gone any smoother if we had all sat together and had a 3-hour briefing and planned it as an exercise."[19]

By the time the helicopters had evacuated all the victims from the roof, the firemen had the blaze contained to the ground level. They began directing those guests who were able to walk down the stairways. More people would have been evacuated by helicopter if the fire department had not been able to contain the fire so quickly.

Approximately 300 people were airlifted from the roof representing seriously injured and smoke inhalation victims.[20] Helicopters brought in self-contained breathing apparatus (SCBA) bottles for use by the firefighters. Relief personnel were flown in to replace exhausted firemen. In addition, bodies were carried to the roof for removal by helicopter to a temporary morgue.[21]

As Air #2 circled the hotel after the rooftop evacuation was complete, it spotted many guests waving for help from their rooms. It used its public address system to tell them to stay in their rooms and remain

TABLE 1
HELICOPTER OPERATORS RESPONDING TO MGM GRAND HOTEL FIRE

1. Air #2, Las Vegas Metropolitan Police Department (first aircraft on the scene, two pilots)

2. "Flight for Life" from Valley Hospital, Las Vegas, NV (Second aircraft on the scene)

3. Silver State Helicopters, Las Vegas, NV (Third aircraft on the scene)

4. Action Helicopters, Las Vegas, NV (Fourth aircraft on the scene)

5. Bauer Helicopters (made several trips to Glendale and Overton, NV for air packs)

6. E.G. & G., Las Vegas, NV

7. Environmental Protection Agency, Las Vegas, NV

8. San Bernardino Sheriff's Office, San Bernardino, CA

9. Loma Linda University Medical Center, Loma Linda, CA

10. Air #1, Las Vegas Metropolitan Police Department (one pilot)

11. Nellis Air Force Base, Las Vegas, NV supplied nine helicopters: six UH-1N Hueys and three CH-53 Sea Kings, with an average of five persons per helicopter.

calm.[22] It positioned the Air Force's CH-53's so that they could rescue people from balconies. They were equipped with hoists and penetrators (a device with seats that fold out like flower petals).[23] In order to move the sling close to the balconies, the CH-53 had to stay above the rooftop level to offset the diameter of the rotor. Even then, overhangs on each balcony prevented the slings from moving close. The rescuer would throw a cargo strap to the people on the balcony and they would pull him in by swinging him like a pendulum. Once on the balcony, he got out and strapped people in, one or two at a time, depending on their cooperation.

Colonel David Wallace was in charge of the three CH-53s. He recalls that,

> everyone who watched that particular operation admired the effort, but recognized the limitations of it. We're just not designed for massive evacuations, and it was a tedious, slow process; we couldn't take a large number of people because of that.
>
> It can also be argued that, hovering at that altitude, we caused more risk by being up there than the good that we were able to do. There was a lot of activity going on down on the ground, and if a rotor had hit the building and we had dropped the chopper down into those masses, we could have killed a lot more people than we actually saved. We can't argue with that, but at the time, it seemed like the smart action to take.[24]

The operation had to be suspended after only 15 (NFPA reported 12) people had been rescued; the draft created by the rotors was fanning the fire and disrupting the operations in one of the triage areas.[25] Supplies were being blown around and communications between rescuers required shouting.

As noted earlier, the last reported involvement of helicopters in the MGM Grand fire was in helping to evacuate the dead from the roof. The writer surmises that most of the casualties occurred on or above the 20th floor of the 26-story structure as a result of the inoperative alarm system. The firemen found it easier to carry the corpses up 1 to 6 stories rather than down 20 to 26 stories (elevators inoperative). According to one report,

> The helicopters flew for 3 hours in a nonstop, looping, counterclockwise circle; up from the parking lot to the roof, empty, and back down again with 3 bodies on stretchers. As the helicopters approached, their prop wash forced coroner's deputies to stand on the empty body bags to keep them from blowing away.[26]

In retrospect, the use of helicopters during the MGM Grand fire was controversial. Although helicopters rescued everyone who made it to the roof, several people were believed to have died while trying to get there. It can be argued that seeing the helicopter evacuation in progress persuaded them to leave their rooms when safe passage was impossible.[27]

Rescuers at the scene made the decision to quickly evacuate those they saw on the roof, because they had no way of knowing how serious the fire would become. As it turned out, roof occupants were never in serious danger.

> Shortly after the MGM Grand fire, the New York City Fire Department released a bulletin on its own policy regarding helicopter operations at high-rise fires, ...it can be anticipated that at future high-rise fires, more and more people will ignore fire department advice and will flee to the roof. It is recognized that roof evacuation by helicopter is an extremely hazardous and time-consuming operation and would be undertaken only as a last resort...[28]

2.2.3 Summary

There were several important factors in the helicopter involvement at the MGM Grand Hotel fire. First, the weather was favorably calm and clear. Second, the fire occurred during daylight. And third, there were nine Air Force helicopters (three heavy lift helicopters (CH-53 Sea Kings) and six Hueys (UH-1N)) on temporary duty at nearby Nellis Air Force Base available to augment the normal local helicopter population.[29]

All personnel involved in the helicopter operations agreed that they proceeded smoothly and safely. The only criticism of the operation came from those who questioned whether helicopters might have been over-utilized. Ironically, an effective helicopter disaster relief effort was rapidly developed without the benefit of extensive prior planning.

There were several lessons learned from the MGM Grand fire. None of the disaster drills had anticipated a multitude of helicopters, especially large helicopters, flying above the triage areas.[30] The following should be considered for future operations.

1. Establish landing zones in grassy or paved areas to minimize flying debris from rotor downwash.

2. Shield microphones against rotor noise during transmission from ground based personnel.

3. Consider size of the helicopter in its application to the rescue problem. Large helicopters are generally more disruptive due to the high rotor velocities, rotor downwash, and excessive noise. However, they may be the only suitable helicopter for certain operations such as the balcony rescues.

4. Communications are crucial to the effectiveness of the rescue operations. They include: air-to-air communications into and out of the pickup and dropoff points; and air-to-ground to position aircraft and advise when a landing zone (LZ) is ready for pickup or dropoff and to the command center for responding to additional mission requests.

5. For landing zone safety and support:

   a. a crash fire rescue (CFR) truck should be at the main LZ.

   b. a refueling area should be maintained separate from the main activity of the LZ, but still within the watchful eye of the CFR truck. Refueling ferry time would be minimized and rescue efforts maximized.

2.3 DUPONT PLAZA HOTEL FIRE, SAN JUAN, PR, DECEMBER 1986

A mid-afternoon fire at the Dupont Plaza Hotel in San Juan, Puerto Rico, on December 31, 1986, resulted in 97 fatalities, including 17 employees, and 146 reported injuries. Nearly all the fatalities were located in the casino or in the hotel's main lobby area.

The fire occurred in a nonsprinklered, 20-story hotel complex which had two basement levels. The hotel contained the first-floor grand ballroom, a second-floor (main entrance level) casino, retail shops, restaurants, a registration area, and a function room. In the complex's high-rise tower were 17 guest room floors and a rooftop restaurant.

Local authorities, working with the Bureau of Alcohol, Tobacco and Firearms (ATF), determined that the fire was deliberately set using a single can of a "Sterno-type material" to ignite guest room furniture, still in shipping crates, stored in the unoccupied south ballroom. Once ignited, this abundant fuel load resulted in a rapidly developing fire that quickly ignited other combustibles within the south ballroom as well as the ballroom's combustible interior finish.

The fire was discovered in an advanced stage, beyond the control of some employees who attempted to suppress it. As word of the fire began to spread through the lower levels, flashover [the sudden spread of flame over an area when it becomes heated to the flash point] was reached in the south ballroom. Fire violently vented into an unenclosed stairway foyer area and began to spread products of combustion to the lobby/casino level. As the two-story-high foyer filled with heat and smoke, glass partitions in a masonry wall that adjoined the foyer and the casino soon failed. A smoke front, followed by a flame front, moved through

> the casino and lobby area and vented from the west wall to the exterior. For occupants still in the casino, there was little time between recognition of impending danger from the fire and its movement through that area. Some of the casino's occupants who acted early did escape, using one of the exits, during this time interval; some felt that they were in a smoke free area and closed exit doors to prevent infiltration; others broke exterior glass window walls and jumped to safety as the flame front was moving toward them.
>
> Once the fire reached the lobby/casino level, products of combustion began to spread to the high-rise tower, trapping hundreds of unaware occupants. Rescue workers assisted many of the trapped occupants by directing them to the roof of the building, where they were removed by several helicopters making numerous return trips to complete their mission.
>
> Even though significant amounts of smoke, heat, and toxic gases penetrated the high-rise tower, especially on its lower levels, there was only one fatality in the tower. It is felt that the exterior balconies provided occupants trapped for hours with a safe refuge area until the fire could be suppressed or they could be assisted by rescuers.[31]

2.3.1 Impact of the Fire

> The enormity of the fire upon the fire department's arrival and the vast extent of the rescue effort completely outstripped the department's ability to alter the outcome of the fire or the amount of property damage. This is not an unusual circumstance in large, undivided, nonsprinklered, poorly protected buildings--especially when fire fighters are summoned for help after room flashover has occurred, as in this case.[32]

Although severe heat was able to penetrate the first 10 floors of the high-rise tower, there was no fire extension into the tower. All levels of the tower did show some evidence of smoke damage.[33]

The smoke drove people out onto the balconies where they formed groups by breaking down the glass partitions which separated them. The groups formulated strategies for survival. According to the NFPA, "Apparently these strategies were influenced by a group's location,

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knowledge of fire survival techniques, and rescuers including the helicopters hovering at roof level."[34]

> In spite of significant amounts of smoke that spread throughout the building and the high-rise tower, only a few fatalities can be linked directly to the effects of smoke. Nonetheless, the potential for a much greater number of fatalities existed; only a few fortunate circumstances, such as time of day and the balcony arrangement, prevented further deaths.[35]

There were 97 fatalities and 140 injuries in the fire. Eighty-four of the fatalities were in the casino, five fatalities were in the lobby, three were in an elevator between the basement and the first floor, one was in a guest room on the fourth floor (possibly asleep at the time), two were outside, and two died from burns at local hospitals.[36]

Property damage estimates ranged between six and eight million dollars.[37]

2.3.2 Helicopter Involvement

Helicopter involvement in the Dupont Plaza Hotel fire was influenced by several factors. First, it was daylight. Second, there were 10-knot cross winds which made operations difficult.[38] Third, there was no helipad, nor a flat space large enough to land a helicopter on the roof. Fourth, the fire had vented to the outside and was releasing heavy smoke and superheated, less dense air which interfered with helicopter operations.

There were six helicopters involved in the roof evacuation. Table 2 contains a list of the operators involved. The first helicopter on the scene was a Puerto Rico Police Department Hughes 500. However, the roof had a structure on top for machinery, and on top of the structure was a large sign and an antenna. The police pilot determined that he could not safely land on the roof. Approximately 45 minutes after the fire was reported, a Bell Jet Ranger piloted and owned by Mr. Walker of St. Thomas, Virgin Islands arrived. Mr. Walker had been alerted to the need for helicopters by air traffic controllers as he approached San Juan from the Virgin Islands. He quickly unloaded his charter customers and refueled the Jet Ranger before responding to the FAA's request. The FAA also contacted the U.S. Coast Guard (USCG) and the U.S. Navy to request assistance at the same time; however, the Navy was 30 minutes flying time away and the USCG was 45 minutes away. All that was known and reported at that time by the FAA was that there was "lots of smoke, lots of fire and lots of people on the roof."[39]

Mr. Walker made the first landing on the roof of the Dupont Plaza Hotel.[40] He had to land with one skid off the roof and hold the aircraft in position while people boarded the aircraft. He reported

TABLE 2
HELICOPTER OPERATORS RESPONDING TO DUPONT PLAZA HOTEL FIRE

1.	Puerto Rico Police Department - Hughes 500 (first aircraft on the scene, one skid landings = one skid on roof, one skid in the air)
2.	Chartered Jet Ranger (second aircraft on the scene, one skid landings)
3.	Puerto Rico Army National Guard - (provided local air traffic control (ATC))
4.	US Navy - 2 CH-53 Sea Kings (hoist and basket)
5.	USCG - Dauphin (2 pilots, 1 crewman, hoist and basket)

being blinded at times by the smoke and heat. However, he rescued 21 people by his own count. After the police pilot observed the successful one skid landing, he joined in the evacuation. However, both pilots withdrew after the larger Navy helicopters (CH-53's) arrived.

The Puerto Rico Fire Department had also notified the USCG of the people trapped on the roof. Since the Navy base was 15 minutes closer to the scene, they were alerted by the USCG. Both services responded with large helicopters. The Navy arrived with two CH-53 Sea Kings and the USCG arrived with one Dauphin. Both types of aircraft were equipped with hoists and baskets.

The two Navy helicopters arrived shortly after Mr. Walker's Jet Ranger. They took over the evacuation with their hoist and basket system since it was a safer arrangement. Approximately 15 minutes after the Navy Sea Kings arrived, they were joined by the USCG Dauphin and a Puerto Rico National Guard helicopter. The Dauphin joined in the roof evacuation and the National Guard helicopter offered to perform local air traffic control.

The Dauphin was piloted by Lieutenant Commander R. Larsen. The following quote is from an article he wrote about the rescue:

> I really didn't know what to expect as I approached, but it was not the calmness and organization that we saw. On the roof were dozens of people, young and old, all in casual attire - people who had been forced out of their rooms by fire - calmly waiting to be rescued. There was no panic, no scramble for the helicopter. They were just standing or sitting next to the structure, as if they were waiting for the bus.

There was a policeman on the roof who obviously was in charge. He should be put up for some kind of medal. He calmed the people and kept the crowd under control. When we came in, he must have pointed to the next four or five and said, "You, you, you, and you - you're next."

Our part was fairly easy. I was fortunate that day to have both a co-pilot and a crewman. We hoist people, or practice it, nearly every day. We have a basket about twice the size of a grocery shopping cart. A person sits in it and the crewman lifts it. The crewman, using a headset, guides the pilot so the basket is lowered right to the people. This operation takes practice and coordination, but Coast Guard and Navy helicopters do it routinely.

The vertical distance might be 20 or 30 feet and the hoist may last only a few seconds. But for someone who has never been in the air, 200 feet off the ground, the experience can be terrifying. In addition to the height, there is a lot of noise and wind. But I didn't see anyone who was not willing to go.

We loaded them, three, four or five at a time, and landed a short distance away on the beach. Lots of helping hands were there to care for survivors. None of our passengers was visibly injured, but these people must carry some emotional scars.

After unloading, we headed back to the roof. By now, the smoke was really swirling around, making it difficult to see and to fly. Occasionally, we flew into heated air and, being less dense, it couldn't support our weight. We would sink a little, then have to climb back up to where we wanted to be.

The civilian helicopter had found people trapped on the fifteenth or sixteenth floor, and the Army colonel asked us to try to rescue them. With a 200-foot hoist cable, it was possible to reach them. But, once in position, I could see people leaning out and reaching for the basket. I didn't want to see what would happen next: someone reaching just as we hit one of those hot air pockets and missing the basket. So we got on the PA system and told them to try to get to the roof, and we would take them from there.[41]

Unfortunately, every time a helicopter landed on the beach (75 feet north of the hotel) to drop off survivors, the rotor wash fanned the flames and pushed the smoke toward the firefighters.[42] The noise from the helicopters overhead also made communications difficult. In some cases, firefighters were forced to talk face-to-face.

The Puerto Rico Fire Department tallied 215 persons airlifted to safety.[43] However, a lot of the roof evacuations took place after the fire was under control.

There was no emergency plan for the use of helicopters in existence during the Dupont Plaza Hotel fire disaster. In fact, the Puerto Rico Fire Department had never had a practice helicopter rescue of any kind.[44]

There is no mention in any of the literature about helicopters being used to transport firefighters or their equipment.

2.3.3 Summary

In contrast to other fire rescue operations reviewed in this document, the helicopter involvement was limited to retrieval of guests only. Six helicopters were involved, including civil, military, and commercial aircraft, all operating in a coordinated manner. Possibly one of the reasons that helicopters were not used more extensively is that preplanning and coordination for command and control responsibilities had not been accomplished.

The rooftop evacuation was a success and is credited with rescuing approximately 215 people. However, the helicopter evacuation continued even after the firemen had the fire under control. Once it was clear that the people in the tower were in no immediate danger, perhaps the air evacuation should have been reduced or halted.

2.4 HIGH-RISE FIRE, LOS ANGELES, CA, MAY 1988

> A major after business hours, high-rise office building fire occurred on Wednesday, May 4, 1988 in the city of Los Angeles, California, resulting in one fatality and ultimately destroying four floors of the First Interstate Bank Building.[45]
>
> Constructed during the early 1970's and first occupied in 1973, the building is Los Angeles' tallest high-rise building. When built, the 62-story structure was intended to anchor the skyline for the city's emerging financial district on the south end of downtown.
>
> The building is the corporate headquarters for First Interstate Bank, employing 1500 bank employees at this location. In addition, the

building contains leased office space for additional tenants, including law offices and other banking and financial institutions. On a typical business day approximately 3500 people occupy the building. In addition to office occupancy areas, the building contains an employee cafeteria, sub-grade parking areas, a public banking area located on the street level, and a rooftop heliport.[46]

The Los Angeles City Fire Department described the suppression effort as the most challenging and difficult high-rise fire in the city's history. It took a total of 64 fire companies and 383 firefighters more than 3 1/2 hours to control the fire.[47]

At the time of the fire, there were only about 40 occupants in the building. They included bank employees who were working late, building security and maintenance personnel, a cleaning crew, and workers installing an automatic sprinkler system in the building. Although the building was in the process of being retrofitted with automatic sprinklers, the system was not complete and was not operational at the time of the fire.

2.4.1 Impact of the Fire

One fatality resulted from the fire, a maintenance worker who had taken an elevator to the 12th floor to investigate the cause of the fire alarms. Others were able to evacuate via stairways; eight were lifted off the roof by helicopter. Fire damage was extensive from the 12th to 21st floors. It was estimated to take 30 to 60 days before the floors below the 22nd could be occupied due to a combination of fire and water damage.[48]

2.4.2 Helicopter Involvement

"At approximately 10:35 p.m., Los Angeles City Police Department helicopters AIR 8 and AIR 3 observed a major fire in progress..." at the bank building. Between the two helicopters, they rescued six maintenance persons from the roof.[49] A fire department Bell 206 command ship and a Bell 205 were soon on the scene. The 206 searched the building floor by floor, illuminating the scene with its Nightsun searchlight.[50] The 205 dropped a paramedic team off on the roof to search for more victims. Two other fire department helicopters arrived on the scene and transported more fire crews and support equipment to the roof. The first 205 on the scene stayed on the roof, idling in the event a quick escape by the rescue teams was necessary. Meanwhile, the fire department's EMS-equipped Bell 412 was standing by

at the scene. The searching 206 spotted a man trapped on the 50th floor and the 412 was used to evacuate him from the roof.

In all, fire department helicopters logged 26.9 hours on the scene and the police helicopters logged 2.6 hours. A total of four fire department and two police helicopters were involved.

2.4.3 Summary

Helicopters were pivotal in identifying victim locations along the windows of the building. They were able to search, spotlight, and hover along all sides of the building while looking for victims of the fire. Their participation was particularly important because of the building's height and because it was night. It would have been difficult or impossible to spot victims from other buildings or from the ground in nighttime conditions. The helicopters contributed in many other roles during this fire. The night search capability was particularly prominent in this incident.

2.5 ONE MERIDIAN PLAZA FIRE, PHILADELPHIA, PA, FEBRUARY 1991

> On the night of Saturday, February 23, 1991, fire struck One Meridian Plaza in Philadelphia, Pennsylvania. It was to become one of the worst high-rise fires in history. Three firefighters died and 24 were injured. Nine floors of the 38-story office building were completely destroyed, causing millions of dollars in damage. Operations and logistics were severely hampered by failure of major building operating systems: main electrical power, emergency generator power, and, most important, water pressure from the standpipe system.
>
> The 38-story Meridian Building, the eighth tallest of approximately 500 Philadelphia high-rise buildings (6 stories/75 feet or more), was built in 1968 and 1969 under the 1949 Philadelphia Building Code. There is a helistop on the roof, with two landing pads. Approximately 2,500 people worked in the building. Tenants included law offices and brokerage, banking, and accounting firms. Two of the tenant spaces contained open interior access stairs between floors. In general, fire loading on all the floors was heavy - heavy wood paneling, heavy wood furniture, and an abundance of office machinery. Three people - security/maintenance personnel - were in the building at the time of the fire.[51]

2.5.1 Impact of the Fire

> Shortly after 8 p.m., a smoke detector activated on the 22nd floor. The signal was sent both internally to the security desk and externally to the central station alarm company. Instead of notifying the fire department, the alarm company called building personnel. An individual from lobby control rode the elevator to the 22nd floor to investigate. When the doors opened, the employee was hit with extreme heat and smoke; he buckled to his knees. He was unable to reach up through the heat to the control panel to bring the elevator down. Fortunately, he communicated with a second employee at lobby control via portable radio and since elevator recall from the lobby is possible in the Meridian building, he was brought back down. The third employee took the stairs from the 30th floor and met with the two other employees. They called the alarm company, which finally called the fire department. Precious time was wasted. The fire had been burning for at least 20 minutes. The initial alarm to the dispatch center was received at 8:27 p.m. from a caller on the street who reported smoke rising out of the building. Four engines, two ladders, and two chiefs responded on the first-alarm assignment.[52]
>
> At the height of the fire, 51 of the city's 61 engine companies were operating at the scene as well as 11 truck companies, 21 chief officers, and numerous medical and support vehicles. Citywide response never dropped below 20 pumpers because of recall personnel manning reserve rigs.[53]

The fire was burning so hotly that it had spread to the 24th floor. Conditions in the stair towers which the firefighters were using become intolerable. When the fire was fought on lower floors, the stairway door was opened to allow the advancement of hose lines. Smoke and heat rapidly filled the stairwell.

> ...three members of engine company 11 were ordered to the roof via the center stairs to open the bulkhead door and vent the stairwell. They were to proceed across the roof and open the doors to the other stair shafts.[54] Some time later, Captain David Holcombe of Engine 11, a 28-year veteran of the Philadelphia Fire Department, calmly reported over the command channel that his team was experiencing a problem on the 30th floor

en route to the top of the stair tower. They had exited the stair tower and wanted to break a window but didn't know what side of the building they were on. Commissioner Ulshafer ordered a fireground announcement for all personnel to stay clear of the perimeter of the building until the window was broken. ...Smoke was so heavy at this time that units on the ground were unable to determine which window was broken. Firefighter Phyllis McAllister from Engine 11 radioed that the team was in real trouble now. The captain was down and they needed help.[55]

2.5.2 Helicopter Involvement

Ulshafer assigned Deputy Chief Matthew McCrory the task of assembling a search and rescue team to proceed immediately up the center tower to the 30th floor. Then he ordered Acting Chief James McGarrigle and three firefighters to prepare for a helicopter lift to the roof, from where they were to accomplish three objectives: vent the stair towers, assist in the rescue of Engine 11 if possible, and assist any injured to the roof for removal by helicopter. Calls for helicopters were placed to the nearby University of Pennsylvania Hospital trauma center and to the Coast Guard station in Cape May, New Jersey, 75 miles away.

Command received another transmission from Engine 11:"Help us, we're in trouble. We're running out of air."

The search team, now at the center stair tower, 22nd floor, faced the prospect of an untenable, extremely heavy heat and black smoke condition in the stair towers above the fire. McCrory advised command that doors to the fire floors would have to be closed before they could proceed to the 30th floor and advised McGarrigle, awaiting helicopter transport, to open the door to the center stair tower first.

The trauma center helicopter arrived after a one-minute flight and delivered the vent team to the roof (one firefighter was left below because there was too much weight in the helicopter). Firefighters were accompanied by a nurse and a paramedic. Initial survey of the area indicated two helicopter landing pads on a flat roof; no ventilating system components, bulkheads, or

> doors were visible. There were no clear indications of stair shaft openings.
>
> Two narrow sets of steps on either side of the helipad, similar to an exterior fire escape, led to the 38th floor. The team located a door on the west side. When they opened it, heavy smoke pushed out. Using a rope as a guide, two members entered. They encountered heavy smoke conditions in the 38th floor mechanical room. They were ordered back up to the roof. They propped open all the doors they found on the way there.[56]

Meanwhile the rescue team that was working its way up from the 22nd floor found that some of the heat and smoke were beginning to lift from the center stair tower. Eight firefighters each with an extra air bottle were desperately trying to locate their fallen comrades. When they opened the stairway door to the 30th floor, however, they found heavy smoke had banked down. They searched floors 30 through 33 but did not find the stricken firefighters (they were on 28).

> With their air now running low and being so close to the roof level, the teams decided to use the roof for egress. The tower was smokey but passable. It led to a large mechanical room with a 24-foot-high ceiling, filled with heavy equipment, with catwalks and wall ladders that seemed to lead to nowhere. The firefighters closed the door to the stair tower. Six air cylinders were empty; two had only quarter tanks left. The firefighters searched for an exit to the roof and were unsuccessful, and contracted McGarrigle, who was on the roof. They were starting to experience trouble.
>
> Accompanied by a firefighter, McGarrigle descended that stairway and encountered a locked electrical closet. They returned to the roof and descended the stairs on the other side, entering one door and then yet another before finally entering the mechanical room. They located the trapped firefighters and led them up to the roof, from where they were brought via helicopter to the ground.
>
> McCrory made his way back to staging and radioed Chief Brady in the lobby, requesting that he put the helicopter into operation to search for a window that Engine 11 might have knocked out.[57]
>
> Through the intense smoke pouring out of the building, the helicopter discovered a partially

> broken window at the southeast quadrant, or rear corner of the 28th floor. There was a medium-to-heavy smoke condition on the 28th floor that didn't lift. Firefighters with flashlights were positioned every 20 to 30 feet forming a chain. Battalion Chief Cuniff found the three fallen firefighters of Engine 11 near the partially broken window. Attempts to revive them were futile. They were discovered hours after their last radio transmission.[58]

The fire teams were not making any progress on the 24th floor. The 25th floor was superheated and smoke was down to floor level. A ninth alarm had been called. The building was creaking, groaning, cracking, and shifting. On the advice of a structural engineer the building was evacuated.

> Firefighters watched as One Meridian Plaza free-burned, extending to the 30th floor. Nine sprinkler heads on that floor were activated - two in the interior of the floor and seven along the perimeter. They controlled and extinguished the fire. Commissioner Ulshafer declared the fire under control at 3 p.m. Sunday afternoon.[59]

2.5.3 Summary

One Meridian Plaza had sprinklers installed on floors 30, 31, 34, 35 and 37.[60] Despite the efforts of over 300 firefighters and the eventual improvement of water pressure in the standpipe system, the fire was knocked down by nine sprinkler heads.

> One Meridian Plaza was built nearly a decade before Philadelphia passed a high-rise sprinkler ordinance. The high-rise ordinance, adopted in 1981, required owners of existing high-rises to install sprinklers in the following locations: basements; storage rooms greater than 120 square feet; assembly and mercantile occupancies; commercial kitchens; occupancies other than residential when located below a residential occupancy; and trash chutes and rooms.[61]

The trauma helicopter was used to transport firefighters to the roof to vent the stairways. It was also used to help evacuate fire fighters who wanted to egress the building from the roof as opposed to walking back down hot, smokey stairways past the fire floors. When the helicopter arrived the flight crew reconfigured the helicopter (a BK117) to accommodate the firefighters and their gear. Each firefighter still wore a seatbelt (one reportedly was belted to the floor). The helicopter remained staffed with a pilot, paramedic, and flight nurse during all operations.

3.0 DESIGN CRITERIA FOR ROOFTOP EMERGENCY HELIPORTS

For purposes of this study, the current FAA Heliport Design AC 150/5390-2, several city codes, and the three major building codes were reviewed with regard to structural design criteria for rooftop heliports. Non-structural guidelines for the installation of helicopter facilities also are available in NFPA standards[62].

Particular emphasis was placed on emergency rooftop heliports (or helistops) on high-rise buildings. The criteria in terms of both standard construction and construction specifically designed to accommodate a rooftop heliport was examined.

The overall objective was the development of recommendations for the requirements of rooftop emergency heliports. Requirements to be evaluated include minimum landing zone dimensions; obstacle heights; marking and lighting; and structural considerations such as vibration, harmonic resonance, and weight bearing capabilities.

3.1 MAJOR BUILDING CODES

Table 3 reflects the three primary building codes (publishers also produce fire codes as a separate volume) that are used by most cities and municipalities throughout the United States. These code books contain requirements for the construction of rooftop heliports and helistops.

TABLE 3 MAJOR BUILDING CODES

CODE	PUBLISHER	AREA OF COVERAGE*
Uniform Building Code[63] (UBC)	International Conference of Building Officials (ICBO)	West
Standard Building Code[64] (SBC)	Southern Building Codes Congress International (SBCCI)	South
National Building Code[65] (NBC)	Building Officials and Code Advisors (BOCA)	East

* These are the general areas of coverage throughout the United States; however, there is a significant amount of crossover and each of these codes may be found in all areas of the country.

Most cities use these building and fire codes verbatim and incorporate them directly into their own city or municipal codes. In some instances, these codes are supplemented by the specific requirements of an individual city.

The major building codes require buildings or other structures, and all components thereof including roofs, be designed and constructed to safely support all dead loads, live loads, and snow loads, without exceeding the allowable stresses for the materials of construction in the structural members and connections.

Review of the building and fire codes focused on design loading criteria, construction criteria, and the extent of specific criteria set forth for heliport design. Cross references to FAA criteria and approvals, and various other building and fire codes were also reviewed.

3.1.1 Major Building Code Strengths

3.1.1.1 Uniform Building Code (UBC)

1. The Uniform Building Code clearly addresses the loads to be applied and the load combinations to be checked in the design. It defines three separate loading conditions, impact factors for both skid type and hydraulic shock type landing gear, and footprint (or contact area) to be used.

2. The load application or "footprint" to be used is simplified. The code requires the use of a 1 square foot area for all helicopters, whether skid or hydraulic landing gears. This would be slightly more conservative for larger helicopters, since footprints vary. However, it makes sense to standardize the footprint for design purposes, since it is likely the heliport would accommodate a variety of helicopters.

3. Helicopter "impact" loadings comply with the FAA AC for heliport design. The impact factors of 1.5 x the fully loaded weight for skid type and 0.75 x the fully loaded weight for hydraulic type are the same as provided in the AC.

4. The application of helicopter loads is more conservative than the AC in that the helicopter load is being applied as a single point load. Although, the AC assumes the helicopter's main landing gear will always hit simultaneously on both sides, it is more realistic to design for an uneven landing.

5. The application of helicopter loads is much simpler than the AC in that a single load is being applied. In designing a structural system, it is a straightforward task to apply either uniform or single point loads (as required by the code). The application of multiple loads at different points requires more analysis in order to determine the "worst case" loading.

3.1.1.2 Standard Building Code (SBC)

1. This code clearly addresses the loads to be applied and the load combinations to be checked in the design. As with the UBC, three loading conditions, an impact factor, and a footprint are defined.

2. This code simplifies the load application or footprint to be used. As with the UBC, a 1 square foot contact area is used. Unlike the UBC, however, the SBC requires the use of two loads, or contact areas, spread 8 feet apart. This corresponds more closely with the AC but is less conservative than the UBC.

3. Helicopter impact loadings correspond with the AC requirements for "skid type" landing gear. The SBC uses the same impact factors called for in the AC for skid type landing gear.

4. The application of helicopter loads is more conservative than the AC in that the helicopter load is always considered to be from a skid type landing gear. This does not allow the use of a lesser impact factor for hydraulic gear. This approach is useful, since it may be difficult operationally to limit the types of helicopters to hydraulic landing gears.

5. Snow load is considered in combination with the helicopter weight. This loading condition, not found in the other building codes, is an important loading condition to be considered, particularly in areas of high snow loading. It provides for consideration of landings on rooftops which may not have been cleared of snow prior to landing.

3.1.1.3 National Building Code (NBC)

No particular strengths regarding rooftop heliports were noted during the review process.

3.1.2 Building Code Weaknesses

3.1.2.1 Uniform Building Code (UBC)

1. No specific direction is included on the application of helicopter load for loading condition No. 1: roof dead load + weight of helicopter. No footprint or contact area is specified and no specific definition of helicopter weight is given, i.e., gross takeoff weight.

2. The code does not make provision for the application of loads from very large helicopters with large tread distance. This may also be considered a strength in that the application of single point loading results in a more conservative design. However, for very large helicopters, this could result in a significant increase in the size of structural members and increased costs. A balance needs to be maintained.

3. No reference is made to the FAA AC.

4. Although a loading condition for snow is available, it is not considered in combination with aircraft weight.

3.1.2.2 Standard Building Code (SBC)

1. No specific direction is included on the application of helicopter weight for loading condition No. 1: roof dead load + weight of helicopter + snow load (see UBC).

2. Landing gear tread distance is fixed at 8 feet when actual distance varies anywhere from approximately 6 feet for small helicopters to nearly 20 feet for very large helicopters. This may also be considered a strength, as it would lead to more conservative designs for larger helicopters. However, it would not be quite as conservative as the UBC which requires single point loading.

3. No reduction of impact factors is allowed in the case of the controlling helicopter having hydraulic shock absorbers. This may also be considered a strength, depending upon one's perspective. It will lead to a more conservative design which will likely cost more.

3.1.2.3 National Building Code (NBC)

1. This code does not specify impact factors or load combinations with helicopter loading. The very general approach taken by the NBC requires the design engineer to make several assumptions since there is no specific direction for heliport design. The designer must decide on several criteria such as load distribution, load combinations, and magnitude of uniform live load. This could lead to different criteria being utilized and different designs in the same region, governed by the same code.

2. Minimum uniform live loads to be used are not clearly defined. Once again, the NBC leaves the design engineer to make decisions on how to classify a helistop/heliport. This classification determines which live load to apply.

3. No guidance is provided on the application of helicopter loading (i.e., footprint or number of loads).

4. Neither the FAA AC nor any other source of heliport design criteria is referenced for further requirements. This is a particularly important weakness of the NBC, as so little specific direction is given.

3.1.3 Analysis and Comparison of Major Building Code Structural Design Criteria

In order to make a comparison between the three major building codes, the main girder of a roof's structural framing system was analyzed. The methodology consisted of applying loading conditions required by each of the three codes, for two different column spacings. For case 1, columns were assumed to be spaced 20 feet apart, while for case 2, columns were assumed to be spaced 30 feet apart. Two column spacings were analyzed in order to produce a wider range of data.

Each of the three building codes directly or indirectly (in the case of the NBC) requires the engineer to review three separate loading conditions in the design of a rooftop heliport. Those loading conditions are:

1. helicopter weight + dead load of roof*,

2. helicopter impact + dead load of roof, and

3. uniform live load + dead load of roof.

* SBC requires the addition of snow load to this condition.

The design dead load for a roof design consists of the weights of materials of construction, including roofing, insulation, deck, and interior ceiling loads. In addition, the weight of fixed service equipment such as plumbing stacks and risers, electrical feeders, heating, ventilating, air conditioning, and sprinkler systems must be added. The design dead load utilized must be equal to or greater than minimum unit dead loads as established by the various codes.

The design live load to be assumed in the design of a roof is to be the greatest load produced by the intended use and occupancy. However, the design live load can not be less than the minimum uniformly distributed unit loads required by the codes. Helicopter loading would be considered a special case live load and would control the design of a roof when the stresses produced by the helicopter load exceeded the stresses produced by the minimum specified uniform live load established by the codes.

The design snow load to be used in the design of a roof is based on the maximum anticipated snowfall in a given geographical area. Consideration of roof slopes, configurations such as adjacent upper and lower roof decks, shielding from adjacent buildings, and exposure must be included in the determination of design snow loads for a given roof design.

The analysis used the assumptions described below.

1. Dead load was assumed to be 20 pounds per square foot (psf) for all cases. This number is representative of the magnitude of a typical

dead load for a roof. Actual roof dead load would be determined for each structure based on the actual materials of construction.

2. Live load used were the minimum uniform live load required by each of the three codes, with allowable reductions taken where applicable. Loads used were as follows:

CODE	SPAN	LIVE LOAD
UBC	20 feet	80 psf
UBC	30 feet	72.3 psf
BOCA	20 feet	100 psf
BOCA	30 feet	100 psf
SBC	20 feet	60 psf
SBC	30 feet	60 psf

3. Snow load was taken to be 40 psf for all cases. Actual snow load for a given building would depend upon geographical location, physical characteristics of the building roof, and other factors. Snow load was combined with dead load only, except for the SBC cases which include the condition of dead load + snow load + helicopter weight.

4. Existing roof loading was assumed to be dead load (20 psf) + snow load (40 psf) for all cases, since the older building codes required a minimum roof live load of only 20 psf unless the roof was to be used for promenade (60 psf) or assembly (100 psf) purposes. Certainly many older roofs would have been designed for the higher live loads and thus would have a higher capacity than is reflected in the results. However, the approach was to indicate a "worst case" scenario for existing roofs.

5. Roof designed for heliports loading was assumed to be dead load (20 psf) + live load (see live load assumptions in paragraph 2). This loading is based on load condition number 3. For many small and medium helicopters, this load condition is sufficiently robust that the weight of the helicopter need not be considered. However, for larger helicopters, load conditions 1 and 2 must be considered.

The loading conditions required by each code were applied to the main girder of the roof framing system. The girder is the beam which runs from one column to the next and is physically connected to and supported by each column. The roof stringers, or deck supporting members, run perpendicular to and are supported by the girders. To simplify the analysis, the stringers were not considered.

Each loading condition produces different loads on the roof structure and consequently, different loads on the girder. The loading condition which produces the most load on the girder "controls" the design.

In this analysis, loading condition number 3 produced the maximum load to the girder without consideration of specific helicopter weights under either loading conditions number 1 or 2.

Once loads to the girder produced by loading condition number 3 for each of the three codes were determined, helicopter weights that would produce the same effect were then calculated. These weights were considered to be the "maximum helicopter weights" which could be carried by a girder designed for loading condition number 3. Only helicopters with weights exceeding this "maximum" would require the engineer to review loading condition numbers 1 and 2 to determine design load to the girder.

Results of the analysis are depicted in several ways. Table 4 summarizes "maximum helicopter weights" which can be carried by the girders according to loading condition number 3, as specified in each code. Both 20 foot and 30 foot column spacing are included.

TABLE 4
MAXIMUM HELICOPTER WEIGHTS BY CODE
(Based on specified uniform live loads applied to girders)

CODE	COLUMN SPACING	
	20 ft x 20 ft	30 ft x 30 ft
UBC	10,666 lbs	21,700 lbs
NBC	13,333 lbs	30,000 lbs
SBC	6,677 lbs	12,275 lbs

The results from figures 1 through 6 indicate that the NBC produces the greatest girder design moment. For this analysis the NBC produces the most rigid minimum design standard, followed by the UBC and the SBC. This is the case for both column spacings. Table 4 shows that the minimum design requirements spelled out in each code will result in the design of a main structural system (i.e., girders, columns, and foundations) to carry up to the "maximum helicopter weights" listed. Helicopters exceeding the listed weights would then require analysis using loading condition numbers 1 and 2.

Graphic representations of the results of the analysis are depicted in figures 1 through 6, showing the relationship between the three loading conditions for each of the three codes, and for both 20-foot and 30-foot column spacings, case 1 and case 2 respectively.

Consideration was also give to rooftop heliports on existing buildings. The loading on the girder caused from the dead load plus an average snow load of 40 pounds per square foot was determined.

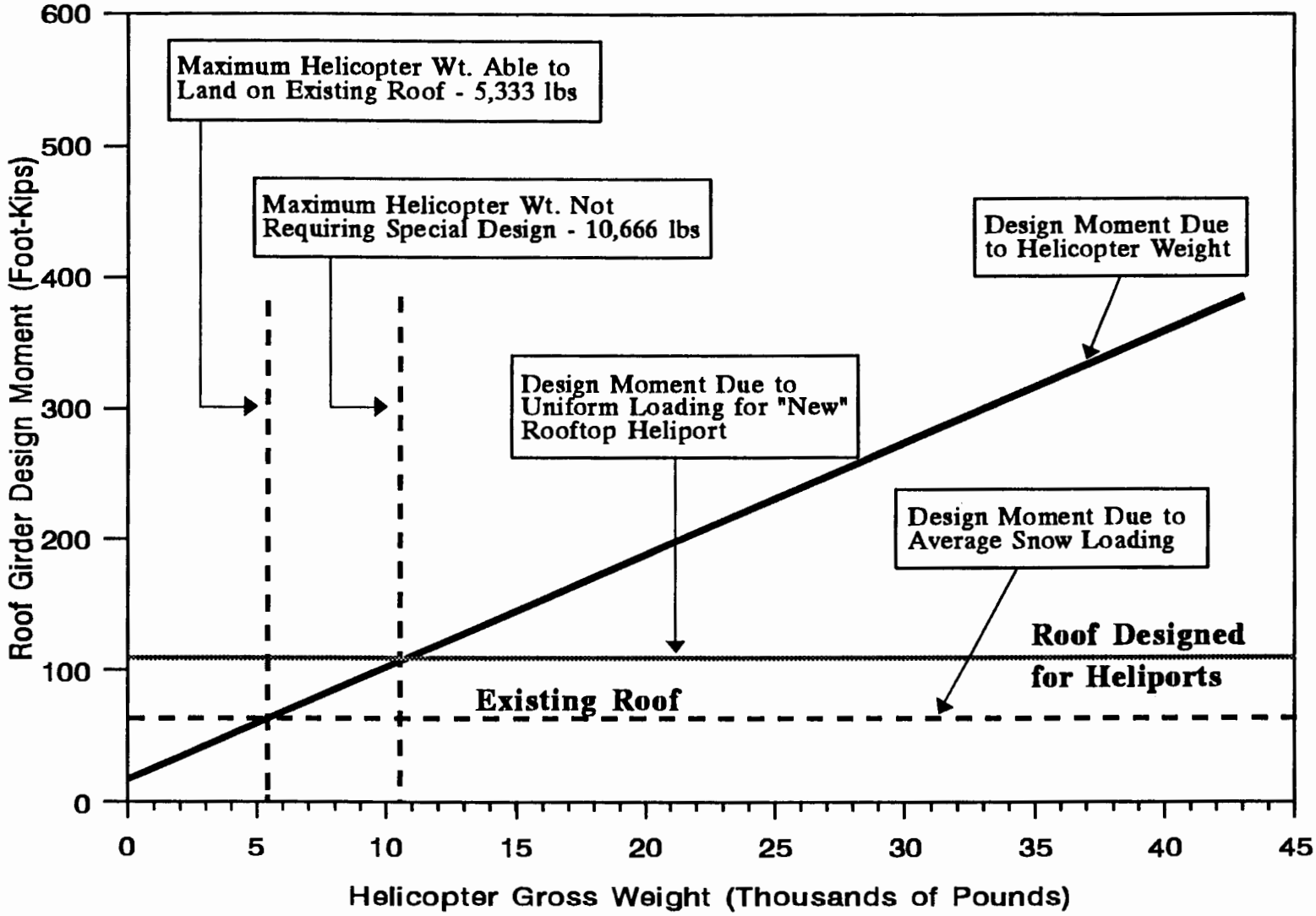

FIGURE 1 UNIFORM BUILDING CODE, 1991 - CASE 1: 20′ X 20′ BAY SPACING WITH 20 PSF DEAD LOAD

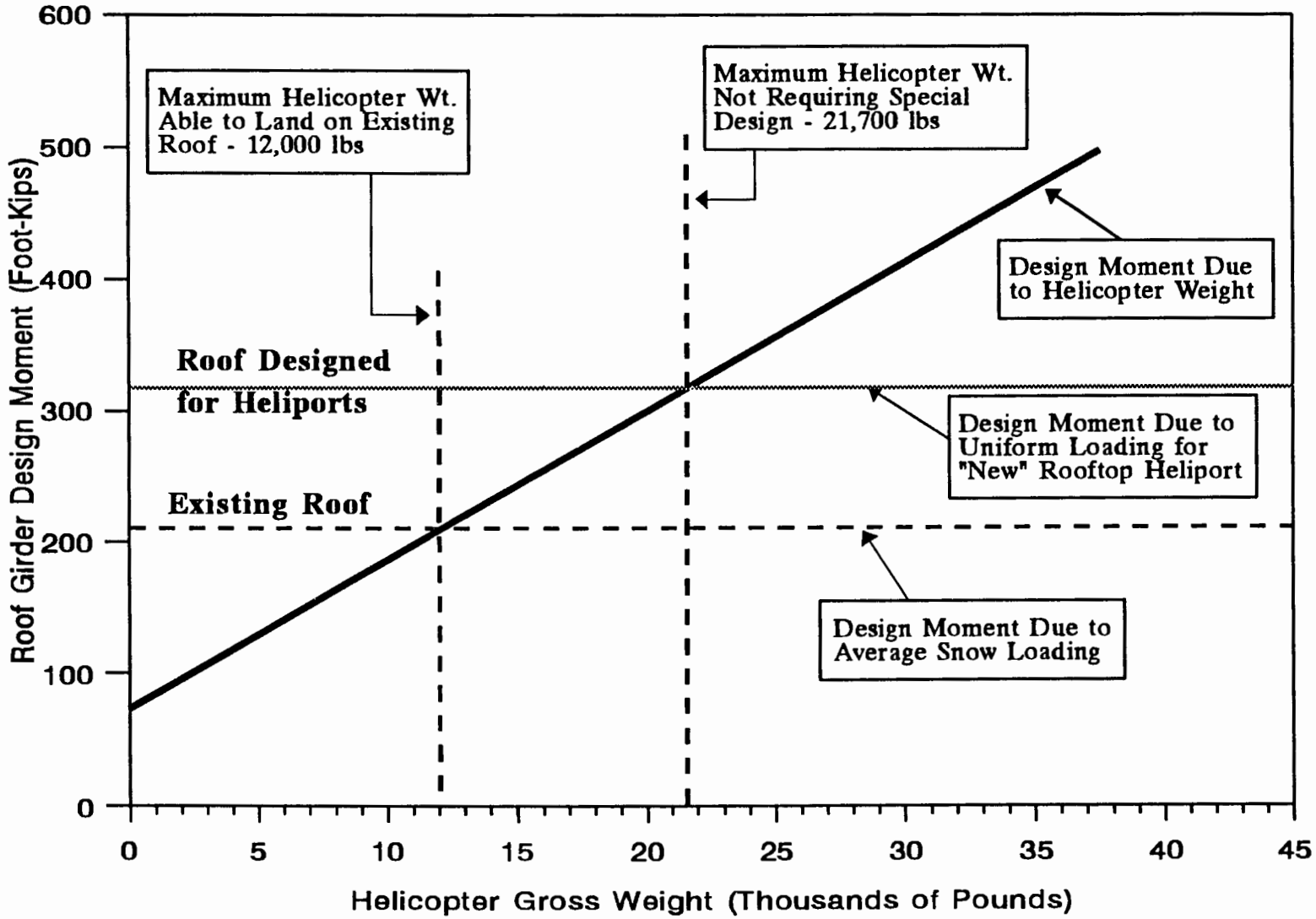

FIGURE 2 UNIFORM BUILDING CODE, 1991 - CASE 2: 30′ X 30′ BAY SPACING WITH 20 PSF DEAD LOAD

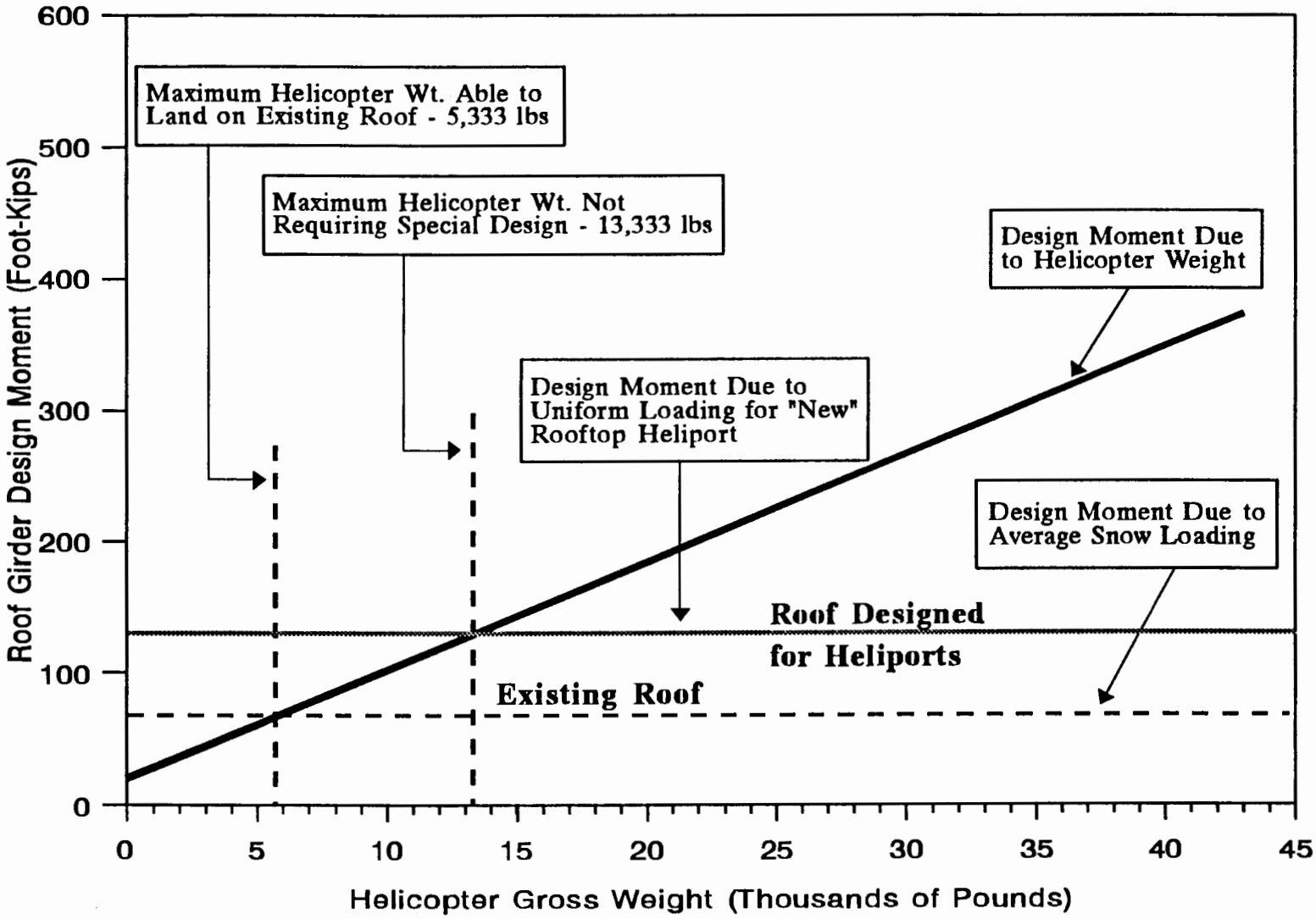

FIGURE 3 NATIONAL BUILDING CODE, 1991 - CASE 1: 20′ X 20′ BAY SPACING WITH 20 PSF DEAD LOAD

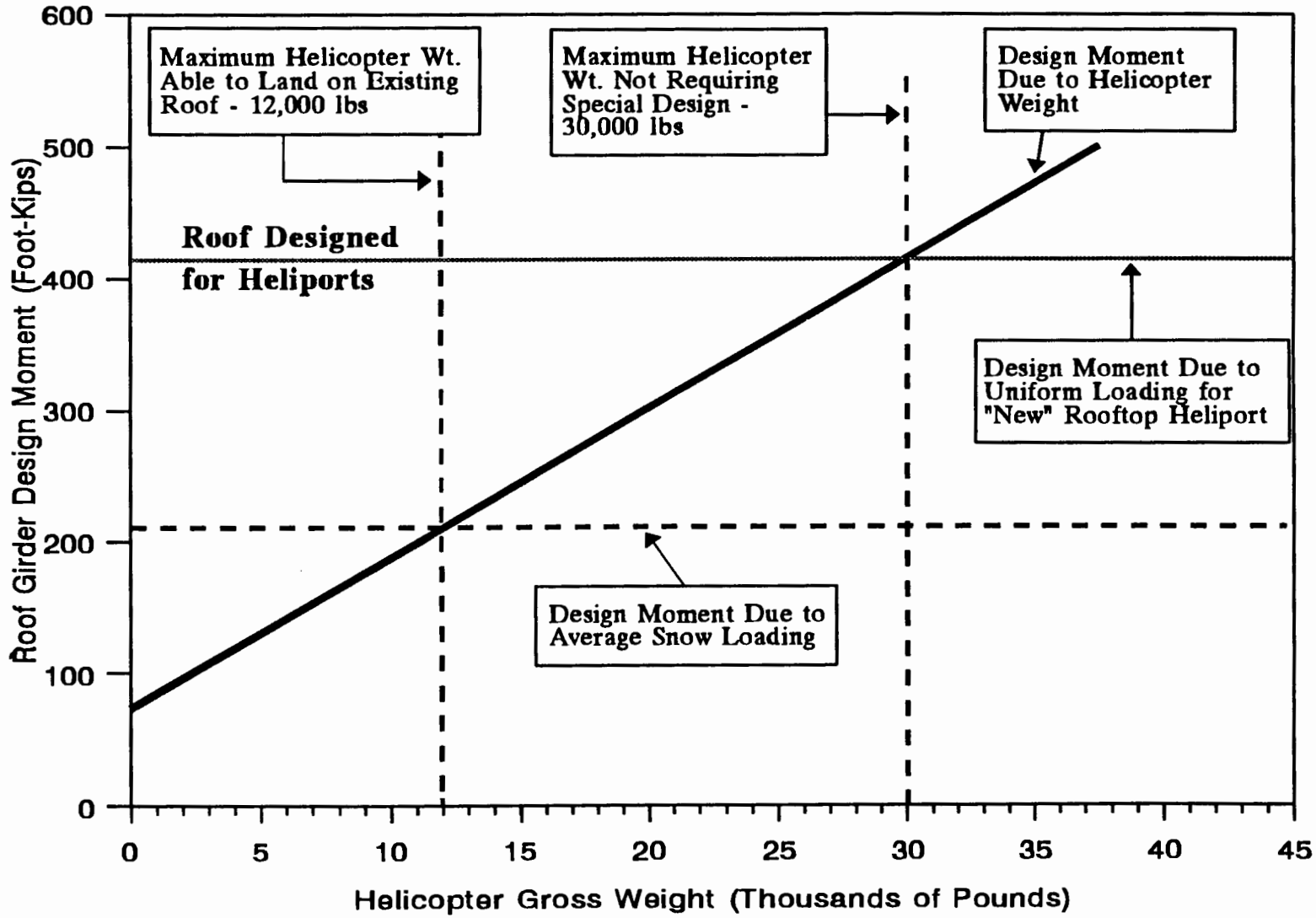

FIGURE 4 NATIONAL BUILDING CODE, 1991 - CASE 2: 30′ X 30′ BAY SPACING WITH 20 PSF DEAD LOAD

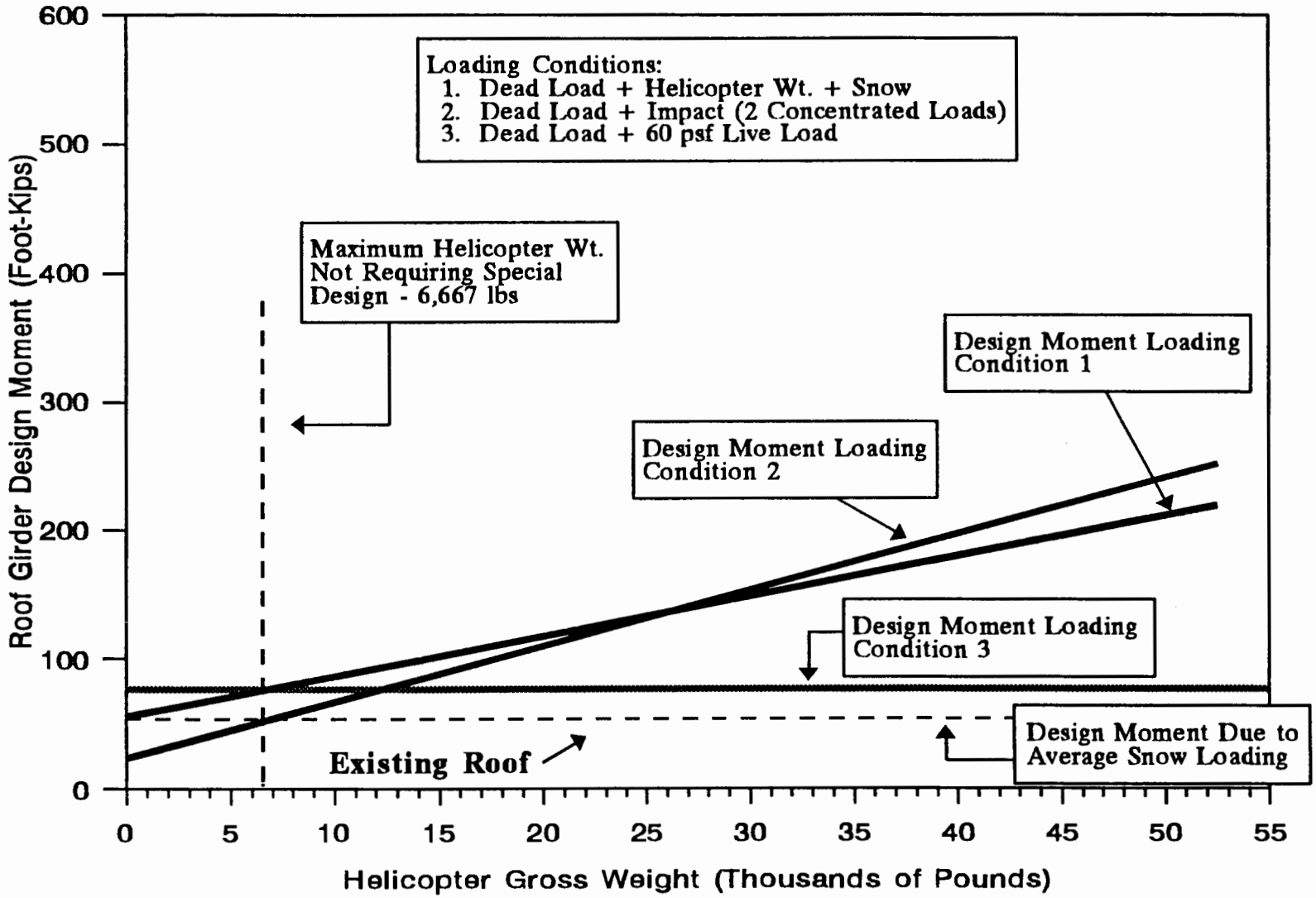

FIGURE 5 STANDARD BUILDING CODE, 1991 - CASE 1: 20′ X 20′ BAY SPACING WITH 20 PSF DEAD LOAD

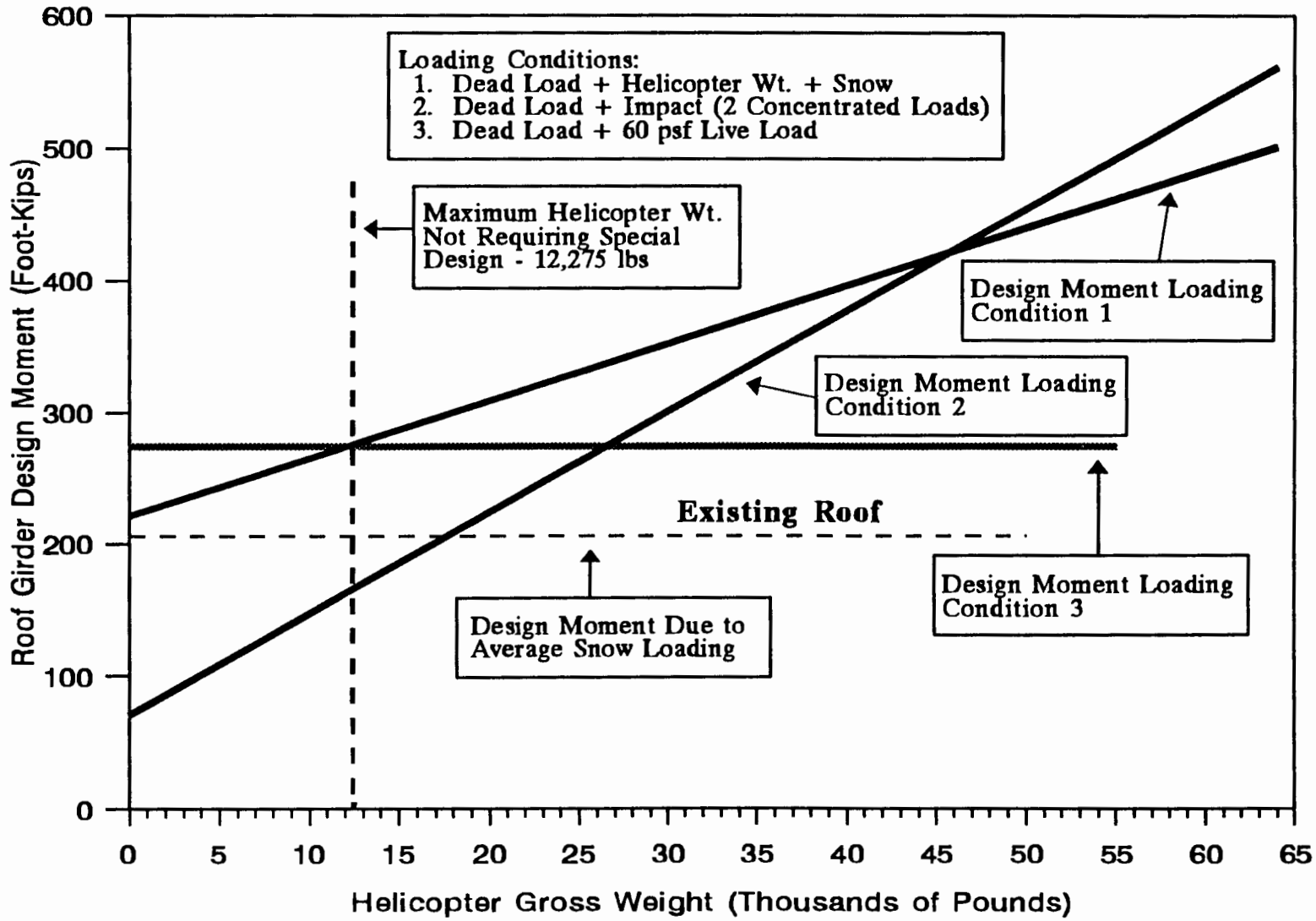

FIGURE 6 STANDARD BUILDING CODE, 1991 - CASE 2: 30′ X 30′ BAY SPACING WITH 20 PSF DEAD LOAD

This would be a typical controlling loading condition for a standard (non-heliport) roof designed per the building codes and is indicated in the figures as a fourth loading condition. The design moment caused by this loading is represented by a horizontal dashed line in the figures and is labeled "existing roof."

The figures show design moments which are caused by each of the loading conditions. Design moments were used because they allow comparisons of different types of loading which could not otherwise be compared. The horizontal lines, representing loading condition number 3 and the non-heliport roof loading, represent the uniform loads which are independent of the weights of the helicopter. These are the minimum loads for which the roof is to be designed.

The sloped lines represent the bending moments caused by the actual helicopter weights, applied in accordance with loading condition numbers 1 and 2. The point at which the sloping lines cross the horizontal lines indicates the helicopter gross weight which causes the same bending moment in the girder as the uniform load.

Specifically, the point where the sloped line crosses the dashed line (existing roof) represents the maximum helicopter weight which could be carried by the girders of a roof designed for a 40 pound per square foot snow load, but not specifically designed for heliport loading. The point at which the sloped line crosses the solid horizontal line represents the maximum helicopter weight which can be carried by the girders of a roof specifically designed for heliport loading. In the case of two sloped lines representing two separate loading conditions, the point of crossing closest to the y-axis of the graph determines the maximum helicopter weight.

Loading condition number 1 is considered for the SBC only, as the inclusion of a uniform snow load makes it the controlling loading condition. For the UBC and the NBC, loading condition number 2 is shown, because it is always the controlling condition.

3.1.4 Highlights of Selected Local Codes

In conducting research for applicable building codes, representatives were interviewed from 2 federal agencies, 3 technical organizations, 3 states, and 16 cities. From that sampling, only the three following localities had unique requirements for rooftop heliports.

San Diego, California Municipal Code[66] - This code requires that heliports be designed for a minimum helicopter weight of 5,000 pounds, with load factors and loading combinations per the UBC. When only one interior smoke tower is installed, and the lowest livable floor is higher than 75 feet above the point at which the fire department would gain access to the building, San Diego requires an emergency rooftop heliport to be installed. However, some helicopter operators state that most heliports are not usable because of the close proximity of other buildings and winds.

Pasadena, California Fire Department[67] - This code requires design for a minimum 15,000 pound helicopter weight. It also requires submittal of calculations and material specifications for approval. Further, Pasadena requires an emergency rooftop heliport to be installed on new high-rise construction where an occupied floor of the structure is 75 feet or more above the lowest point at which the fire department would gain access to the building.

Los Angeles, California Fire Department[68] - Los Angeles also requires an emergency heliport for all new high-rise construction any time an occupied floor of the structure is 75 feet or more above the lowest point at which the fire department would gain access to the building. This requirement applies even if two interior smoke towers are installed.

3.1.5 Major Fire Codes

Review of the major fire codes did not reveal any structural requirements. These fire codes include the following:

- National Fire Code[69],
- Uniform Fire Code[70], and
- Standard Fire Code[71].

3.2 SUMMARY OF STRUCTURAL DESIGN CRITERIA

Table 5 summarizes the Uniform, Standard, and National Building Codes in regards to design load and construction criteria. Table 6 provides a similar summary for the Pasadena, California Fire Department code and two San Diego, California municipal codes.

3.3 AIRCRAFT MANUFACTURER'S DATA

There appears to be adequate manufacturer data available in the open literature to provide the necessary helicopter information for design of a rooftop heliport/helistop. Several sources were reviewed and found to vary in their suitability for structural design purposes.

Descriptions of data provided in the sources reviewed are discussed in the following sections.

3.3.1. FAA Heliport Design Advisory Circular

The FAA's AC provides data from 12 manufacturers on 50 different helicopter models, including several tandem rotor models. The data provides information on weights, sizes, landing gear, wheelbases, treads, tire contact areas, and rotor diameters.

This document provides adequate information for computation of the design loads necessary for rooftop heliport/helistop structural design.

TABLE 5 SUMMARY OF STRUCTURAL DESIGN CRITERIA - MAJOR CODES

CODE	REFERENCE SECTIONS	DESIGN LOADS			CONSTRUCTION CRITERIA		
		STATIC	IMPACT (DYNAMIC)	VIBRATION, TORQUE/DOWNWASH, RESONANCE	SIZE	DESIGN	FAA APPROVAL
UBC - 1991	409, 701, 710, 2308	1. Roof dead load + wt. of helicopter 2. Dead load + 100 psf live load (with reductions per sec. 2306)	Roof dead load + concentrated load of: 0.75 x fully loaded wt. of helicopter/1 s.f. (hydraulic shock absorb) or 1.5x fully loaded wt. (skid type landing gear)	None	For helicopter <3,500 lbs: 20'x20' min. w/15' min. ave. clear area on all sides w/no width < 5 feet	Non-combustible material. Confine any Class I, II, or III-A liquid spillage & drain away from exits/stairways. 2 or more exits.	Required prior to operation.
NBC - 1990	614 (ref. NFPA 413; Ch. 3)	Design for loads imparted to the structure due to helicopter landing, incl. single skid point landing. loads not further defined None	None	Design for vibration (not defined) None	None	None - 2 hr. fire rating - Drainage - Noncombust., nonporous Class A roof cover - Curbing - 2 means of egress - Foam fire protection system	Required prior to operation.
SBC - 1991	412.9, 1128.1.2, 1207.3	1. Roof dead load + wt. of helicopter + snow load. 2. Dead load + 60 psf live load.	Roof dead load + 2 concentrated loads, (1sf ea. @ 8 ft apart) equal to 0.75 x gross helicopter weight.	None	For helicopter <3,500 lbs: 20'x20' min. w/15' min ave. clear area on all sides w/no width < 5'	Non-combustible material. Confine any Class I, II, or III-A liquid spillage & drain away from exits/stairways. 2 or more exits.	Not referenced.

UBC - Uniform Building Code
NBC - National Building Code
SBC - Standard Building Code

TABLE 6 SUMMARY OF STRUCTURAL DESIGN CRITERIA - LOCAL CODES

CODE	REFERENCE SECTIONS	DESIGN LOADS			CONSTRUCTION CRITERIA		
		STATIC	IMPACT (DYNAMIC)	VIBRATION, TORQUE/DOWNWASH, RESONANCE	SIZE	DESIGN	FAA APPROVAL
Pasadena Fire Department - Fire Prevention Division	Specification #20 Ref. AC 150/5390 AC 70/7460 NFPA 418 UBC UFC	None	15,000 lbs load applied to landing deck structure Calculations & material specs required with application.	None	Min. 50' x 50' (2,500sf)	-Non-combustible Type I construction -Drainage -Two means of egress -Visual aids -Fire protection/life safety -Safety barriers	Not referenced.
1989 San Diego Municipal Code	68.0209 68.0210 68.0211	None	None	None	None	Extensive requirements for: parapets; curbs; roof openings; exits; spill containment; standpipes; electrical; hazardous locations; clearances; fire protection; communications	Not referenced.
1990 San Diego Municipal Code	Div. 7: 91.071	Min. 5,000 lbs helicopter w/load combinations & load factors per UBC - 1988	Min. 5,000 lbs helicopter w/load combinations & load factors per UBC - 1988	None	For helicopter <3,500 lbs: 20'x20' min. w/15' min ave. clear area on all sides w/no width < 5'	Non-combustible material. Confine any Class I, II, or III-A liquid spillage & drain away from exits/stairways. 2 or more exits.	Required prior to operation.

3.3.2 Business and Commercial Aviation - 1992 Planning and Purchasing Handbook

This handbook provides less complete data from 10 manufacturers on 31 different models.[72] No data is provided on tandem rotor models, nor is information provided on landing gear, wheelbases, treads, and contact areas. The information provided is directed more towards the helicopter's performance and is not adequate for computation of the design loads required for rooftop heliport/helistop structural design.

3.3.3. Helicopter Association International's (HAI) 1992 Helicopter Annual

HAI's Annual provides data similar to that contained in Business and Commercial Aviation's handbook, with 17 manufacturers and 60 different models being presented.[73] Data is presented for tandem rotor models, but no information is provided on landing gear, wheelbases, treads, and contact areas. The information is once again directed more towards the helicopter's performance and is not adequate for computation of the design loads required for rooftop heliport/helistop structural design.

3.3.4 Helicopter Association International's (HAI) Heliport Development Guide

This guide from HAI presents data from 14 manufacturers on 67 different models, including several tandem rotor models.[74] This information is similar to that provided in the FAA's AC and is considered adequate for computation of the design loads necessary for rooftop heliport/helistop structural design. However, it is recommended that these data be used in conjunction with data in the AC.

3.4 HELIPORT DESIGN ADVISORY CIRCULAR 150/5390-2

Six specific classifications of heliports/helistops referenced in the AC and the design criteria associated with each were examined.

All of the specific classifications of helicopter landing sites can be used in an emergency evacuation incident if necessary. The classification "emergency evacuation facility (EEF)" is interpreted to mean a facility with no other designated uses beyond that of an available landing site in an emergency situation. However, this does not mean that either a public- or private-use heliport could not be used as an emergency evacuation site.

3.4.1 Heliport/Helistop Types

The heliport/helistop types examined in this report as defined in AC 150/5390-2 are described below.

Private-Use Heliport - A facility for exclusive use by the owner or other persons having prior authorization to use the facility.

Public-Use Heliport - A facility available for the takeoff and landing of helicopters without prior authorization being required.

Hospital Heliport - A public-use or private-use heliport supporting helicopter air ambulance services.

In addition to defining these types of heliports, the AC describes three additional types of heliports that are used as strictly VFR facilities.

Emergency Evacuation Facility (EEF) - A designated and cleared area at rooftop or ground level intended exclusively for emergency evacuation operations by helicopters.

Temporary Landing Sites - Sites intended to be used only under visual flight rule (VFR) weather conditions, for a period of less than 30 consecutive days, and with no more than 10 operations per day.

Medical Emergency Sites - Unprepared landing sites, such as at the scene of an accident or incident, used at the discretion of the pilot.

3.4.2 Advisory Circular Design Criteria Summary

Standards for EEFs and temporary landing sites vary from the criteria set forth for public-use heliports in significant areas.

- Takeoff and landing area markings are optional for EEFs and temporary landing sites, while they are mandatory for public-use heliports.

- The maximum weight that can be supported by the landing surface must be marked for public-use heliports, while markings are optional for EEFs and temporary landing sites.

- There are no specific requirements for egress, passenger walkways, or fire protection for EEFs or temporary landing sites. However, public-use heliports are required to comply with various standards intended to increase the safety level of the passengers.

Table 7 summarizes the design criteria for each type of heliport/ helistop from the FAA's Heliport Design AC 150/5390-2.

TABLE 7 SUMMARY OF DESIGN CRITERIA FROM FAA'S HELIPORT DESIGN AC 150/5390-2

AC CLASSIFICATION	PRIVATE USE HELIPORT	PUBLIC USE HELIPORT	EMERGENCY EVACUATION FACILITIES	TEMPORARY LANDING SITES	MEDICAL EMERGENCY SITES
DEFINITION	Prior authorization required for use	Available for use without prior authorization	Designated and cleared area intended exclusively for emergency evacuation operations	Sites intended for 30 consecutive days or less of operation at 10 or less operations/day	Unprepared landing sites at the scene of an accident/ incident, used at the discretion of the pilot.
FAA NOTIFICATION REQUIREMENTS	Per FAR Part 157	Per FAR Part 157	FAA Air Traffic Facility	FAA Air Traffic Facility	None
STATE & LOCAL NOTIFICATIONS AND APPROVALS	Per applicable Building & Fire Codes	Per applicable Building & Fire Codes	Per applicable Building & Fire Codes	Per applicable Building & Fire Codes	None
DESIGN LOADS	STATIC } DYNAMIC } per paragraph 51 DOWNWASH}	STATIC } DYNAMIC } per paragraph 51 DOWNWASH}	STATIC } DYNAMIC } per paragraph 51 DOWNWASH}	STATIC } DYNAMIC } per paragraph 51 DOWNWASH}	None
MARKINGS	Optional; weight limits MAY be indicated	Takeoff & landing area designated by "H" at center; FATO markings optional; WEIGHT LIMITS MUST BE MARKED	Optional; weight limits MAY be indicated.	Optional; weight limits MAY be indicated	None
SIZE & CLEARANCES					None
TAKEOFF & LANDING AREAS	Size: 2x rotor diameter Clearance: 1/3 rotor diameter; not < 10 feet	Size: 2x rotor diameter Clearance: 1/3 rotor diameter; not < 10 feet	Size: 2x rotor diameter Clearance: 1/3 rotor diameter; not < 10 feet	Size: 2x rotor diameter Clearance: 1/3 rotor diameter; not < 10 feet	
FINAL APPROACH & TAKEOFF AREA (FATO)	None	Size: rotor diameter of single rotor helicopter or length of tandem rotor helicopter Clearance: 200 feet center to center of adj. FATOs	None	None	
PARKING AREAS	Size: 1.5x undercarriage	Size: 1.5x undercarriage	Size 1.5x undercarriage	Size: 1.5x undercarriage	
AIRSPACE	Per FAR Part 77 Subpart C	Per FAR Part 77 Subpart C	Per FAR Part 77 Subpart C	At least one unobstructed approach and departure route.	None.
EGRESS	None	Passenger walkways, primary & secondary signs; warning signs per para. 33c	None	None	None
DRAINAGE	Uniform gradients per para. 50	Uniform gradients per para. 50; slope away from passenger walkways	Uniform gradients per para. 50	Uniform gradients per para. 50	None
FIRE PROTECTION	None	FAR Part 139 certified HELIPORTS: per: NFIPA 403 or 418 & FAR Part 139 requirements	None	None	None

Note: Hospital heliports should be designed according to the requirements of public use or private use heliports based on whether prior authorization for use is needed.

4.0 CONCLUSIONS

4.1 CASE STUDIES

Helicopters have made significant contributions to the successful outcome of high-rise fires. In addition to removing those persons from the roof who have no other means of escape at their disposal, helicopters have provided other services as well. Fire department personnel and equipment were moved to and from the roof when it was not reasonable for those activities to be conducted by way of either stairs or elevators. Helicopters also were used to report the progress of the fire and direct rescue personnel to occupants who were near windows.

In the past, most high-rise rooftop rescue efforts involving helicopters were spontaneous, unplanned responses by well-intentioned helicopter operators and pilots. Although these efforts have been largely successful and have saved numerous lives, their impromptu nature is cause for concern that such high risk operations could result in an accident having potentially tragic consequences.

There is a broad divergence of opinion among fire-fighting professionals on the need for and use of rooftop emergency heliports. In certain areas, the West Coast in particular, rooftop emergency heliports are a necessary element for the construction of high-rise buildings. Alternatively, in other areas of the country, such heliports are not given any consideration at all. It is the opinion of professionals in these locations that early notification and rapid evacuation of occupants down stairways and out of burning buildings is most desirable. It is further believed by some that the known presence of a rooftop heliport encourages occupants to go to the roof rather than take the safer route down stairways.

Fire departments in cities that have rooftop heliports available for use during emergencies do not support the idea of passenger staging areas on the roof, particularly those that are enclosed.

4.2 BUILDING CODES

All of the major codes lack a specific approach to rooftop heliport design. However, the heliport loading requirements for the Uniform Building Code and the Southern Building Code are adequate. Heliport loading requirements for the National Building Code are generally adequate but are not specific with regard to uniform live load for heliports. As a result, the designer must make assumptions regarding the appropriate uniform live load to use.

None of the major codes mandate inclusion of rooftop heliports or emergency evacuation helistops in high-rise construction. Cross-reference to the FAA's Heliport Design AC was not found in any of the codes.

No clear direction or special consideration as to the fire rating of a roof to be used as a rooftop heliport was found in any of the codes.

Vibration, rotor downwash, and resonance loadings are not specifically considered in any of the codes. However, this omission is not believed to be a problem since these loads are less than impact loads and will not control design.

Each of the three building codes requires the application of a uniform live load to the roof structure, independent of the size or weight of the design helicopter. Except for the case of a large design helicopter, this loading condition is likely to control design of the main structural components of the roof, i.e., the columns and girders, as well as the building's foundations. The inclusion of this loading condition helps to ensure the building's main structure will be adequately designed for most small and medium helicopters.

The design helicopter weight (including impact factor) must be considered in design of the roof deck and deck supporting stringers in order to insure that the complete roof system will be able to carry the helicopter loading.

4.3 ADVISORY CIRCULAR

Many cities and municipalities are using outdated versions of the Heliport Design AC.

The AC does not currently emphasize the need for emergency evacuation facilities, nor does it recommend specific guidelines for their inclusion in new high-rise construction. This omission is considered appropriate in light of the controversy by fire-fighting professionals regarding the use of rooftop heliports during high-rise fires.

Requirements for markings for emergency evacuation facilities are optional. This creates a potential for inappropriate use of such a facility during an emergency situation (e.g., exceeding the weight capacity of roof or use of a wrong location for the takeoff and landing area).

The design condition for rooftop heliports that considers "hard landings" (dynamic loading) appears to assume that both wheels of the main landing gear (or both skids) will "hit" the roof at the same time. This is an unrealistic design approach, as it is quite possible that one side of the landing gear will strike the roof before the other. This approach may lead to a less than adequate design for impact loads.

The AC contains a comprehensive database of helicopter physical characteristics. This data is useful to the heliport designer in determining loads for the purpose of designing the heliport supporting structure.

The AC lacks cross-reference to applicable building codes. This lack of cross-reference increases the potential for an inadequate rooftop heliport design.

Organization of information in the AC regarding emergency evacuation facilities, temporary landing sites, and medical evacuation sites requires the reader to assimilate information from other areas of the document. This type of organization increases the potential for the user to miss needed information.

5.0 RECOMMENDATIONS

Disaster planners should consider the availability and operation of rooftop heliports in their disaster plans. Operational and communications procedures should be planned in advanced and practiced as necessary to ensure the minimum possible risk during emergency situations. All helicopter operators in the region should be informed of these procedures so that each operator knows if and when they should respond to specific emergencies. For guidance in the use of helicopters in disasters, planners should obtain copies of two reports entitled "Guidelines for Integrating Helicopter Assets into Emergency Planning," (see reference 2), and "Rotorcraft Use in Disaster Relief and Mass Casualty Incidents - Case Studies," (see reference 1). These documents are available to the public through the National Technical Information Service, Springfield, Virginia 22161.

When multiple helicopters respond to an emergency situation, they should be under the guidance of a command and control (C&C) aircraft. The C&C aircraft will identify pickup, drop-off, and standby landing zones and coordinate communications between the aircraft and the incident commander. Further, the C&C aircraft will ensure that the most appropriately sized and properly equipped helicopters respond.

Whenever possible, persons to be evacuated from the roof should be briefed on the highest, safest floor prior to the roof. This permits a briefing to be held in relative calm without the interference of noise and visual distractions. Should significant numbers of people need to be briefed, they can be brought to the briefing area in small groups so that order can be maintained. Once briefed, rescue personnel would accompany them to the roof and assist with their boarding on the helicopters.

5.1 BUILDING CODES

The publishers of the major building codes should reference the FAA's Heliport Design AC in their codes. In this way, high-rise building designers will be provided with appropriate information for the design of a rooftop heliport.

A minimum fire rating for roofs to be used as rooftop heliports should be established and included in the major building codes. This would provide added protection for building occupants and fire-fighting personnel forced to use the rooftop during a fire. The case studies reviewed indicated a significant range of time required to evacuate persons from the roof, which leads to the concern that the building's roof be designed to withstand a fire below, for the time necessary for evacuation. Some minimum standard should be established, taking into consideration numerous factors such as height and occupancy, type of construction, fire protection devices within the building, etc.

5.2 ADVISORY CIRCULAR

The following recommendations are made for improvement of the FAA's Heliport Design AC with regard to emergency rooftop heliports/ helistops:

1. The AC should be distributed to the publishers of National, Uniform, and Standard Building Codes with a request by the FAA that the AC be referenced and/or followed by the codes. This will help to ensure that building designers and state and municipal officials are kept abreast of the latest guidelines for heliport/helistop design as published by the FAA.

2. When the FAA publishes revisions to the Heliport Design AC, copies of these revisions should be sent to the publishers of the major building codes.

3. The AC should include reference to local building codes, i.e., "Rooftop heliport design is to comply with local building codes as applicable...." This would help to ensure that the AC is not used as the sole criteria for design of a rooftop heliport.

4. The AC should contain a loading condition for dead load of the structure plus a minimum uniform live load. This would provide an assurance that high-rise buildings are designed using minimum overall standards consistent with the major building codes. The AC should direct designers to use the greater of the uniform live load stated in the AC or the applicable building code.

5. The application of dynamic loads (from hard landings) should be applied through one gear only. This would provide a more conservative design load and would reflect a possible loading condition caused by the uneven landing of a helicopter which might occur during extreme conditions of an emergency evacuation.

6. Minimum marking standards for emergency evacuation facilities including takeoff and landing areas (with weight limit markings), walkways, and signs identifying the facility as an emergency facility should be established for the AC. This could vastly aid fire-fighting personnel in the control of persons being evacuated via the rooftop of a high-rise. It would also aid pilots in their usage of the rooftop emergency facility. It is important to note that should markings be adopted, it becomes necessary for building owners to ensure their building stays in compliance with all clearance and approach criteria even though the rooftop might only be utilized in an emergency situation.

LIST OF ACRONYMS

AC	Advisory Circular
ATC	Air Traffic Control
ATF	Bureau of Alcohol, Tobacco and Firearms
BOCA	Building Officials and Code Advisors
C&C	Command and Control
CFR	Crash Fire Rescue
EEF	Emergency Evacuation Facility
FAA	Federal Aviation Administration
HAI	Helicopter Association International
ICBO	International Conference of Building Officials
LZ	Landing Zone
NBC	National Building Code
NFC	National Fire Code
NFPA	National Fire Protection Association
SBC	Standard Building Code
SBCCI	Southern Building Code Congress International
SCBA	Self-contained Breathing Apparatus
SFC	Standard Fire Code
UBC	Uniform Building Code
UFC	Uniform Fire Code
USCG	United States Coast Guard
VFR	Visual Flight Rules

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