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Composite Profiles of Helicopter Mishaps at Heliports and Airports

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Final Report

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16. Abstract <p>In a companion report entitled "Analysis of Helicopter Mishaps at Hel ports, Airports, and Unimproved Sites," DOT/FAA/RD-90/8, National Transportation Safety Board and U.S. Army mishap reports were reviewed in order to determine the types of mishaps that have occurred at helicopter landing sites. Based upon these mishap records, helicopter composite mishap profiles were developed and are presented here in order to demonstrate the types of mishaps that have occurred at or near heliports and airports. Each composite profile includes a description of the mishap, facility design factors which contributed to the mishap, nondesign-related contributing factors, and operational safety enhancements where appropriate.</p> <p>This document is intended to be a learning and teaching aid. The intended audience includes helicopter landing area designers, managers, and operators, as well as pilots. The goal of the report is to broaden awareness in the helicopter community in order to promote safety.</p> <p>This report is one in a series of three dealing with helicopter mishaps at landing sites. The other reports are:</p> <p>"Analysis of Helicopter Mishaps at Heliports, Airports and Unimproved Sites," DOT/FAA/RD-90/8, and "Analysis of Helicopter Accident Risk Exposure near Heliports, Airports, and Unimproved Sites," DOT/FAA/RD-90/9.</p> <p align="right">DOT/FAA Composite profiles of helicopter RD-91/1 mishaps at heliports and airports 00026692</p>					
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PREFACE

The efforts herein were managed by the Federal Aviation Administration (FAA) Vertical Flight Program Office (ARD-30) through a contract with Systems Control Technology (SCT), Air Transportation Systems Division, Arlington, Virginia. SCT was assisted in this effort by Advanced Aviation Concepts (AAC) of Jupiter, Florida. Mr. Len Dzamba and Mr. Bill Sampson, the project leaders, are with SCT. Mr. Richard Adams is with AAC.

The authors would like to thank Mr. Philip Umbreit for his fine efforts in creating the illustrations used in this document. We would also like to thank Ms. Linda LaBelle for her many contributions in editing this document. Finally, we would like to thank Ms. Michelle Vaughn for patiently typing and retyping the document, and for all her efforts in organizing the material within.

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to present scenarios of the types of mishaps* that may occur at heliports and airports. These mishap scenarios are based upon historical mishap records and were developed to highlight facility design issues and factors that have contributed to mishaps. The mishap scenarios are designed to be realistic and are meant to provoke reader interest and thought concerning facility design and safety.

This report is intended to be used as a teaching and learning aid for facility designers, managers, and operators, as well as for pilots. It is hoped that by presenting mishap scenarios, the report's intended audience may gain a better appreciation for the types of issues that are unique to helicopters and their operating environment. For instance, helicopter accident data shows that airport operational areas originally designed primarily for fixed-wing aircraft may not necessarily support helicopter operations safely. Factors that are unique to helicopters need to be considered when designing areas intended for helicopter operations.

1.2 BACKGROUND

In an effort to understand the types of mishaps that have occurred at heliports, the FAA supported efforts to review the historical helicopter mishap database. The results of these efforts were published in a document entitled "Analysis of Helicopter Mishaps At Heliports, Airports, and Unimproved Sites," DOT/FAA/RD-90/8 (reference 1). The focus of the study was basically twofold:

- o to understand how and to what degree heliport design may be a factor in heliport mishaps, and
- o to provide recommendations to help reduce the role that heliport design may play in helicopter mishaps.

The study showed that although heliport design is a factor in some mishaps, it is not a contributing factor in the majority of helicopter mishaps. In fact, a companion report entitled "Analysis of Helicopter Accident Risk Exposure at Heliports, Airports, and Unimproved Sites," DOT/FAA/RD-90/9 (reference 2) suggests that as a first order approximation, facility design is a contributing factor in approximately 4 percent of the annual civil helicopter accidents. This number includes mishaps at all types of landing facilities, not just heliports. The study also concludes that the number of mishaps, occurring at dedicated heliports, in which heliport design is a contributing factor is near 2 percent. Finally, the study concludes that the number of design-related mishaps occurring at facilities designed in accordance with the Heliport Design Advisory Circular 150/5390-2 (reference 3) is probably less than 1 percent of annual helicopter mishaps.

* NOTE: In this document, the term mishap is meant to represent an accident or incident. It is used to represent an event, regardless of the number of injuries and/or monetary losses.

Although facility design is a contributing factor in only a small percentage of helicopter mishaps, the cost of such mishaps is potentially very high. A rotating main or tail rotor striking an object can result in a catastrophic event that may include fatal injuries. Many heliports in existence today are not designed in accordance with the Heliport Design Advisory Circular. Therefore, it is important to understand the manner in which heliport design may contribute to mishaps. Measures that can be taken to reduce the already low number of facility design-related mishaps are discussed throughout this report.

1.3 MISHAP SCENARIOS

The mishap scenarios presented in this document were developed by the authors and did not actually occur. They are based upon a review of actual civil and military mishap reports. Design issues and contributing factors were taken from these reports to generate the hypothetical mishap scenarios presented. However, the scenarios have been written with the intent of disassociating them as much as possible from actual mishaps. Details within the composite mishap scenarios differ from actual events and therefore should not be directly compared to actual mishaps.

1.4 DOCUMENT APPROACH

In general, this report is written using a different tone than the two companion reports. They were written as technical documents presenting historic facts. This report is intended to be a learning and teaching aid. Therefore, this document presents issues, facts, and concepts in a reader-oriented manner that is designed to be of interest to both the technical and non-technical reader.

Section 2.0 presents 16 composite mishap scenarios that illustrate the types of facility design-related mishaps that may occur. The major focus of these scenarios concerns obstacle strike mishaps. The mishap analysis report showed that the majority of facility mishaps involve obstacle strikes. Therefore, the majority of the mishap scenarios developed for this document address this issue. Other scenarios include less common mishaps which nevertheless deserve attention (see table 1). They address issues including rotorwash damage, stuck skids, refueling fires, engine failures on takeoff, power required/available on takeoff, and on-ground collisions involving multiple aircraft.

In addition to facility design, pilots play an extremely important operational role in the facility safety equation. Therefore, a discussion of factors that influence pilots' capabilities and performance is included in section 3.0.

TABLE 1 TYPES OF COMPOSITE MISHAP SCENARIOS

<u>COMPOSITE NUMBER</u>	<u>FACILITY</u>	<u>LOCATION</u>	<u>MISHAP TYPE</u>
1	Airport	Parking	Obstacle strike - light pole
2	Helicopter	Approach Groundspace	Rotorwash damage
3	Airport	Taxiway	Multiple aircraft on-ground collision
4	Airport	Parking	Ground mishap (stuck skid)
5	Airport	Refueling	Obstacle strike - sign pole
6	Airport	Parking	Obstacle strike - tie-down anchor
7	Helicopter	Approach/Departure Airspace	Obstacle strike - wires
8	Helicopter	Parking	Multiple aircraft - main rotor blade contact
9	Helicopter	Parking	Obstacle strike - building
10	Helicopter	Departure Groundspace	Insufficient power for takeoff - density altitude
11	Helicopter	Departure Groundspace	Engine failure on takeoff
12	Helicopter	FATO	Insufficient power - downwind landing
13	Helicopter*	FATO	Obstacle strike - parapet
14	Airport	Refueling	Refueling fire
15	Helicopter	FATO	Obstacle strike - perimeter light
16	Airport	Parking	Tail rotor strike - personnel

* Elevated

2.0 COMPOSITE MISHAP PROFILES

Section 2.2 presents 16 composite profiles which highlight the types of mishaps that have occurred at helicopter landing facilities. Section 2.1 discusses the manner in which the actual mishaps upon which the composite profiles are based were selected.

2.1 BACKGROUND DATA SOURCES

The composite mishap profiles contained in section 2.2 are based upon both civil and military helicopter mishaps that have occurred at landing facilities. Many operations on or about military landing facilities are principally the same as those at civilian facilities; in fact, military helicopters routinely make use of civil facilities. In addition, a number of the military mishaps reviewed for this effort occurred at civil facilities. Therefore, the use of military mishap reports as background for developing the composite profiles is appropriate.

The civil mishap reports were obtained from the National Transportation Safety Board (NTSB), while the military reports were obtained from the United States Army. Reference 1, the mishap analysis study, describes in detail the manner in which the mishap reports were initially chosen for review. Figure 1, taken from reference 1, illustrates the percentage break-down of mishap types at or near heliports and airports. These accident types were used as a basis for developing the 16 composite accident scenarios.

2.2 COMPOSITE MISHAPS

Each composite mishap includes a description of the mishap, relevant design issues, contributing factors, a graphical presentation of the mishap, discussions of design and operational safety enhancements where appropriate, and a second graphic depicting an improved, safer heliport design. Since only a limited number of mishaps could be presented herein, the reader is encouraged to envision each mishap occurring under a variety of circumstances. For example, composite profile number 1 depicts a main rotor strike of a light pole. However, main rotor strikes can occur with any obstacle that is at main rotor height in the vicinity of the operational areas. Therefore, readers are encouraged to imagine circumstances under which similar types of mishaps may occur and to work to prevent such mishaps.

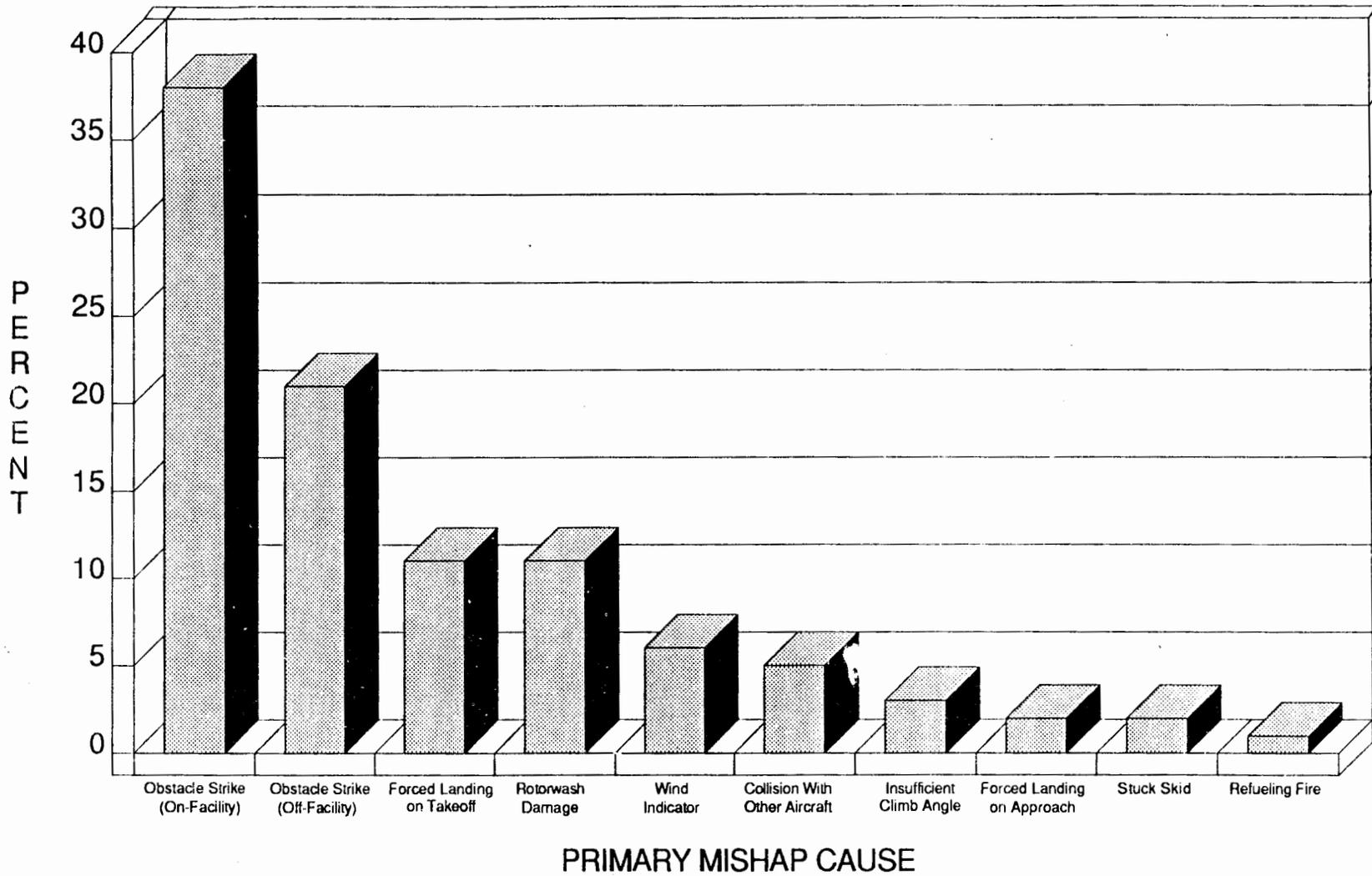


FIGURE 1 GENERAL MISHAP TYPES

COMPOSITE #1

MISHAP TYPE: OBSTACLE STRIKE - LIGHT POLE

DESCRIPTION: The large, twin-turbine helicopter was being used to ferry corporate marketing personnel to several cities as part of an effort to promote a new product line. The pilot began his work day at 6:30 a.m. At 4:10 p.m., he took off for the fifth and final stop of the day. The weather was typical for a late autumn day, with gray skies and a cold light rain. The pilot leveled off at 1,000 feet to stay below the 2,000 foot overcast en route to his final destination.

Inbound to the uncontrolled airport, the pilot called the only fixed-base operator (FBO) located on the airport to insure that overnight parking would be available. After arriving at the airport, the pilot hover-taxed the helicopter to the FBO in order to deplane the passengers. While at the FBO, the "line boy" told the pilot where to park overnight and also said that he would assist the pilot in parking the aircraft.

A chain link fence surrounded the parking area and two 40 foot high light poles were equally spaced along one side of the fence. The gray metal light poles were adjacent to the parking area, approximately 15 inches outside the fence. A number of helicopters were already parked in the area, leaving a limited amount of room for the latest arrival. The "ground handler" signaled the pilot to taxi along the fence and then make a right turn into the parking spot. As the helicopter proceeded along the fence, the "ground handler" positioned himself next to another helicopter that was parked adjacent to the intended parking space. The pilot made note of the light poles that he would pass during the taxi. As the pilot prepared to turn the helicopter into the parking space, he watched for hand signals from the "ground handler" to let him know that the rotor blades would clear the parked aircraft. When the pilot was about to initiate a right turn into the parking space, the main rotor blades contacted one of the light poles (see figure 2). The pilot later stated that the gray poles blended in with the sky and that he momentarily forgot about them.

DESIGN ISSUES:

Obstacle Marking - Marking obstacles that lie in or near operational areas is an extremely important consideration. This is particularly true when the obstacle may blend in with the background under certain conditions. Heliport designers should consider marking obstacles with reflective materials, flood lights, or obstruction lights (reference 8). Using reflective tape or paint to place stripes on an obstacle may be the simplest means of making obstacles more visible.

Obstacle Location - Operational areas may contain obstacles such as fences, poles, or other aircraft. Placing permanent obstacles in or near operating areas must be done with care and consideration. At airports, helicopters typically operate in areas designed primarily for fixed-wing use (parking, fuel, taxi). These areas are often designed without considering any special needs of helicopters. A suggestion for installing lights in this

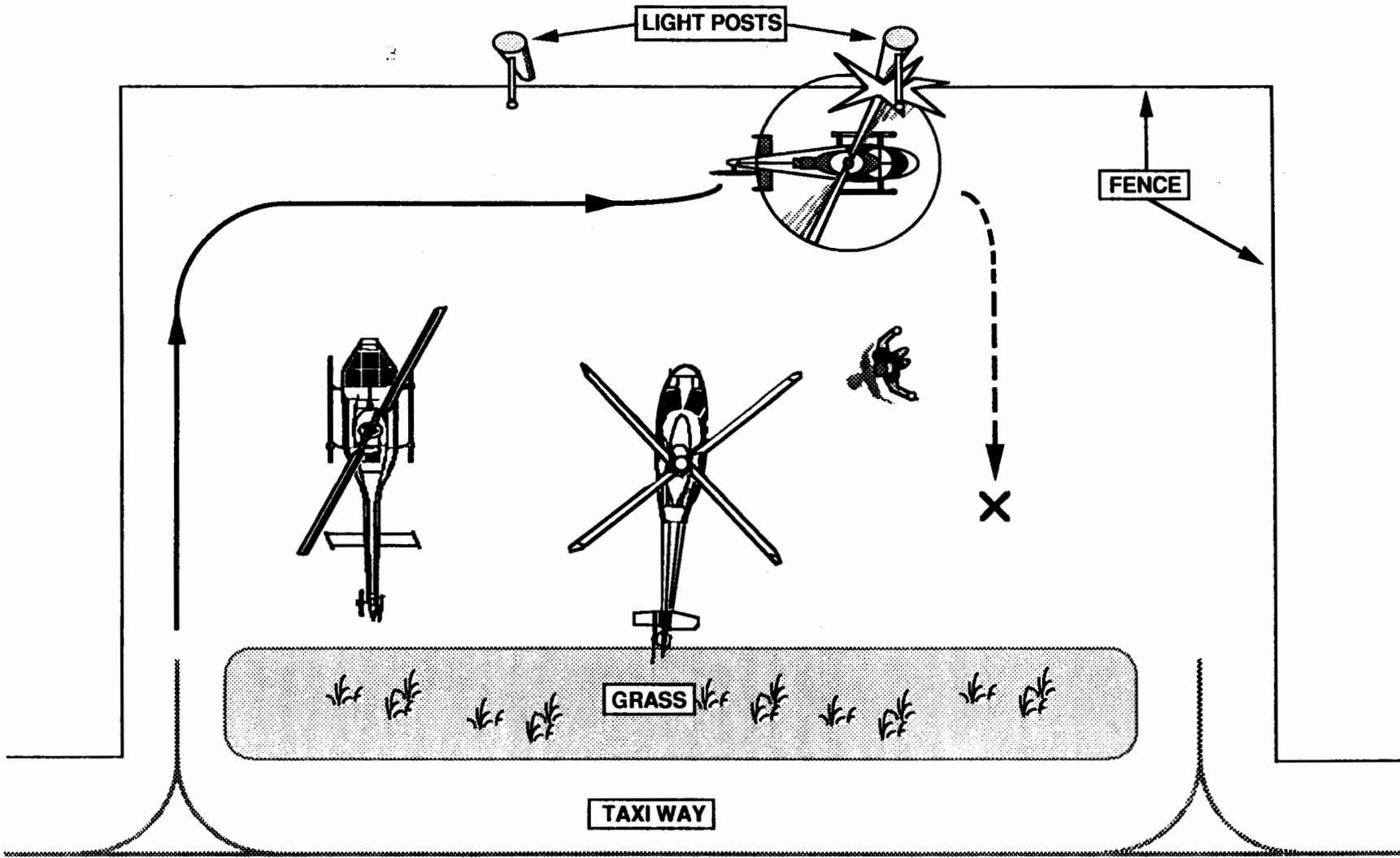


FIGURE 2 OBSTACLE STRIKE - LIGHT POLE

instance is to mount them low on the fence itself, thereby combining two obstacles into one. Groups of obstacles are usually more noticeable than individual obstacles.

Parking Ramp Marking - Hover taxi lines from the taxiway to each parking spot should be in place on those ramps which have dedicated parking areas.

Confined Area Operations - The maneuvering space in the parking area was too small and placed high demands on the pilot. Had the parking area been located farther from the fence, the pilot would have been able to safely maneuver the helicopter. Facility designers and operators should consider the type of demands their facility design and operations will place on pilots. Pilots must be extremely cautious when operating in confined areas.

Whenever possible, the clearest taxi route should be used. As the pilot was not familiar with the parking area, the ground handling personnel should have had the pilot continue on the taxiway, entering the parking area on the far end. This would have removed the need to hover between parked aircraft and the fence. Figure 3 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

Weather - The weather was definitely a contributing factor in this mishap. The gray metal light pole blended in with the gray overcast skies. Even though pilots are aware of the hazard that obstacles represent, individuals may momentarily let down their guard if an obstacle does not stand out sufficiently from the surroundings. This is more likely to occur when the pilot is hungry, tired, stressed, or distracted.

Ground Handling Personnel Positioning - The ground handling personnel was not in position to clear the helicopter of all obstacles. Had the ground handler positioned himself in front of the helicopter, he may have been able to clear the aircraft of both the light pole and the parked aircraft. The mishap database highlights the fact that the use of personnel in assisting pilots during taxi operations does not preclude a mishap from occurring. Line personnel may or may not be trained as ground handling personnel (see Airman's Information Manual (AIM), figure 4-6, paragraph 259).

Fatigue - The pilot was flying his fifth flight of a long work day. It was late in the afternoon when the helicopter arrived at its final destination, and fatigue had set in. The fact that the pilot stated that he momentarily forgot about the pole was in part due to fatigue. It is important for pilots to be constantly aware of their physical well-being. They must be able to determine when factors such as fatigue are affecting them. This would caution them for the need to be even more alert.

Pilot Overconfidence - It is very important for pilots not to be overconfident in their ability or the ability of personnel assisting them. In this instance, the pilot relied on ground handling personnel to assist in

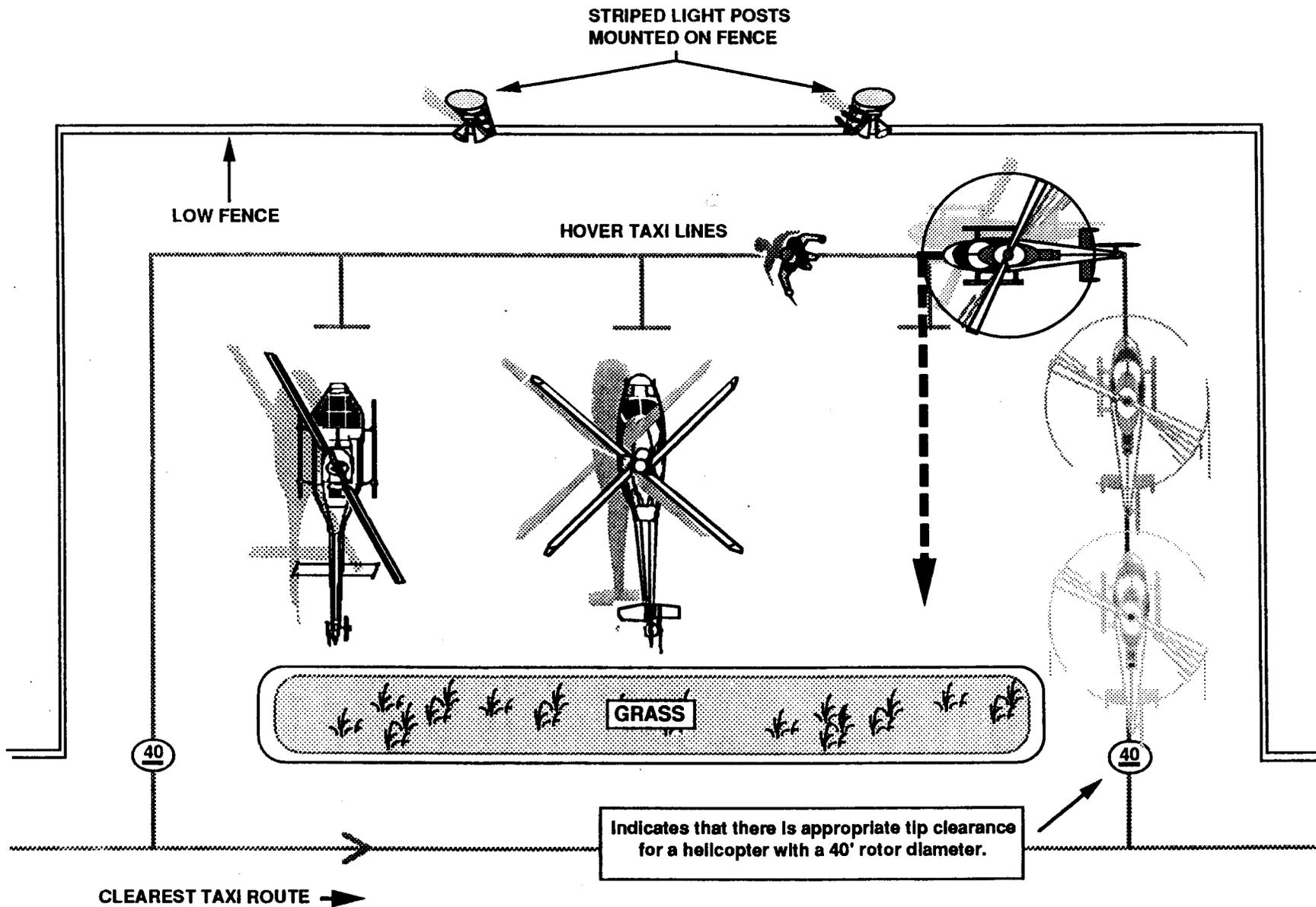


FIGURE 3 IMPROVED HELIPORT DESIGN AND OPERATION - OBSTACLE MARKINGS

parking the helicopter. It is easy to become complacent and overconfident of your ability to maneuver under difficult circumstances. Avoiding this trap will help ensure safety of operations.

OPERATIONAL SAFETY ENHANCEMENTS:

Ground Handling Personnel Training - When ground personnel are used to assist pilots in ground operations, some level of training will prove quite valuable. This is particularly true at airports where the number of helicopter operations is typically low when compared to the total number of operations. Basic training in the handling qualities and capabilities of helicopters should include operations under all wind conditions. Training should also include correct ground handler positioning with respect to ground handler safety and aircraft guidance while assisting in taxi operations. This training should include the use of proper hand signals, such as those found in section 247 of the Airman's Information Manual, in directing aircraft. It should also include the turning aspects of helicopters, especially tandem rotor helicopters, at locations where they may operate.

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Composite profiles of helicopter
mishaps at heliports and airports

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COMPOSITE #2

MISHAP TYPE: ROTORWASH DAMAGE

DESCRIPTION: The pilot, her husband, and another couple departed the airport for the 90-mile trip to a well-known restaurant. Although the pilot had never been to the restaurant heliport before, she had been told that the helipad was well-marked and that she should have no trouble locating the pad.

The pilot and her husband were very excited to be showing off their new helicopter to their friends. The cool summer weather was perfect, with sunny skies and unrestricted visibility. The restaurant was located next to a large lake which the pilot noticed when the helicopter was about 10 miles from the restaurant. She told her husband that since the helicopter was not equipped with floats, she would avoid an approach that would take them over the lake.

Approximately 1 mile from the heliport, the pilot made a prelanding check as she lined-up the helicopter for the final approach to the pad. The pilot noticed that her final approach would take the helicopter over a corner of the parking lot. However, she decided that since there were no people in the area, an approach over the parking lot would be acceptable. As the helicopter slowed to land, the approach placed the helicopter over a truck with a camper shell attached. When the helicopter was at 20 feet AGL, the rotorwash blew the camper shell off of the truck onto a car. Both the car and truck received considerable damage (see figure 4).

DESIGN ISSUES:

Clear Groundspace - Rotorwash has been the cause of personnel injury and property damage in a number of mishaps. It is important to control the groundspace under the approach/departure path to at least the recommended distance of 280 feet from the edge of the primary surface (reference 3). In addition, as was shown in the mishap presented above, the approach/departure path that a pilot will choose cannot be guaranteed. Therefore, the facility operator may wish to ensure that, where possible, groundspaces under other potential approach/departure paths have limited access because of the possibility of mishaps due to rotorwash.

CONTRIBUTING FACTORS:

Approach/Departure Paths - Pilots should attempt to adhere to the recommended approach/departure path whenever conditions allow for such procedures. At times, it may seem easy to put aside established procedures when there appears to be plenty of clear space surrounding a heliport. When the wind is not a significant factor, a pilot may choose to approach a heliport from a direction other than that prescribed by the heliport markings. However, judicious approach/departure paths are designed based on several factors, not just prevailing wind. Helicopter performance, safety, noise, obstacles, and objects underlying the approach/departure paths must be considered. Whenever possible, avoid flying over people, vehicles, and structures, particularly during takeoffs and landings. Figure 5 depicts the proper approach.

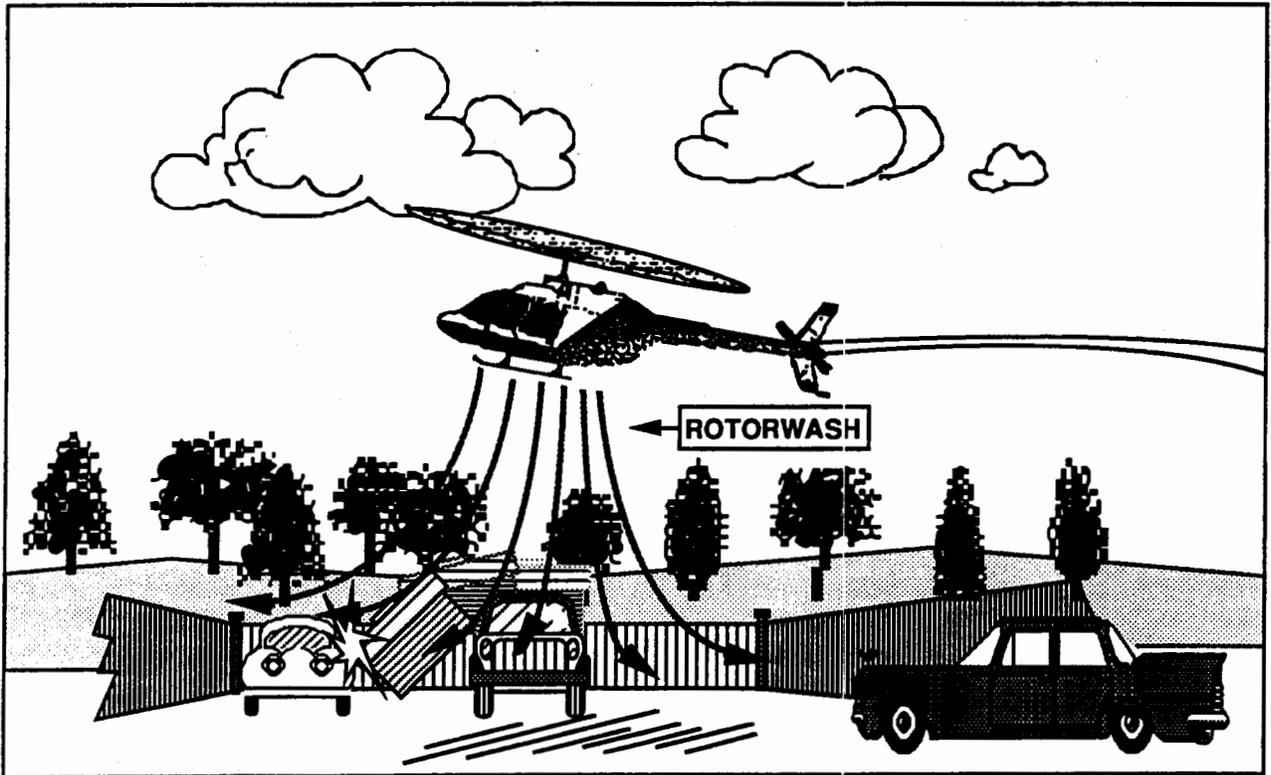
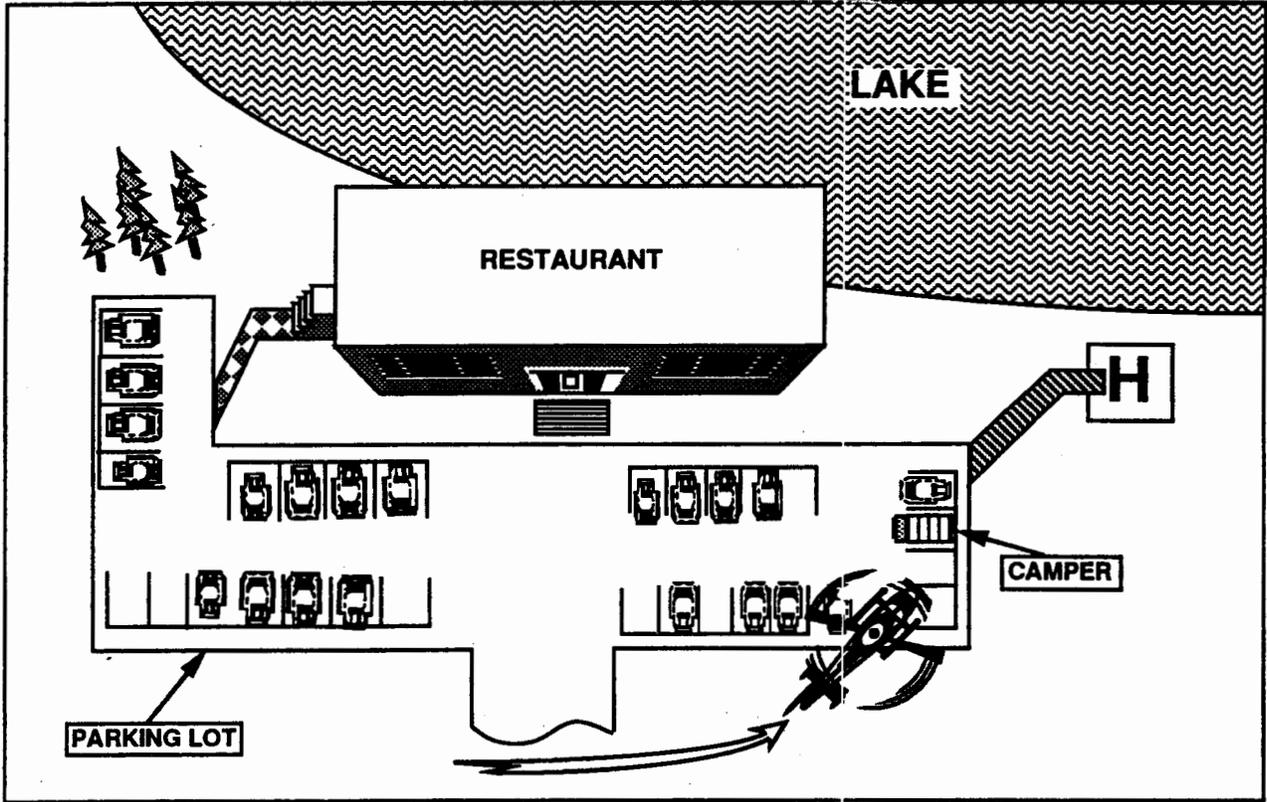


FIGURE 4 ROTORWASH DAMAGE

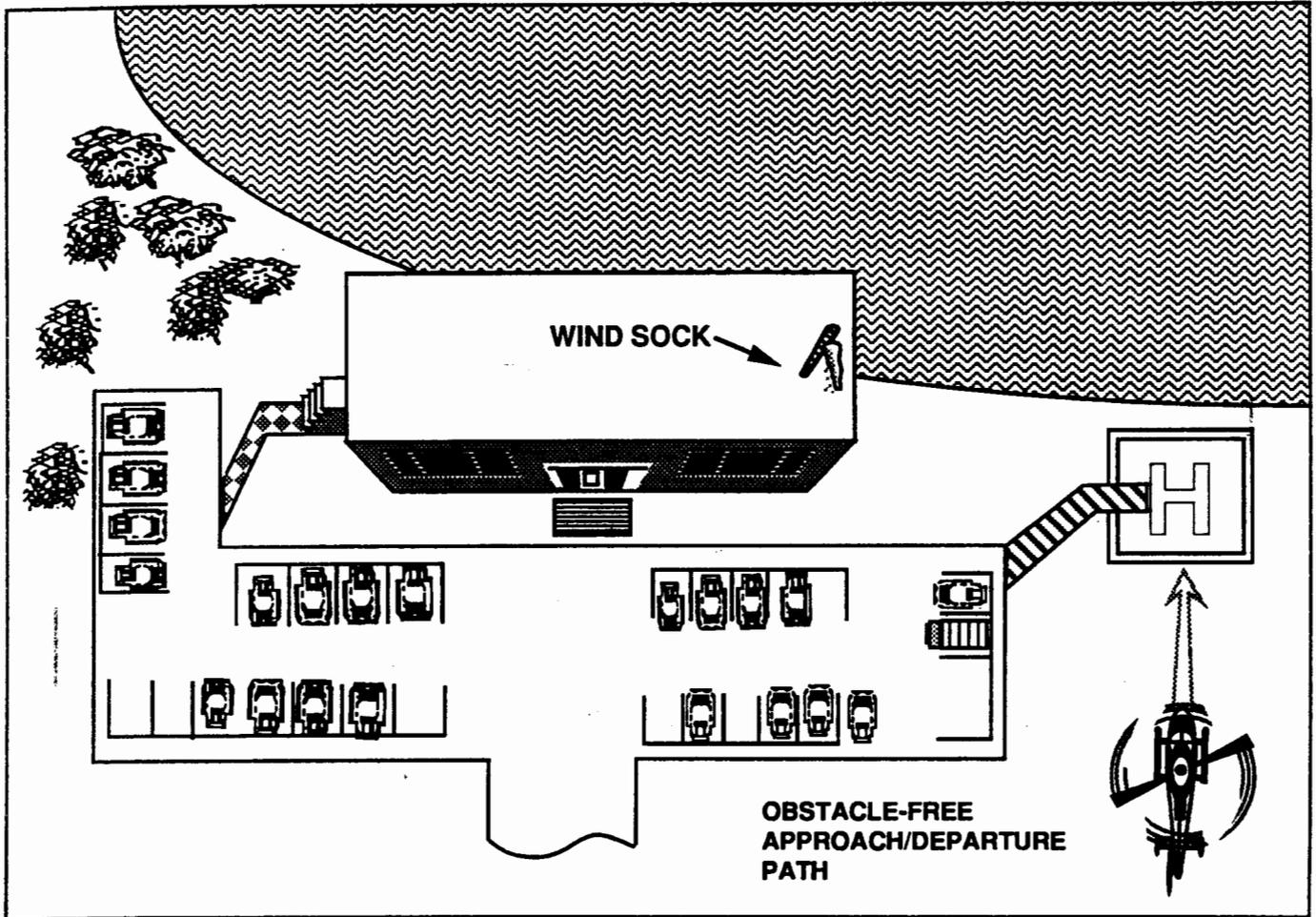


FIGURE 5 IMPROVED HELIPORT APPROACH/DEPARTURE PATHS

COMPOSITE #3

MISHAP TYPE: MULTIPLE AIRCRAFT ON-GROUND COLLISION

DESCRIPTION: The pilot arrived at the airport at 8:30 p.m. to ferry the single-engine turbine helicopter back to the company's private heliport. Earlier that day the pilot had brought two company executives to the airport and all three had planned to remain overnight. However, at 7:30 p.m. the pilot was called and told to ferry the helicopter back to the company helipad in order to fly the CEO to a meeting the following morning. The pilot had to cancel plans he had made for that evening.

As the pilot began to preflight his aircraft, he noticed another pilot and passenger on board a medium sized, twin-turbine helicopter parked on an adjacent pad to his right. After preflight, the pilot started the helicopter and completed the final checks. Since the part-time airport tower was closed, the pilot set the aircraft radio to the automatic terminal information service (ATIS) frequency at a nearby airport to check the weather and obtain a local altimeter setting. While listening to the ATIS broadcast, the pilot hover-taxed down the taxi lane to the taxiway. At the same time the twin-turbine pilot was also taxiing his aircraft out to the taxiway. While taxiing down the taxi lane, the twin-turbine pilot noticed the aircraft to his left taxiing from the parking pad to the taxi lane. The twin-turbine pilot stopped his aircraft and attempted to contact the other pilot on the airport tower frequency. He was unable to contact the pilot and the two rotor systems intermeshed (see figure 6).

During an interview with the mishap investigator, the single-turbine pilot stated that this trip was his first into the airport and he was not familiar with local procedures. He also stated that he was primarily looking to his left during the taxi to insure that he would not hit the aircraft parked to his left. He did recall that he looked to the right as he started to taxi. However, he stated that the curtain that was behind the co-pilot's seat had partially blocked his view.

DESIGN ISSUES:

Parking Area Layout - The parking area design contributed to this particular mishap. The parking pads were designed to intersect the taxi lane at a 45 degree angle. Therefore, the pilot in this case would have had to look over his right shoulder to insure that no other aircraft was taxiing down the taxi lane from his right. Placing the parking pads at a 90 degree angle to the taxi lane is preferable in order to provide maximum visibility to the pilot. Figure 7 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

Visual Obstacles - The single-turbine pilot's visibility was hampered by the curtain that separated the cockpit from the cabin. In most operational situations, the curtain may not have presented a hindrance to the pilot.

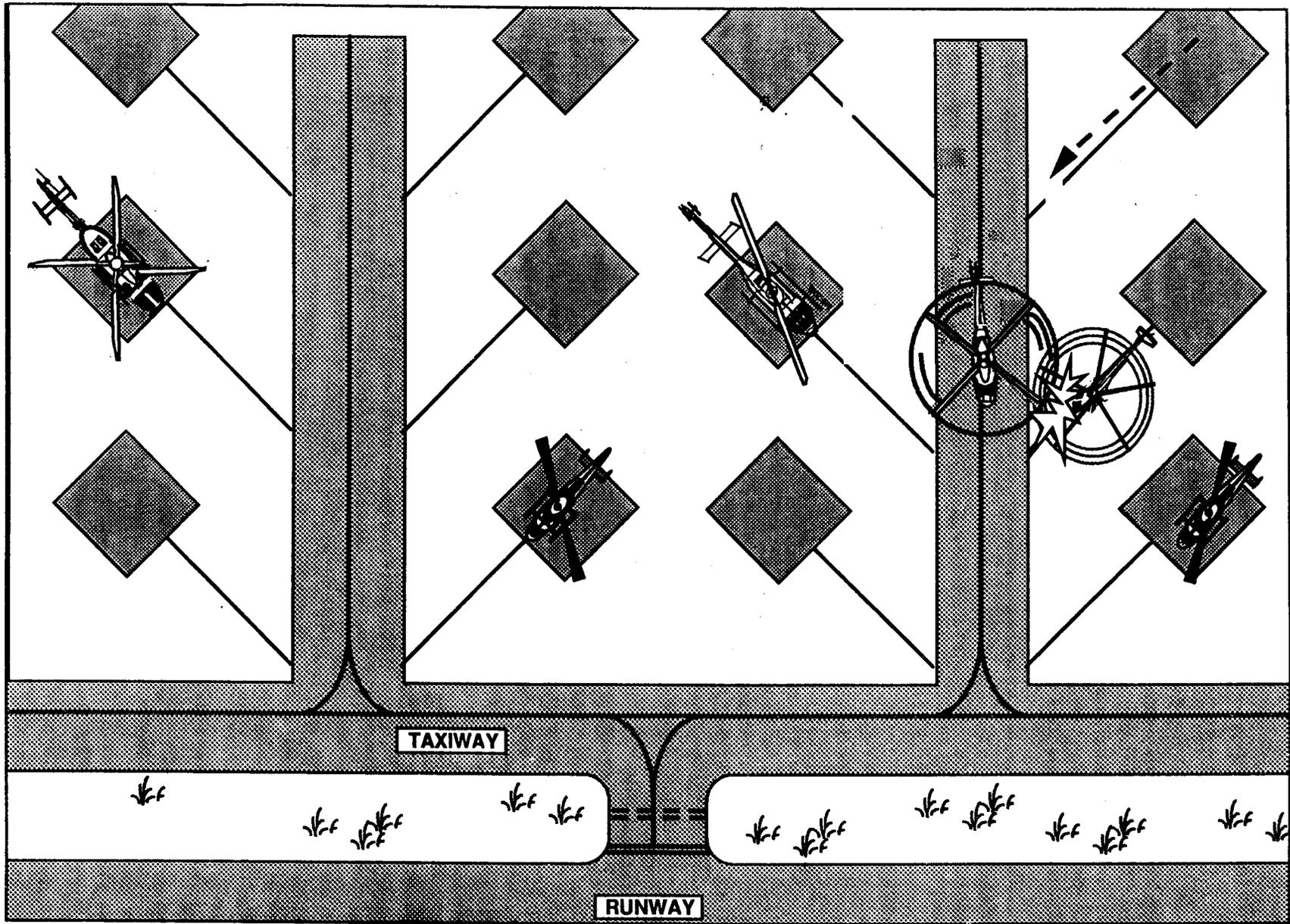


FIGURE 6 OBSTACLE STRIKE - MULTIPLE AIRCRAFT ON-GROUND COLLISION

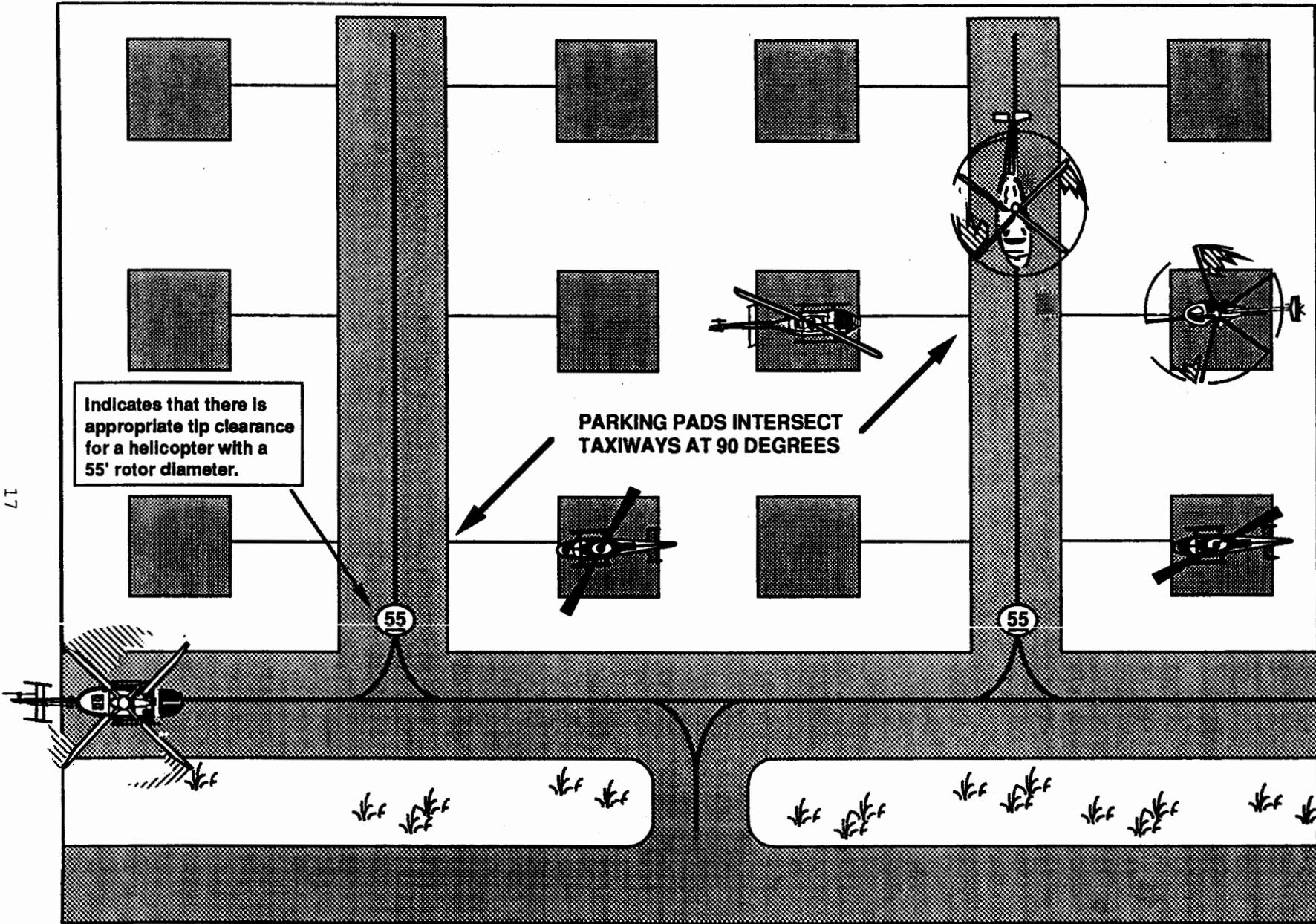


FIGURE 7 IMPROVED HELIPAD AND TAXI LANE ALIGNMENT

However, in this particular instance the design of the parking area necessitated that the pilot be able to see more than 90 degrees to his right.

Communications Frequency - In this mishap scenario, the local control tower was operational only during daytime hours and, therefore, control of movements around the airport was left to pilot's discretion at night. The fact that the two aircraft radios were tuned to different frequencies contributed to this mishap. When a control tower is closed, the airport's common traffic advisory frequency (CTAF) should be used (see AIM, chapter 4, paragraph 4-8). Had both pilots correctly used the CTAF frequency prior to and during aircraft movement, this mishap may have been prevented.

COMPOSITE #4

MISHAP TYPE: GROUND MISHAP (STUCK SKID)

DESCRIPTION: The air taxi flight was chartered for a business flight that included an overnight stay in a small town, followed by a return flight in the morning. After one stop earlier in the day, the helicopter arrived at the destination airport at 4:30 p.m. The midsummer afternoon was hot and the temperature was 96 degrees when the flight arrived. After unloading the passengers, the pilot hover-taxied the helicopter to the ramp and parked the helicopter. He then arranged to have the aircraft refueled by truck for the return flight in the morning.

After taking a shower the next morning, the pilot received a phone call from one of the passengers informing him that the CEO wished to leave immediately rather than the original schedule of 2 hours later. The pilot agreed to meet the passengers in the hotel lobby in a few minutes. He knew that this company was an important client and that he needed to do everything possible to keep them happy with his service. The pilot called for a weather briefing and was informed that there was fog at his destination, but that it would probably burn off by mid-afternoon. Since the pilot was not instrument-rated, he preferred delaying the takeoff but knew that his passengers would not be pleased with a delay. The pilot finished packing and then rushed down to the hotel restaurant to get a cup of coffee for the ride to the airport.

Upon arriving at the airport, the pilot paid for the fuel. He then did a quick "walk around," boarded the passengers, ran through the checklist, and proceeded with a normal engine start. The aircraft was near maximum gross weight, but the pilot knew that the helicopter would have no trouble taking off in the cool morning air. As he pulled collective, the pilot added right back cyclic to counter the 10 knot right quartering tail wind. As the left skid rose from the asphalt, the helicopter began to lean to the right rear because the back part of the right skid had become embedded in the asphalt the previous afternoon. The pilot applied left cyclic to break the right skid free. When the right skid broke free the helicopter began to quickly roll left. The pilot applied right cyclic but could not overcome the roll to the left. The main rotor blades then struck the asphalt parking ramp (see figure 8).

DESIGN ISSUES:

Surface Material - It is important that operational areas be capable of supporting the full weight of the aircraft. These areas include FATOs, refueling areas, and parking pads. Concrete is preferable to asphalt. This is particularly true for locations that experience high daytime temperatures during the year. Figure 9 depicts the heliport with design improvements that enhance safety.

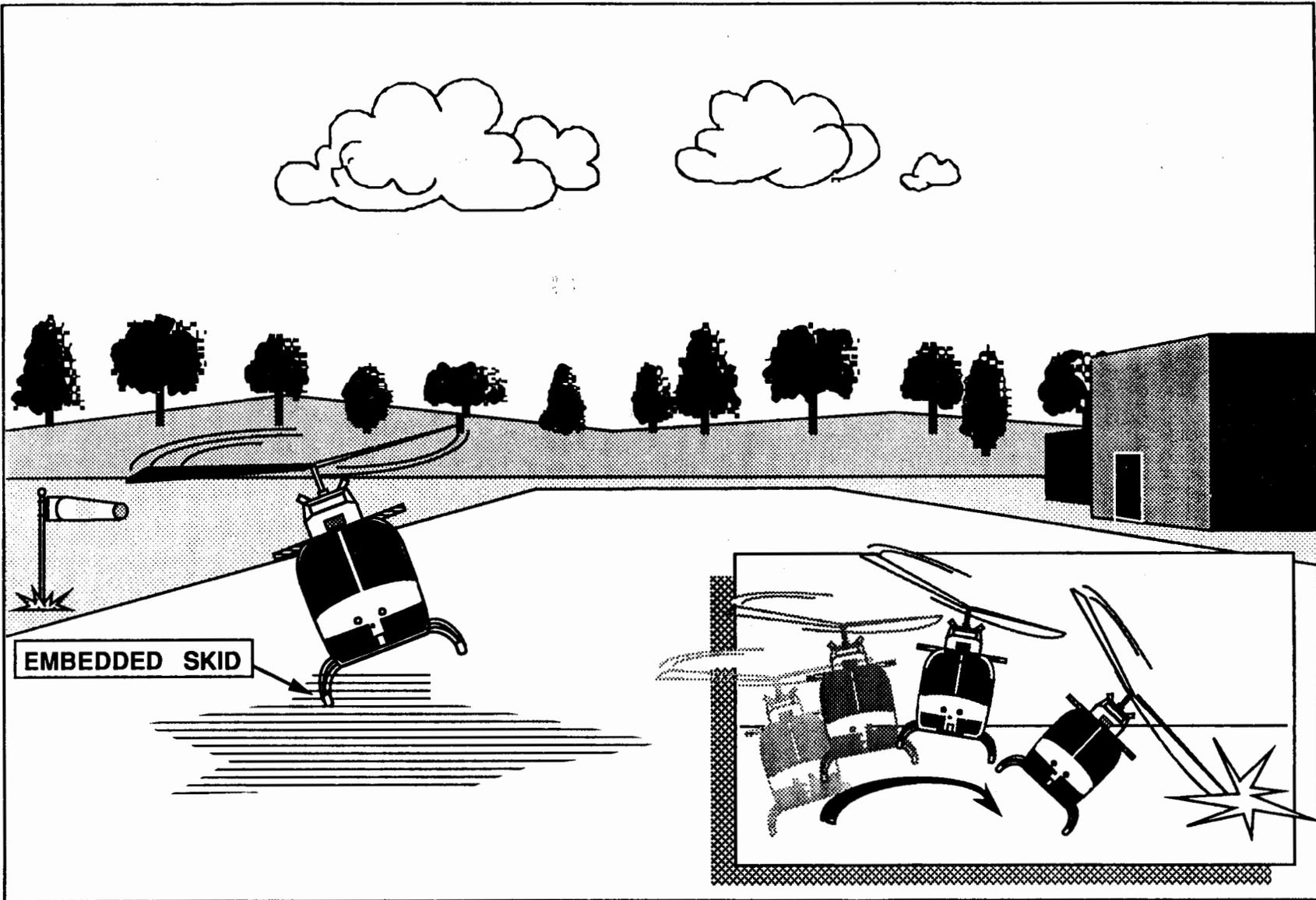


FIGURE 8 GROUND MISHAP (STUCK SKID)

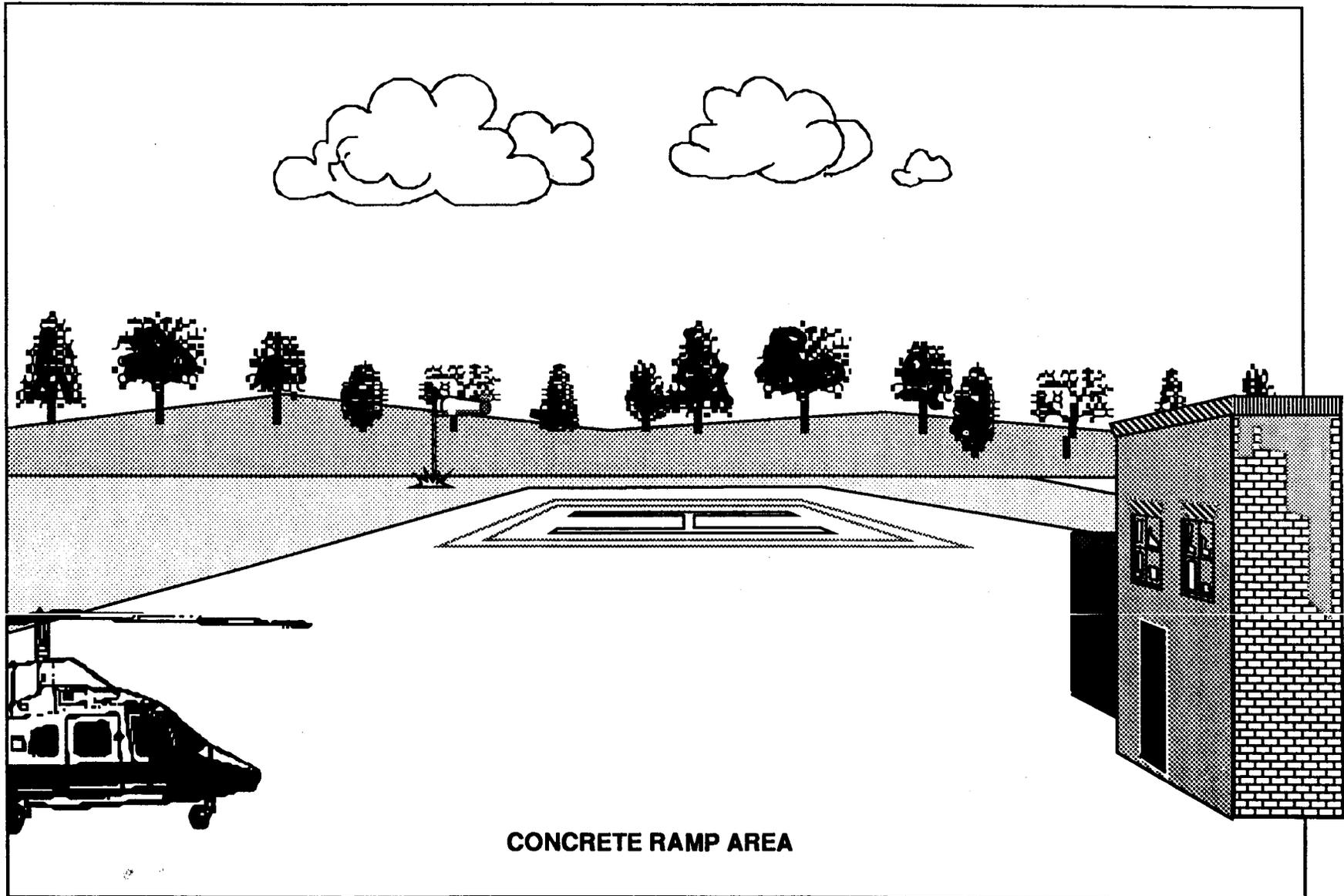


FIGURE 9 IMPROVED HELIPORT SURFACE COMPOSITION

CONTRIBUTING FACTORS:

Weather - The extremely high ambient temperature the previous afternoon contributed to this mishap. The temperature was sufficient to soften the asphalt enough to allow the aircraft's right skid to sink into the asphalt.

Preflight Procedure - The pilot's preflight procedure was obviously inadequate because he failed to notice that the skid had sunk into the asphalt. The condition of the surface around the skids should always be checked. Any cracks, bumps, or indentations can lead to mishaps.

Situational Stress - The amount of stress that the pilot experienced increased when he received the phone call informing him that the passengers wanted to leave immediately. He had yet to do a number of things, including calling for a weather briefing, checking out of the hotel, paying for the aircraft's fuel, and preflighting the aircraft for departure. This was all to be done as quickly as possible under the observation of his passengers. The pilot was also preoccupied with the fact that there was fog at his destination.

Pilots must realize when they are under additional stress. It is important that under these circumstances pilots adhere to training, which includes following checklists and keeping an overall awareness of the situation. Pilots must also be willing to postpone or cancel a flight when conditions warrant such action.

Pilot Technique - A contributing factor to this mishap was pilot technique. The pilot attempted to free the skid by pulling collective and using the helicopter to fly out of the asphalt. This is not recommended at any time. The best solution to the problem is to physically loosen the landing gear with the engine off during the preflight inspection. Ground handling equipment can be helpful in this regard. Depending on aircraft model, it may also be possible to free the landing gear by moving the tail boom.

COMPOSITE #5

MISHAP TYPE: OBSTACLE STRIKE - SIGN POLE

DESCRIPTION: The helicopter departed the airport after refueling for the final stage of a three-stage trip. The pilot had decided to fly his new helicopter to a small airport located near a mountain resort for three days of hiking and camping with his young son. Approximately 1 hour from their destination, they encountered a lowering ceiling and a flight watch specialist reported that there were embedded thunderstorms in the area. The early morning weather forecast stated that the front would not be in the area until later that night. While "scud running" beneath the lowering overcast, the helicopter proceeded through the hills as the pilot followed a road which led to the airport. When the pilot saw the airport, he was very relieved and noticed that he was feeling tired from the strain of the long day and what had been a very stressful flight.

As the helicopter approached the uncontrolled airport, the pilot announced his intentions to land at the parking ramp. After landing, the pilot decided to refuel the aircraft rather than waiting until the return trip to refuel. The pilot hover-taxed the aircraft to the refueling area and followed the faded arrows on the taxi line in the refueling pit. As the helicopter approached the fuel pumps which were located on the left side of the aircraft, the pilot noticed that the refueling hose seemed to be rather short. As the helicopter moved parallel to the fuel pumps, the pilot's view from the right seat was partially blocked by his son and the aircraft's fuselage. Since the refueling hose appeared to be short, the pilot decided to move the helicopter closer to the fuel pumps. He planned to set the right skid down on the taxi line. As the helicopter inched toward the fuel pump, the main rotor blades struck a thin sign pole (see figure 10).

After the mishap, the pilot stated that even though the sun had not set, the cloud cover made it appear rather dark at the time of the mishap. He also stated that it was very difficult to see the black sign pole against the background of trees that are located in back of the refueling area. Finally, the pilot stated that he thought that placing the skid on the taxi line would allow sufficient room. However, mishap investigators determined that the helicopter's right skid was inside the taxi line when the mishap occurred.

DESIGN ISSUES:

Obstacle Marking - This is another example of the importance of clearly marking obstacles which lie in operational areas. Mishap records document that numerous poles placed in refueling areas have been struck. These include sign poles, light poles, and vent pipes. Objects that may blend in with the background are potentially very dangerous.

Refueling Hoses - Pilots have stated in mishap investigations that their concern over the length of fuel hoses has been a definite contributing factor to mishaps. In their attempt to get close enough to the fuel pumps,

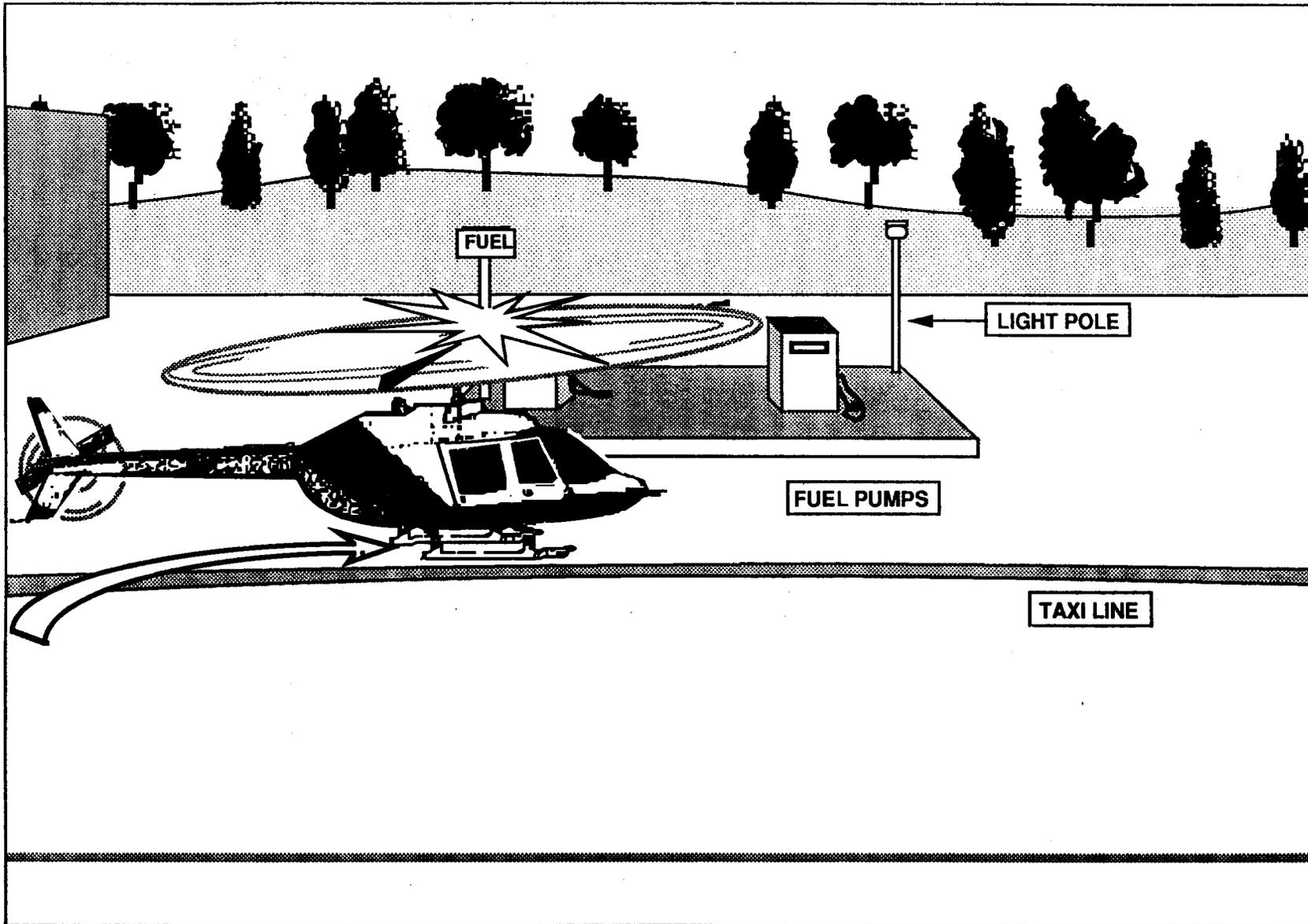


FIGURE 10 OBSTACLE STRIKE - SIGN POLE

their helicopters have struck objects in refueling areas. Refueling hoses should be adequate in length so that an aircraft centered on the taxi line can be refueled. Pilots should not have to concern themselves with the length of a fuel hose. Taxi lines adequate to handle the largest type of helicopter should be marked. However, for the uninitiated, a short sign could be posted, "Fuel - 40 Foot Hose."

Ground Markings - At refueling areas that include service for helicopters, taxi lines must clearly provide adequate clearance for safe operations. That is, if large helicopters may not operate safely in these areas, it should be clearly indicated as such. One method may be to post the largest rotor diameter accommodated on the taxi line. If taxi lines are meant as a guide to fixed-wing aircraft only and are not meant for helicopters, then it should be noted as such. Figure 11 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

Pilot Fatigue and Stress - The mishap occurred at the end of a very long and stressful day for the pilot. It occurred after the third leg of a three-stage trip which had included two refueling stops. The last leg of the trip also turned out to be the most stressful. The ceiling was low and embedded thunderstorms were in the area. The pilot was forced to "scud run" on the last part of the trip. On final approach the pilot noticed that he was feeling fatigued. It is important that pilots continually assess their situation. This assessment needs to include the pilot's mental and physical well-being to determine when certain operations should not be attempted or extra caution is warranted.

Weather - The fact that the pilot chose to "scud run" significantly contributed to his stress. In addition, it was reported that there were embedded thunderstorms in the area. A "lowering" ceiling creates a stressful situation for a pilot; however, the fact that there were also embedded thunderstorms in the area contributed greatly to the anxiety of the situation.

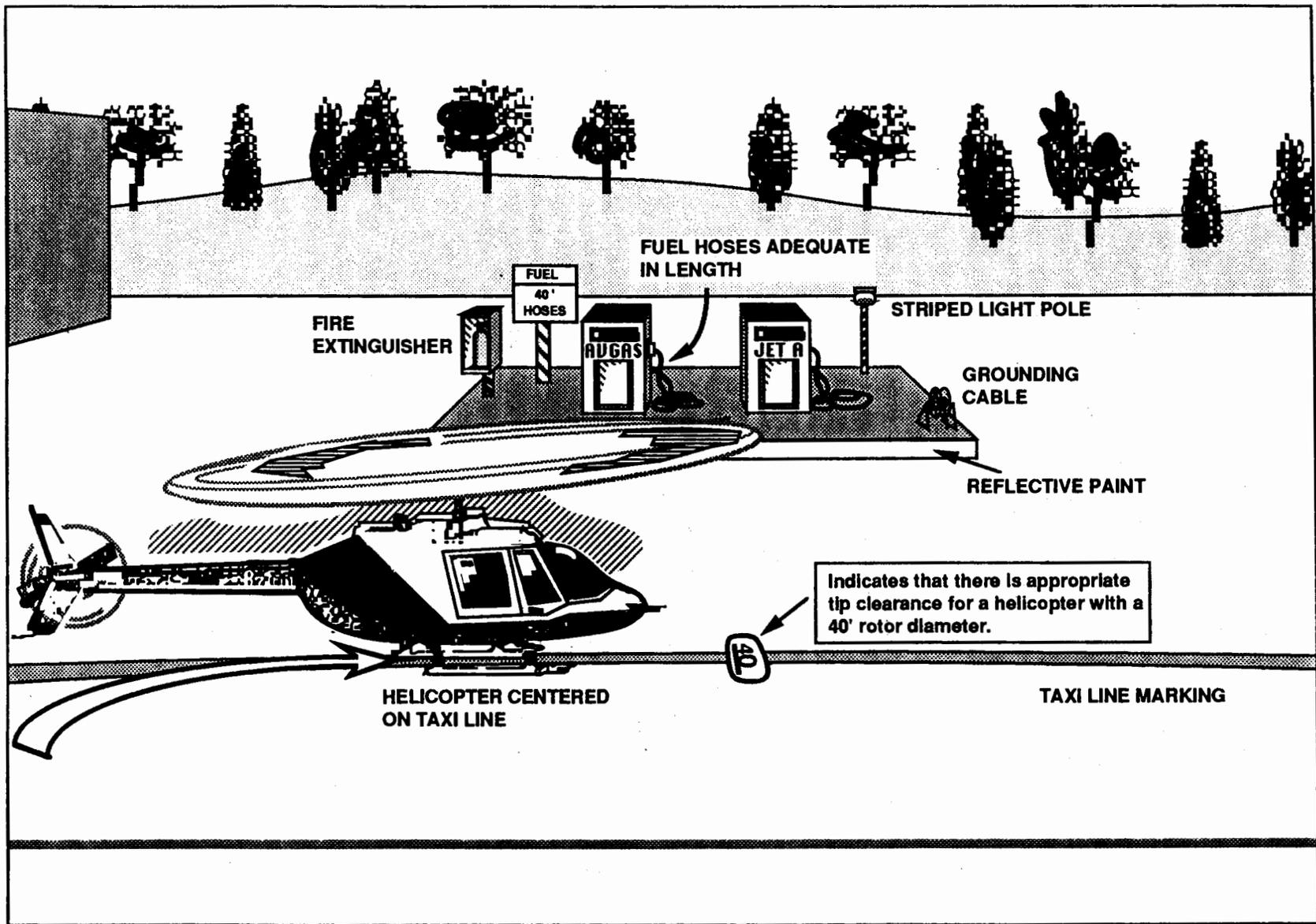


FIGURE 11 IMPROVED HELIPORT DESIGN - TAXI LINE MARKING

COMPOSITE #6

MISHAP TYPE: OBSTACLE STRIKE - TIE-DOWN ANCHOR

DESCRIPTION: The new private pilot decided to take a friend for a helicopter ride to see New York City at night from the air. The pilot and her passenger arrived at the airport, picked up the keys to the aircraft, and walked out to the small, piston helicopter located in the parking area. The helicopters were parked in an area that had been used to park fixed-wing aircraft. To accommodate helicopter operations, the tie-down chains had been removed. However, the U-shaped anchor bolts used for the tie-down chains were left in the concrete surface because of the cost and difficulty of removing them. The parking area was not well lit.

The pilot and her passenger boarded the helicopter for the 30-minute flight to the Hudson River. After engine start, the pilot decided to hover-taxi forward and to the left, because there were helicopters parked to the right as well as in front of her helicopter. As collective was applied and the helicopter became light on the skids, the pilot added left and forward cyclic and the aircraft began to move. Suddenly, the left skid struck one of the anchor bolts and the helicopter swung left and toward a parked helicopter. In the ensuing panic, the pilot pulled collective and mistakenly pushed the cyclic forward. The aircraft did not clear the parked helicopter and a collision occurred (see figure 12).

In post-mishap interviews, the pilot stated that because of the excitement of taking her friend for a helicopter ride, she forgot about the anchor bolts. She also stated that the bolts were not easily visible at night. The owner of the FBO stated that he didn't consider the anchors to be a real hazard, because they only "stuck up about 2 inches above the parking ramp."

DESIGN ISSUES:

Flat Operating Surfaces - Helicopters require flat operating surfaces. Mishap data shows that just about any object protruding above the operating surface has the potential for causing a mishap. Helicopters have caught landing gear on objects such as grounding eyes, bolts, drainage grates, perimeter lights, and helipad lips. Although an object may not appear to be a hazard, it is important to recognize that any object that protrudes above the operating surface represents a potential cause for a mishap. This design consideration is important even when the helicopters using the facility are equipped with wheeled landing gear. Figure 13 depicts the heliport with design improvements that enhance safety.

Lighting - The parking area was not well lit. Had the area contained better lighting, this mishap may not have occurred. Lighting was especially important in this mishap, since the parking area contained obstacles (anchor bolts) that were not easily seen at night.

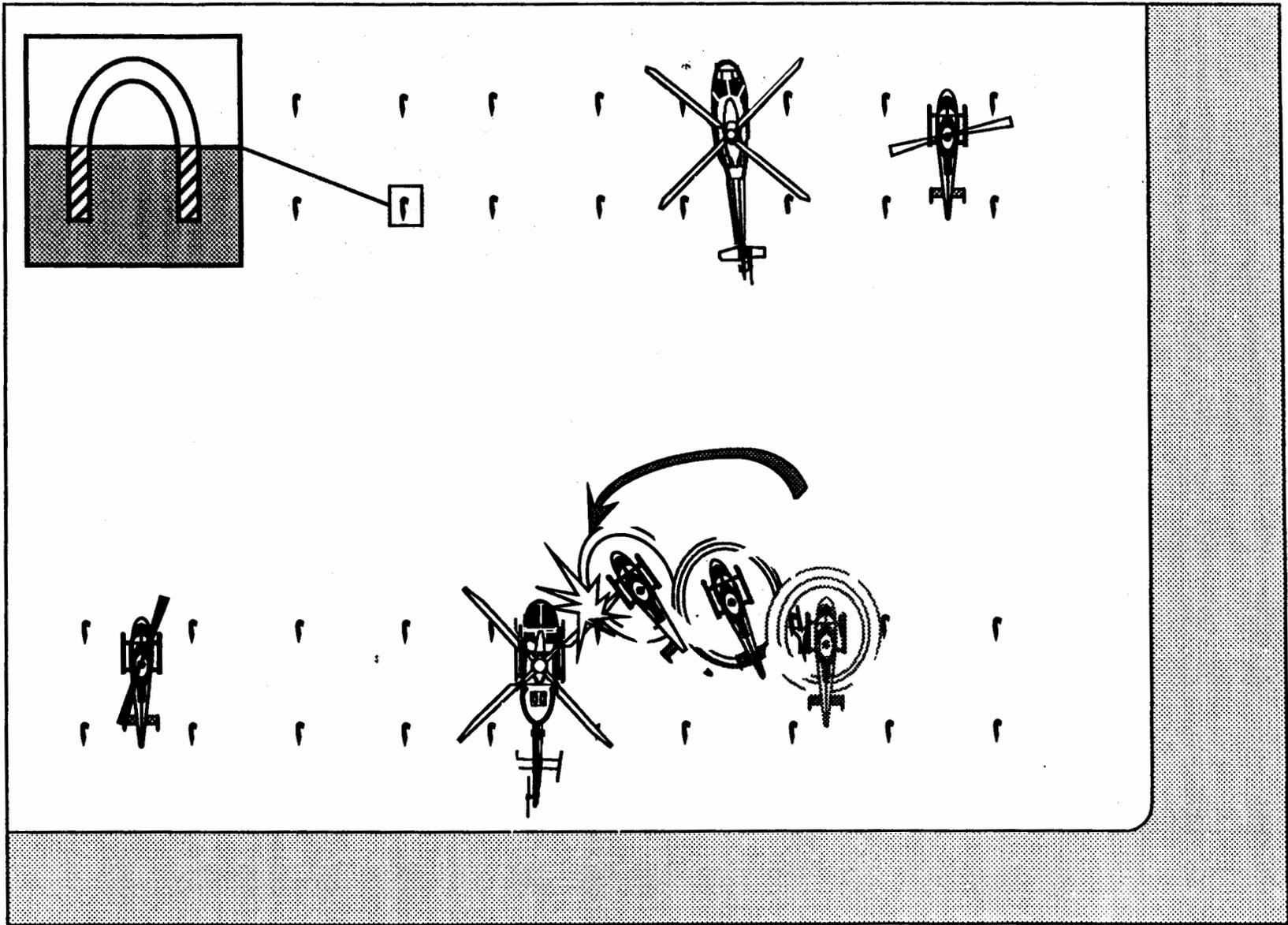


FIGURE 12 OBSTACLE STRIKE - TIE-DOWN ANCHOR

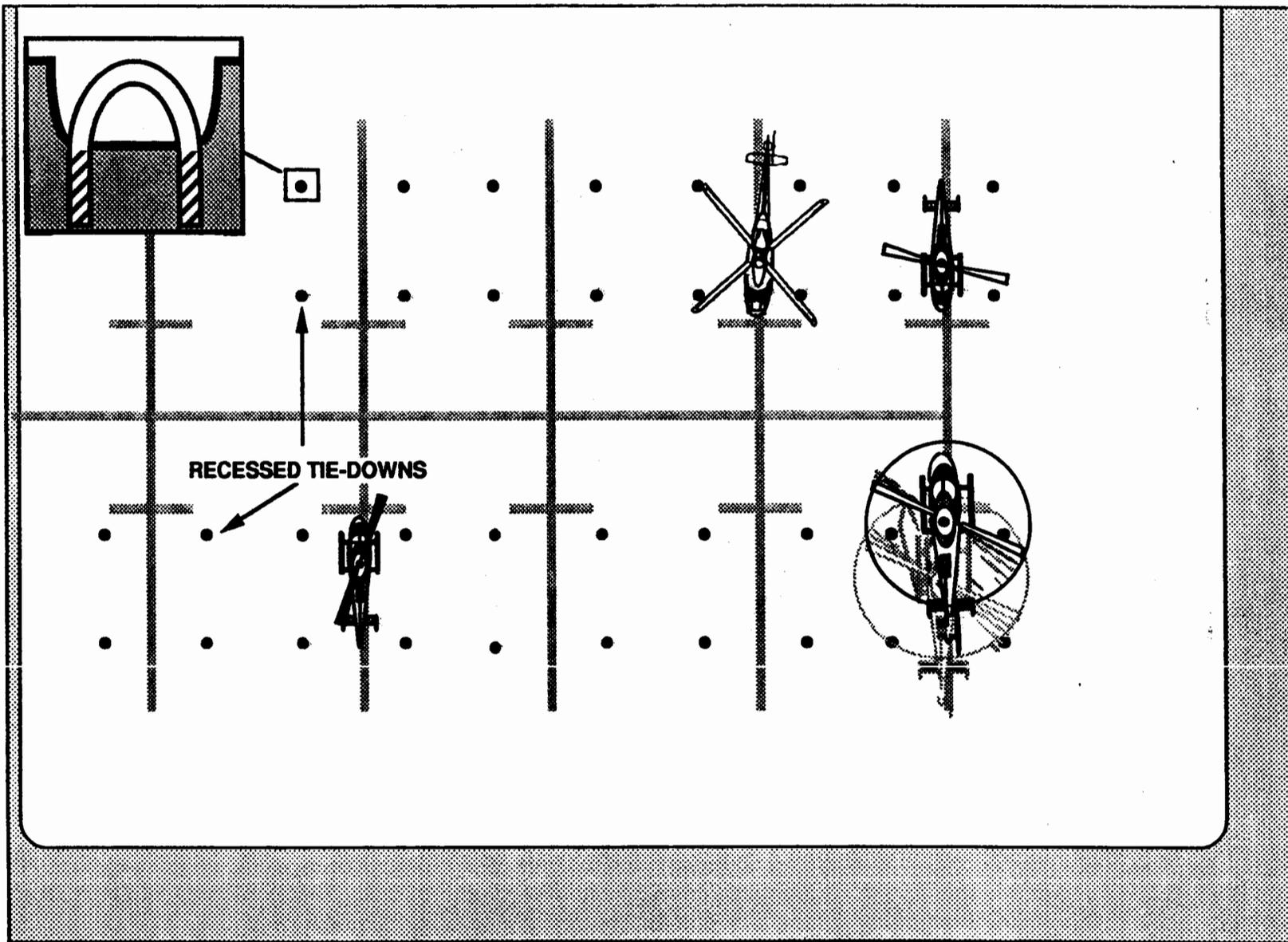


FIGURE 13 IMPROVED HELIPORT DESIGN - TIE-DOWN ANCHOR

CONTRIBUTING FACTORS:

Pilot Attention and Situational Awareness - In this particular mishap, the pilot was excited about the fact that she was taking her friend for a ride. Even though she had taken all of her training at the FBO, she forgot about the anchor bolts when she got caught up in the excitement of the moment. This mishap illustrates the fact that the pilot must constantly be aware and focused on the task of flying the aircraft. Maintaining constant control and vigilance is extremely important. Here too, pilot technique may be cited as a contributing factor. The pilot chose to begin the taxi too low to the ground. It is recommended that a 3 to 5 foot hover be attained prior to initiating any movement. Nevertheless, helicopter landing areas should be designed for skid and wheeled equipped aircraft. All surface obstacles and irregularities should be removed.

COMPOSITE #7

MISHAP TYPE: OBSTACLE STRIKE - WIRES

DESCRIPTION: The 5,500 hour emergency medical service (EMS) pilot was on standby when an emergency call was received requesting an automobile accident scene pick-up. The pilot, a doctor, and a nurse departed the hospital at 5:00 a.m. and headed toward the accident scene 60 miles to the south. The pilot had been on vacation for 2 weeks, and this was his first EMS flight since returning from vacation. Upon arrival at the accident location, the pilot made an uneventful landing to a section of road that had been blocked off by state police.

At the accident site, the doctor told the pilot that the patient desperately needed the immediate services of a trauma center. The patient was placed aboard the twin-turbine helicopter and the pilot departed for a trauma center located 60 miles to the east.

Approximately 20 miles from their destination, the pilot alerted the center that they were inbound with a critically injured patient and estimated their time to the center to be 10 minutes. As the helicopter approached the ground-based heliport, the pilot elected to save time and make a straight-in approach from the west rather than the normal approach from the east. At 6:25 a.m. the pilot slowed the aircraft for the final approach just as the sun was rising directly ahead above the eastern horizon. Even though sun glare resulted in a somewhat difficult approach, the pilot established a shallow final approach that would take the aircraft between the hospital and a new radiation clinic building that was under construction. At approximately 30 feet AGL and 300 feet from the helipad, the pilot noticed powerlines strung across the helicopter's flight path. He immediately pulled collective and aft cyclic but was too late. The aircraft struck the wires and fell to the asphalt (see figure 14). The powerlines had been installed three days prior to the mishap. The pilot stated after the mishap that the wires could not be seen against the background which included the asphalt parking lot and a stand of trees. In addition, the pilot stated that the early morning glare from the sun made it difficult to look straight ahead during the approach. Hospital officials had not notified local area EMS pilots of the powerlines, because the normal approach to the helipad was from the east.

DESIGN ISSUES:

Obstacle Marking - Although the wires were located below the 8:1 protected airspace surface, they remained hazardous to operations. They were difficult to see because they blended in with the background. The mishap analysis report (reference 1) provides guidance for marking wires near heliports which lie below the 8:1 protected surfaces.

Obstacle Location - The fact that the powerlines were located below the approach/departure protected airspace surface did not preclude them from being a hazard to operations. Mishap reports indicate that wires located near heliports have contributed to many helicopter mishaps. Installation

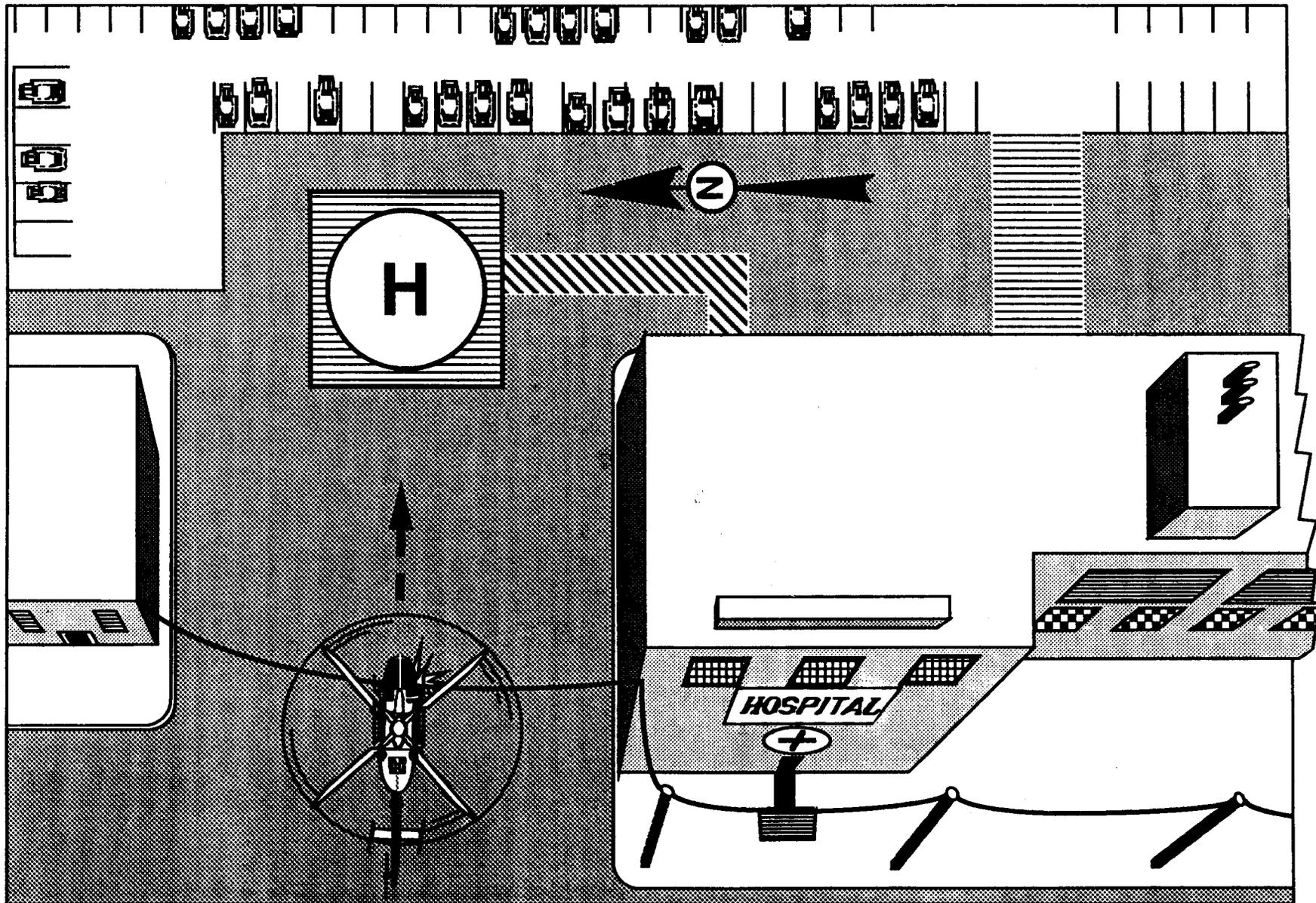


FIGURE 14 OBSTACLE STRIKE - WIRES

of wires near heliports should not be done without giving serious consideration to the alternatives. Figure 15 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

Situational Stress - The pilot allowed the severity of the patient's injuries and the patient's need for immediate attention to pressure him into making an approach that was not normally used at the heliport. Pilots need to realize that it is important to follow procedures, even during very stressful situations.

Notification of Obstacles - Even though the wires were installed very close to the heliport, the pilot had not been notified that the wires were there. Whenever obstacles, especially wires, are installed near a heliport, hospital officials should always notify those helicopter operators who use their facility. If there is a concern about obstacles affecting safe operations, qualified airspace specialists should be consulted.

DESIGN SAFETY ENHANCEMENTS:

Obstacle Marking - Obstacles, especially wires, deserve special consideration when located near a heliport. Even though an obstacle may not penetrate the recommended 8:1 protected airspace surface, it may be prudent to mark obstacles under certain circumstances. The report entitled "Analysis of Helicopter Mishaps at Heliports, Airports, and Unimproved Locations" (reference 1) provides suggested guidelines for marking obstacles underlying approach/departure paths. Essentially, the recommendation is to mark obstacles under certain circumstances which lie under the 8:1 surface and above a 25:1 surface. This recommendation is made to help establish a visual margin of safety for operations near the heliport.

Obstacle Location - Depending upon the location and intended use of a heliport, allowing for additional obstacle clearance below the 8:1 protected airspace surface may be warranted. In the report entitled "Helicopter Physical and Performance Data" (reference 4), takeoff profiles suggest that the 8:1 slope may be inadequate for some helicopter operations under certain conditions. In particular, the 8:1 slope may not provide sufficient clearance for operations under "hot/high" conditions. Therefore, the heliport designer should consider the expected ambient operating conditions, as well as the types of helicopters that will operate at the heliport and their performance capabilities.

Consideration should also be given to obvious approach and departure paths, particularly from the perspective of a pilot who has not landed there before. Although this pilot knew approaches were normally made from the east, the graphic shows that an approach from the west may "appear" to be better.

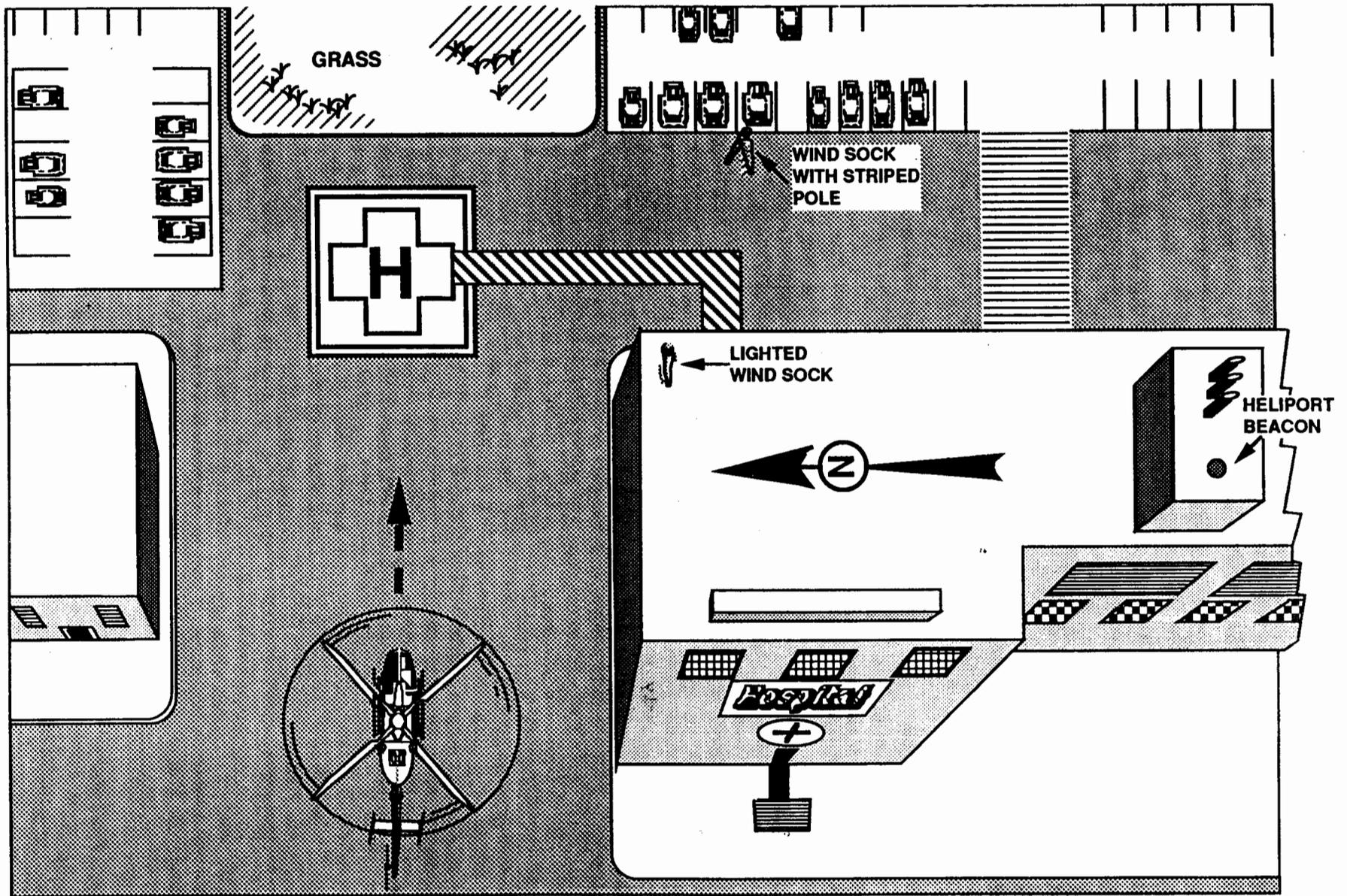


FIGURE 15 IMPROVED HELIPORT DESIGN - REMOVAL OF OBSTACLES

OPERATIONAL SAFETY ENHANCEMENTS:

Wire Strike Protection System - It is strongly recommended that all helicopter operators who conduct missions in unimproved areas, equip their aircraft with wire strike protection systems (WSPS). Also, WSPS should be considered for helicopters that are used for low-level missions such as powerline patrol.

COMPOSITE #8

MISHAP TYPE: MULTIPLE AIRCRAFT - MAIN ROTOR BLADE CONTACT (ON-GROUND)

DESCRIPTION: The multi-engine, turbine helicopter departed the local airport at 3:00 p.m. in visual meteorological conditions to pick up six passengers at the downtown heliport. Upon arrival at the heliport, the pilot was informed by the UNICOM operator that either spot 3 or 4 was available to await the pickup scheduled for 3:30 p.m. The pilot wheel-taxed to spot 3 and set the brakes. He then brought the engines back to ground idle and went through the after-landing checklist.

At about 3:35 p.m., the line crew started to load the passengers into the back of the helicopter. The pilot turned to ask the passengers their destination (he was yet to be informed) and noticed another twin-turbine helicopter preparing to land. The UNICOM operator informed the second helicopter that spot 4 was available. The pilot of the second helicopter informed the crew of the first helicopter of his intention to park next to them. He hover-taxed over to spot 4. While hovering, the pilot saw the crew of the parked helicopter cringe and duck out of sight and the linemen crouch down on the ground. At about the same time, there were several loud noises and pieces of rotor blades from both aircraft flew in all directions. Both pilots immediately shut down and secured the engines (see figure 16).

After the blade contact, the first helicopter was observed to be about 5 feet left of the parking space centerline and the second helicopter was about 1 foot to the right of its designated parking centerline. Both helicopters incurred substantial damage. There were no injuries to the crewmembers, passengers, or line personnel. There was no fire and no other damage as a result of the mishap.

According to post-mishap statements, the parking spots were built with minimum clearance of 10 feet between parking positions. Although the UNICOM operator stated that he was familiar with the maximum size helicopter specified in the parking plan (and also displayed on a sheet of paper at the UNICOM position), he inadvertently directed the large helicopters to spots that were too close to allow a reasonable safety margin.

DESIGN ISSUES:

Parking Area Clearances - The helicopter parking area should allow adequate clearance for adjacent parking of the largest design helicopters. The current Heliport Design Advisory Circular 150/5390-2 (reference 3) recommends "at least 1/3 rotor diameter but not less than 10 feet (3 meters) clearance from a takeoff and landing area or a fixed or movable object." This indicates the need for a clearance between the edges of parking spaces of 1/3 rotor diameter of the largest helicopter expected to use the heliport. As illustrated by this mishap, parking safety can be compromised even with specified parking space/aircraft assignments.

However, recent FAA analysis has raised questions whether the 1/3 rotor diameter tip clearance is adequate. The helicopter requiring the largest

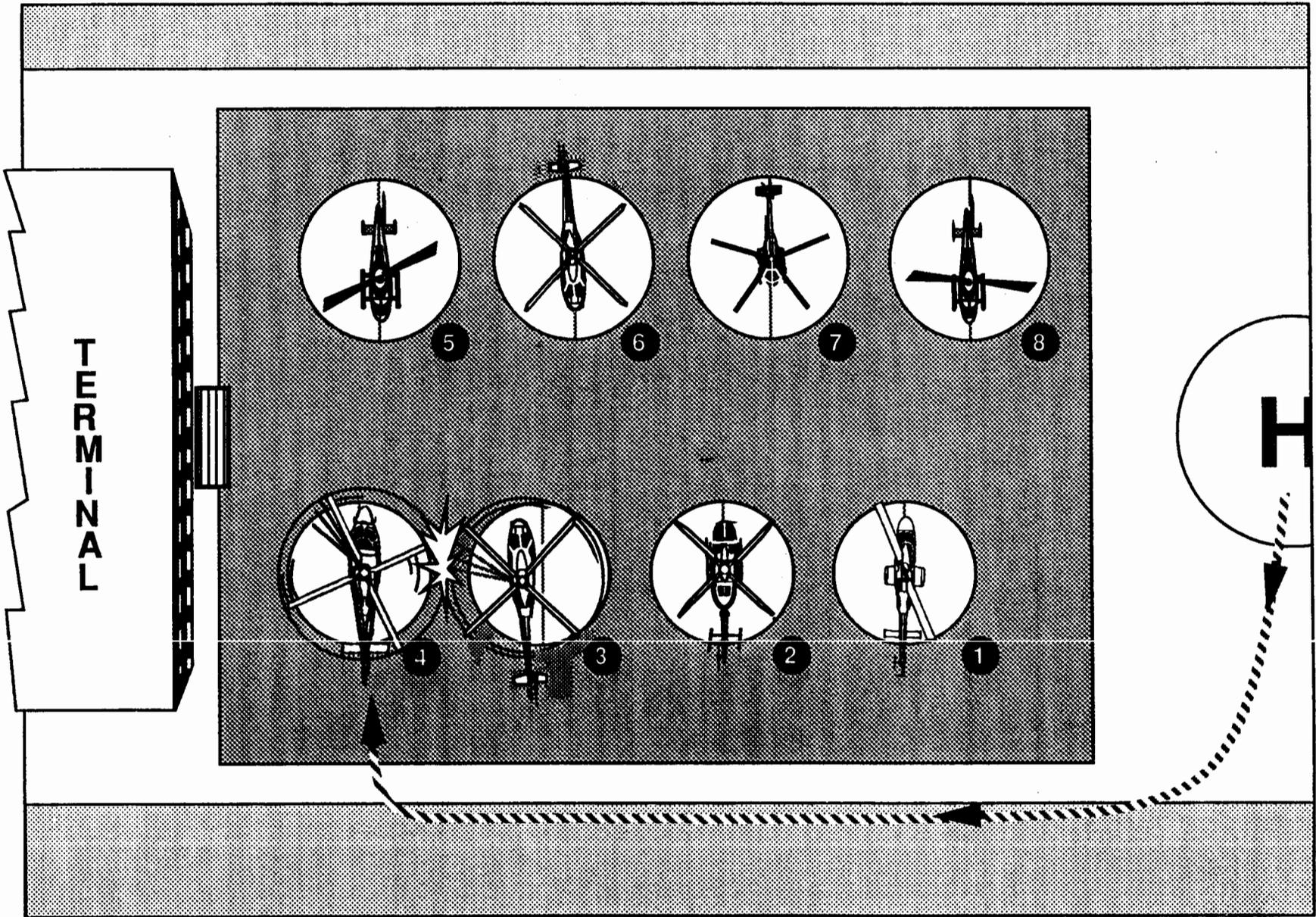


FIGURE 16 MULTIPLE AIRCRAFT - MAIN ROTOR BLADE CONTACT (ON-GROUND)

parking area may be the small, light, skid-equipped helicopter rather than a large, heavy helicopter that will usually taxi on wheels. While larger parking areas may be more expensive to build, they are generally less expensive than one accident. Larger parking areas are particularly important at public heliports where the heliport operator has little or no control over the types of helicopters, minimum pilot skill levels, etc.

Marking - The fact that both helicopters parked off the parking space centerline contributed to the cause of the accident. To facilitate placement of the aircraft at the center of the parking space, centerlines and cross lines need to be clearly marked and visible to the pilot of a taxiing helicopter. Figure 17 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

Procedures - Where space is limited, parking procedures and other operational procedures have been used to provide a low cost means of achieving a desired level of aircraft spacing. These procedures rely on pilots and operational personnel knowing and following such procedures. It should be recognized that these procedures may compromise safety. It should also be recognized that in these situations, the pilots are being asked to compensate for design and/or operational inadequacies. In helicopter mishaps, human error is a contributing factor in approximately two-thirds of the mishaps (reference 7). Therefore, relying on human knowledge, situational awareness, and pilot vigilance may be an inadequate method for compensating for inadequacies. Training and monitoring may not be sufficient to ensure that the desired level of safety can be maintained.

Complacency/Vigilance - The fact that the UNICOM operator had the approved parking space diagram and appropriate designation at his disposal, and that he admitted familiarity with the maximum sizes and helicopter types specified but did not use them may indicate either a lack of professionalism, a certain degree of complacency, or that he may have been distracted at the time of the mishap. The mishap investigation did not indicate distraction as a possibility. Therefore, it is assumed that the "inadvertent" assignment of two large, multi-engine helicopters to the wrong parking spots was due to complacency or an inadequate appreciation of the situation. This may have been caused by a lack of training or vigilance regarding the specified parking procedures.

Communications - Even when radio communications are used, UNICOM operators are not certificated as air traffic controllers, and their information is considered advisory in nature. However, the rather casual suggestion of "spot 3 or 4" and the lack of more specific phraseology by both the helicopter crews and the UNICOM operator may have contributed to the use of non-standard parking procedures. Fixed based operators (FBO's) should consider providing basic parking information to the pilot such as the parking space designator and what diameter rotor system can be accommodated in that spot. This information should be adjacent to the parking space and painted so that it can be clearly seen under all light conditions.

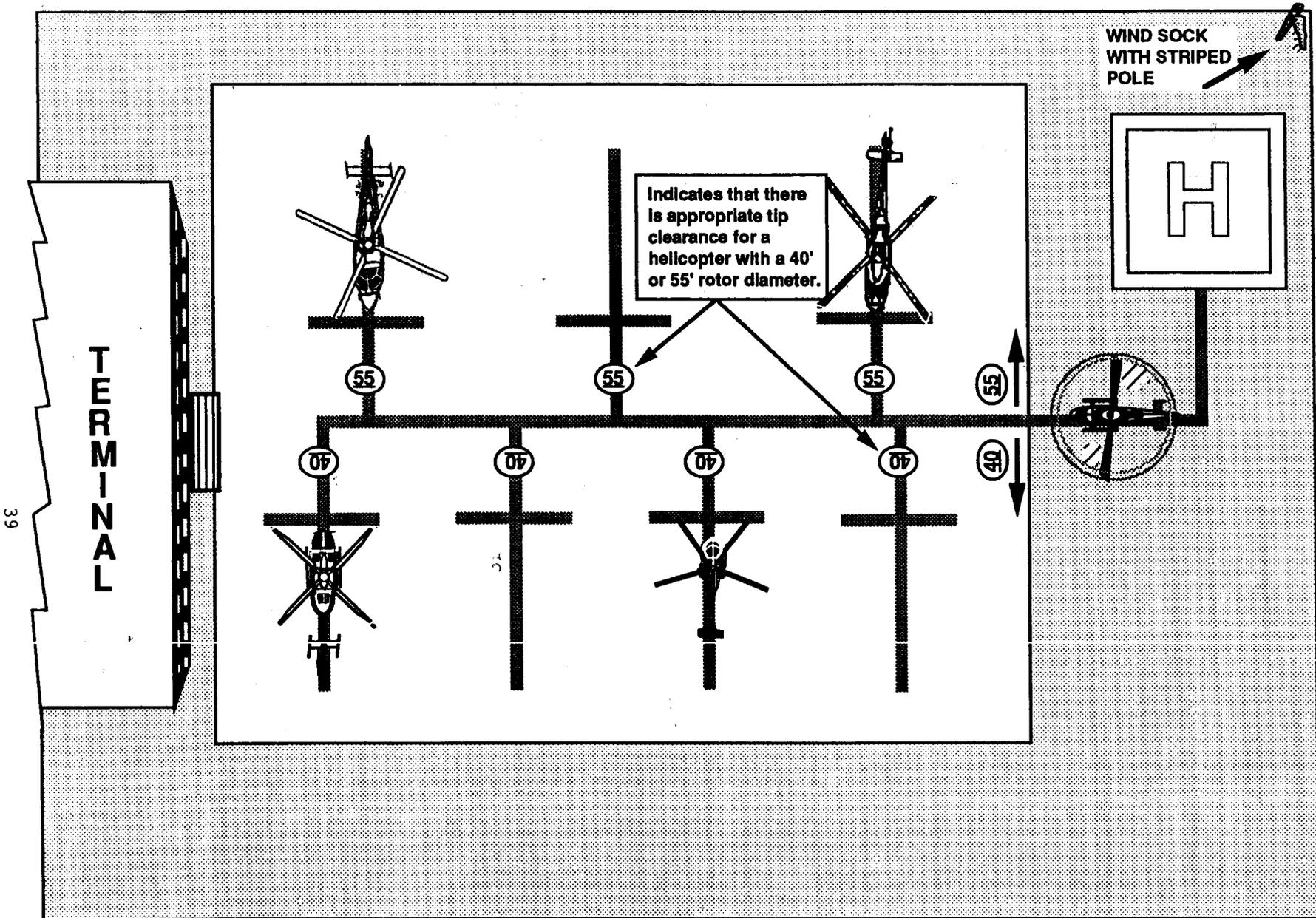


FIGURE 17 IMPROVED HELIPORT DESIGN - ADEQUATE PARKING AREA SIZE

COMPOSITE #9

MISHAP TYPE: OBSTACLE STRIKE - BUILDING

DESCRIPTION: A light, skid-equipped, single-engine, piston helicopter was being operated on a proficiency flight. The 50-year old pilot-in-command possessed an air transport pilot (ATP) certificate with ratings in both single-engine and multi-engine airplanes and helicopters. In addition, he possessed a flight instructor's certificate for single and multi-engine airplane and helicopter. He had accumulated a total of 22,000 hours with over 12,000 in helicopters.

At 5:30 p.m., the local weather was reported as visual meteorological conditions with 10 miles visibility and scattered clouds at 3,000 feet. The wind was from 270 degrees at 15 knots with no gusts reported. The helicopter crashed on takeoff from its base heliport when the rotor blades struck a hangar building.

Upon liftoff from the FATO, the pilot reported that his attention was diverted by the proximity of parked automobiles and the activity in the parking area. A sudden gust of wind blew the helicopter into the hangar (see figure 18). Flying debris struck a ground support crewman standing nearby. He was taken to a local hospital in critical condition with head and leg injuries. The pilot exited the helicopter uninjured, although the helicopter was substantially damaged.

The pilot stated that the helicopter was in its normal takeoff spot with about 5 feet of clearance between the hangar and the rotor blades when lift-off was attempted. According to post mishap statements, the helicopter and all systems were capable of normal operation at the time of the mishap.

DESIGN ISSUES:

Takeoff and Landing Area - Unobstructed takeoff and landing areas are recommended for both private and public use heliport facilities. This area should provide at least 1/3 rotor diameter tip clearance, but not less than 20 feet horizontally from buildings, fences, fueling facilities, windsocks, earth berms, or any other objects that could present a hazard to flight. This is particularly important with light helicopters that are more likely to be affected by gusting winds. Additional clearance can be used to increase the safety margin of such operations. The current advisory circular (reference 3) recommends that the size of the takeoff and landing area be at least twice the rotor diameter (of the design helicopter) in both length and width.

Parking Area Design Clearance - The heliport/helicopter parking area should be designed so that parked helicopters will not interfere with the clear area used for takeoffs and landings. The parking areas should be clearly marked to accommodate the number of helicopters deemed safe.

Wind Effects on Operations near Buildings or Other Obstacles - Windflow, gusts, and the potential for sudden changes in aircraft handling in sudden

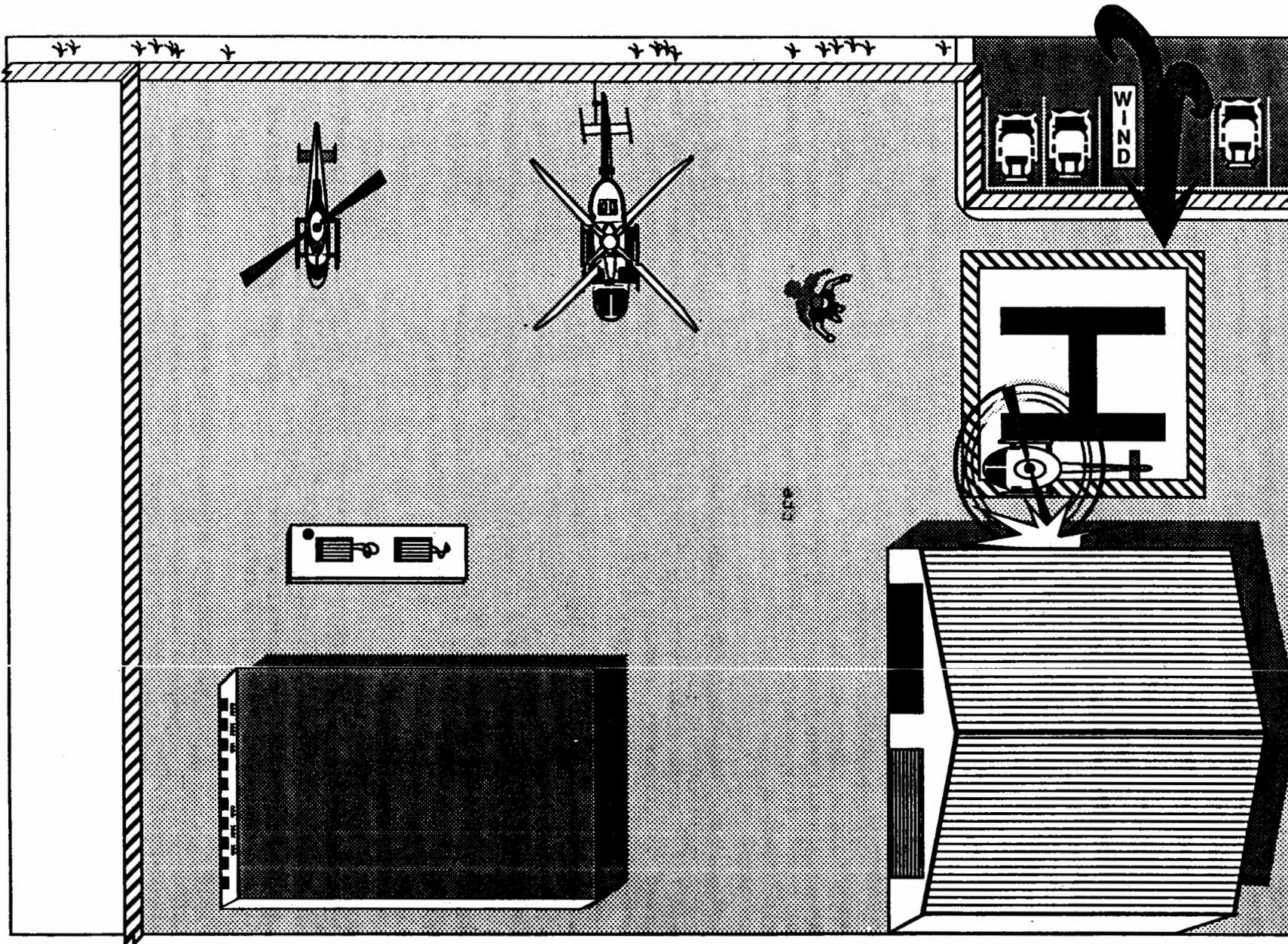


FIGURE 18 OBSTACLE STRIKE - BUILDING

wind changes need to be anticipated, both in heliport design and in operational situations. Several mishaps in the NTSB files that were analyzed illustrated the hazards of operating in proximity to large obstacles and the effects the wind can have during such operations.

Heliport designers need to consider the wind and its potential effect on all phases of operations in and around heliports. Operating close to buildings may also have the effect of disrupting the outflow pattern from rotorwash. This can produce a burble over the rotor blades which will increase pilot workload in the hover, thereby making operations near buildings more difficult. Reference 6 addresses this topic in detail. Figure 19 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

FATO Size - The operation occurred in an area that was well below recommended design standards. As previously mentioned, the edge of the FATO should be located at least 1/3 rotor diameter, but not less than 20 feet, from structures. Recent FAA analysis has raised questions whether the 1/3 rotor diameter tip clearance is adequate for small helicopters. The helicopter requiring the largest tip clearance may be the small, light helicopter that is more easily affected by wind gusts than larger, heavier helicopters.

Pilot Situational Awareness and Attention - Situational awareness is required during all phases of flight. This mishap aptly illustrates the need for enhanced awareness, even anticipation that something will go wrong during operations at landing sites. A decision to depart from a position more removed from the hangar might have averted this mishap.

Proximity of Parked Automobiles - Although it is often difficult, if not impossible, to remove an automobile parking area from close proximity to a heliport, due consideration should be given to both the distractions to the pilots and the safety of the automobile operators and passengers. Even though it may be desirable to locate parking immediately adjacent to a heliport, locating it away from the approach/departure path is highly desirable wherever geometry and real estate permit.

OPERATIONAL SAFETY ENHANCEMENTS:

Improved Takeoff Procedures - The heliport operator should clearly mark the FATO, particularly where the takeoff and landing area is restricted by buildings or real estate limits. The operator should also consider posting operating procedures and briefing first-time users on ground operations that are necessary to promote safety.

Specified "Clear the Pad" Rules - Normal safe operating procedures would dictate that no personnel are allowed in the vicinity of departing and arriving helicopters. At the very least, a hard-and-fast rule specifying that no personnel be allowed on the pad during liftoff and touchdown seems

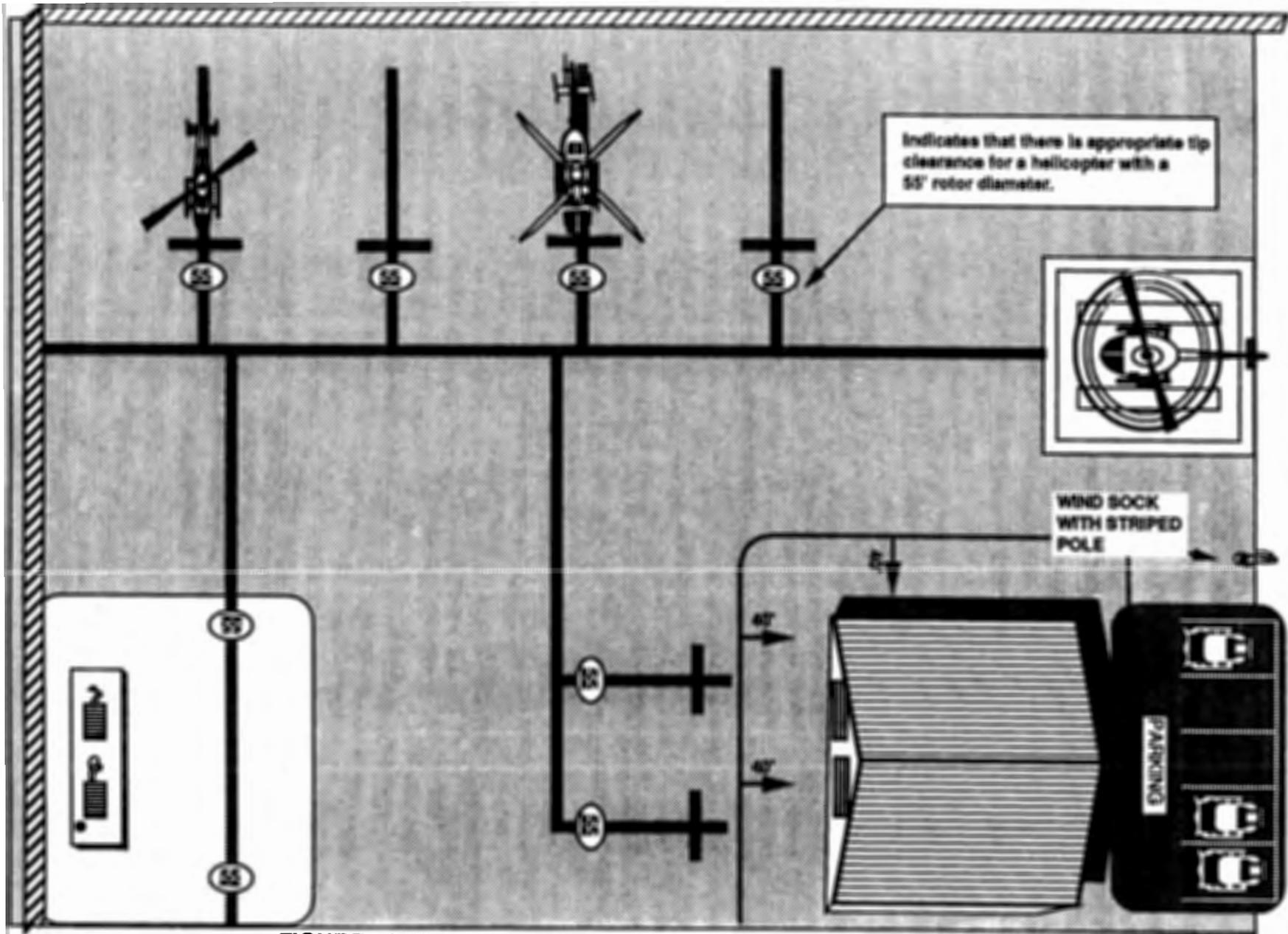


FIGURE 19 IMPROVED HELIPORT DESIGN - LOCATION OF THE FATO

prudent. The heliport operator should consider this risk management as an aspect of his overall safety program.

Taxiway and Parking - Although not a factor in the accident, the heliport has no taxiway and parking space markings. In particular, there are no clearance lines painted in the vicinity of the fuel pumps. These markings would improve the safe movement of helicopters on the heliport.

COMPOSITE #10

MISHAP TYPE: INSUFFICIENT POWER FOR TAKEOFF - DENSITY ALTITUDE

DESCRIPTION: The aircraft was on a flight to pick up a geophysical crew at a contractor's base heliport which was located in mountainous terrain. The heliport elevation was approximately 7,000 feet MSL. During the past month, the 40-year-old commercial pilot had landed at the site several times without incident to drop off passengers or supplies. He described the circumstances surrounding his arrival as normal and uneventful. The pilot loaded his passengers and cargo just before noon. The heliport was located in a saddle between two ridges. According to the pilot, existing weather at the site was excellent with scattered clouds at 5,000 feet and 30 miles visibility. The wind had been from 120 degrees at 0 to 8 knots since he had arrived at the heliport. The temperature was 60 degrees, and since the pilot had flown out of the heliport before, he did not feel the need to compute the density altitude. However, this was the first time the aircraft was loaded to near maximum gross weight.

In preparation for takeoff, the pilot completed a normal engine run-up, and raised the helicopter slowly to a 3-foot hover. After making a 120 degree hovering pedal turn to the right into the perceived wind, he again checked the gages and began a takeoff. About 100 feet in front of the helicopter was an oak tree that was approximately 10 feet higher than the saddle at the takeoff point.

As the takeoff began, the helicopter did not climb. The pilot added power up to the maximum takeoff manifold pressure and increased collective in an attempt to climb away from the oak tree. As the helicopter was about to clear the tree, rotor rpm began decreasing and the pilot observed the tach needles passing through the "bottom of the green." He could not return to the takeoff spot, because rotor rpm was insufficient to control a 180 degree turn and the area was too narrow for any margin of error. According to passengers and observers, the engine's response to the power demand was a gradual power fade until it quit altogether. Due to the steep slope surrounding the area, the pilot elected to land in the oak tree to prevent a downhill roll. He did not flare in order to prevent ballooning over the tree. There was no perceptible bounce and the tree held the helicopter (see figure 20). The time from first branch strike to stop was about 1 second. The helicopter was demolished, but there were no serious injuries.

Assuming the pilot-observed outside air temperature of 60 degrees and approximated heliport elevation of 7,000 feet were correct, the investigators calculated that the density altitude was actually 9,010 feet. The flight manual for the aircraft at the estimated aircraft weight and density altitude showed a hover in-ground effect ceiling (HIGE) of 13,000 feet and a hover out-of-ground effect ceiling (HOGE) of 7,500 feet.

DESIGN ISSUES:

Rejected Takeoff Groundspace - Rejected takeoff mishaps may occur at any altitude; however, the likelihood of this occurring is increased at high

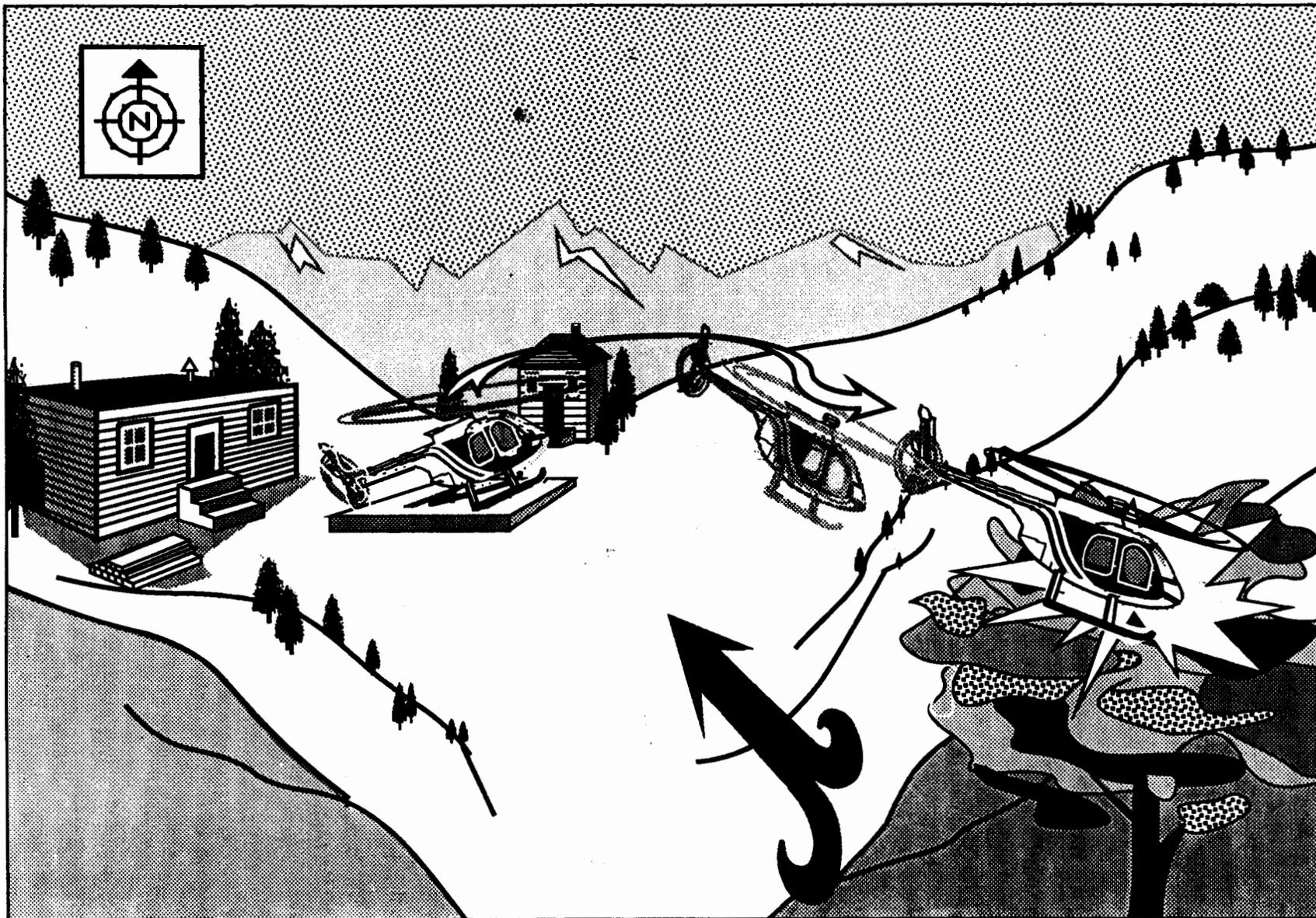


FIGURE 20 INSUFFICIENT POWER FOR TAKEOFF - DENSITY ALTITUDE

density altitudes. In fact, civil mishap reports contain examples of this type of mishap at altitudes from 2,400 to 9,000 feet. During heliport design and site selection, heliport designers and operators should consider the primary use helicopter expected, the missions for which it will be used (i.e., passengers, equipment, supplies, percent of maximum gross weight, etc.), and the helicopter's maximum performance capabilities. Additional clear space for rejected takeoffs is desirable whenever practical.

Obstructions and Hazards to Air Navigation - Heliport visual flight rules (VFR) approach/departure obstruction surfaces are defined in Title 14 of the Code of Federal Regulations (14 CFR), Part 77, Subpart C. They are commonly referred to as the 8:1 surfaces. However, these surfaces should be considered as minimum safety standards to be augmented by the requirements of specific heliport locations and operation types. At high altitude heliports, the 8:1 surface is more likely to require that helicopters operate at well under their maximum gross weight, particularly when the weather is hot. Rejected takeoff mishaps have resulted in helicopters settling into trees, ponds, street intersections, bushes, fences, light poles, fuel pumps, etc. If at all possible, objects under the preferred approach/departure path or near the heliport, including parked helicopters or construction equipment, should be removed, even if they do not penetrate obstruction-free surfaces. Determining and removing the controlling obstacle is recommended as a good design practice. In this instance, the tree was the controlling obstruction.

Heliport Location - Locating heliports in confined areas such as saddles, valleys, wooded areas, or surrounded by tall buildings or towers is not recommended if it can possibly be avoided. However, one of the major benefits of helicopters is their ability to operate in locations that are prohibitive to fixed-wing aircraft. Therefore, whenever such a site is chosen, designers and operators should provide as much clear space under the approach/departure path as practical. If the pilot would have had enough room to accelerate through translational lift, this mishap may have been prevented. Figure 21 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

Density Altitude - Density altitude-related mishaps may be one of the most preventable types of mishaps. The pilot community must be convinced of the basic need to calculate density altitude and to check the helicopter's capabilities and limitations before each flight whenever operating conditions warrant such action.

Pilot Technique - The pilot's takeoff procedures in this situation contributed to the mishap. The operating area was rather tight and the density altitude was questionable. In this situation, the pilot should have been near maximum takeoff power at takeoff, rather than waiting to apply full power.

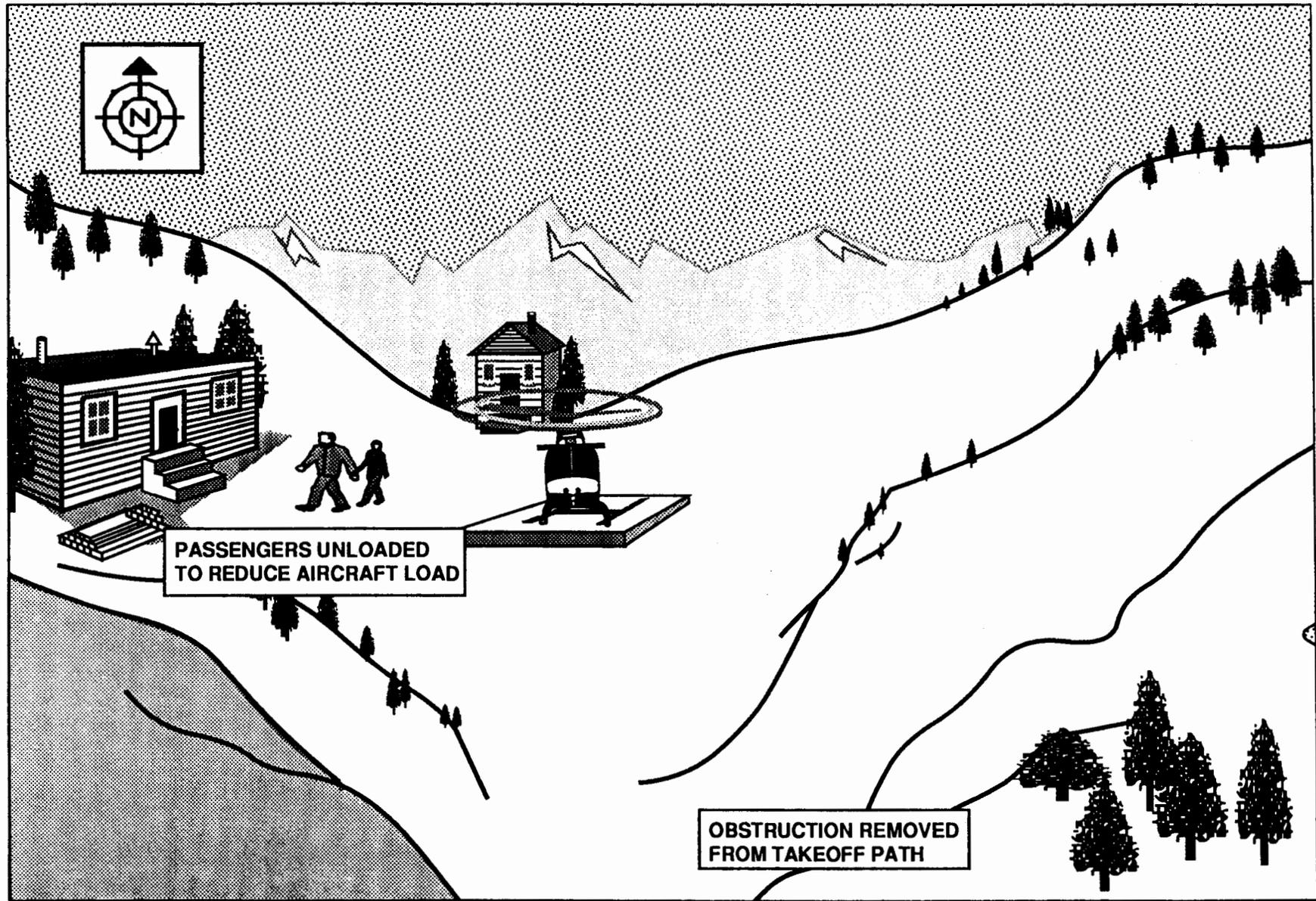


FIGURE 21 IMPROVED HELIPORT DESIGN - INCREASED GROUNDSPACE AND AIRSPACE AT HIGH-ALTITUDE HELIPORTS

COMPOSITE #11

MISHAP TYPE: ENGINE FAILURE ON TAKEOFF

DESCRIPTION: At approximately 3:00 p.m., the pilot dropped off passengers who were departing on a business trip from the local airport. He departed the airport with four passengers and took them to the corporate headquarters about 12 miles away. On final approach, the helicopter cleared an 8-foot security fence which surrounded the corporate heliport. In order to keep the passengers away from the tail rotor, the pilot lanced with the nose of the aircraft facing east toward the exit gate so that the passengers had to leave from the front of the aircraft. Upon landing, the pilot rolled the throttle to flight idle until the passengers cleared the gate.

In preparation for takeoff for his final pick-up of the day, the pilot rolled the throttle up to operating rpm, checked the instrument panel, picked the aircraft up to a hover, did a pre-takeoff power check, performed a 180 degree clearing turn at hover, and initiated his takeoff. Just as the helicopter started across the west compound fence, a loud "bang" was heard followed by substantial power loss and reduction in engine noise. The pilot immediately went into autorotation. The fuselage cleared the fence; however, the tailboom struck the fence and failed. The aircraft hit the ground and rolled on its side (see figure 22). Fire ensued after impact but was controlled by maintenance personnel using hand-held fire extinguishers.

The helicopter incurred substantial damage, and the pilot received minor injuries. A review of the available logbooks revealed that the aircraft was properly registered and certificated in accordance with Federal Aviation Regulations. However, a Commercial Engine Bulletin (CEB) had not been complied with every 300 hours as required. This bulletin required the visual inspection of the compressor mounts for fatigue and vibration-induced cracks. Engine teardown revealed that the compressor mount assembly had failed due to fatigue.

DESIGN ISSUES:

FATO Area Obstacles - Both private and public use landing sites should have an unobstructed area available for takeoff and landing of helicopters when possible. When fences, safety railings, concrete barriers, benches, earth berms, or other objects are used, care should be taken to ensure that they do not pose a potential hazard to normal or emergency operations. Reference 3 provides guidance for desired size and minimum separation standards for helicopter landing and takeoff areas. Barriers should be as low as practical to minimize the hazard to flight operations and yet provide effective barriers to unauthorized personnel. Frangible barriers or hedges are preferable when practical.

Rejected Takeoff Groundspace - Mechanical failures do sometimes occur on takeoff. Even though this event is rare, having clear groundspace below the departure path will help to minimize the effects of such a mishap. Historic mishap data shows that safety measures, lighting, environmental (noise reduction) measures, etc. taken to protect the operator and the

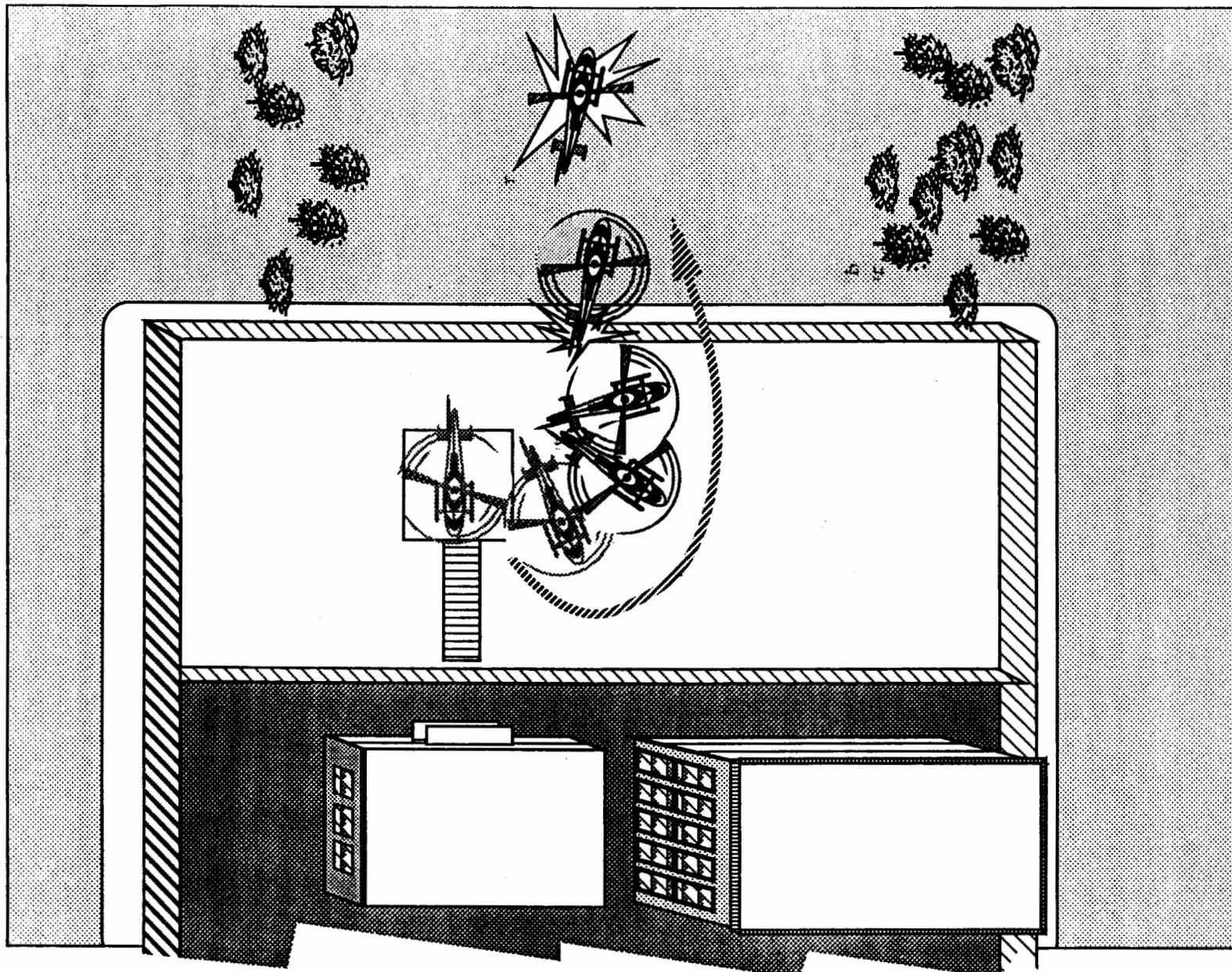


FIGURE 22 ENGINE FAILURE ON TAKEOFF

public may become obstacles during an engine failure or a mishap during approach or departure. The desirable size and the practicality of providing rejected takeoff groundspace are controversial issues. Data from related studies including the helicopter performance (reference 4) and the helicopter rejected takeoff studies (reference 5) may be consulted for guidance. Figure 23 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

Mechanical Failure - Catastrophic engine failures, fuel control malfunctions, bearing failures, and compressor mount fractures have contributed to engine failure/malfunction during takeoff. Since these events are generally survivable, it is important to consider the possibility of their occurrence during heliport design.

Approach/Departure Path - At first glance, the takeoff flight path chosen by the pilot and depicted in figure 22 seems unreasonable. Even though a departure path perpendicular to that flown would have given the pilot more room, mishap data shows that pilots do not always choose the most appropriate approach/departure path. The obvious lesson here is that pilots should give themselves as much leeway as possible in all situations. A good rule of thumb to remember is that "short cuts generally short cut safety."

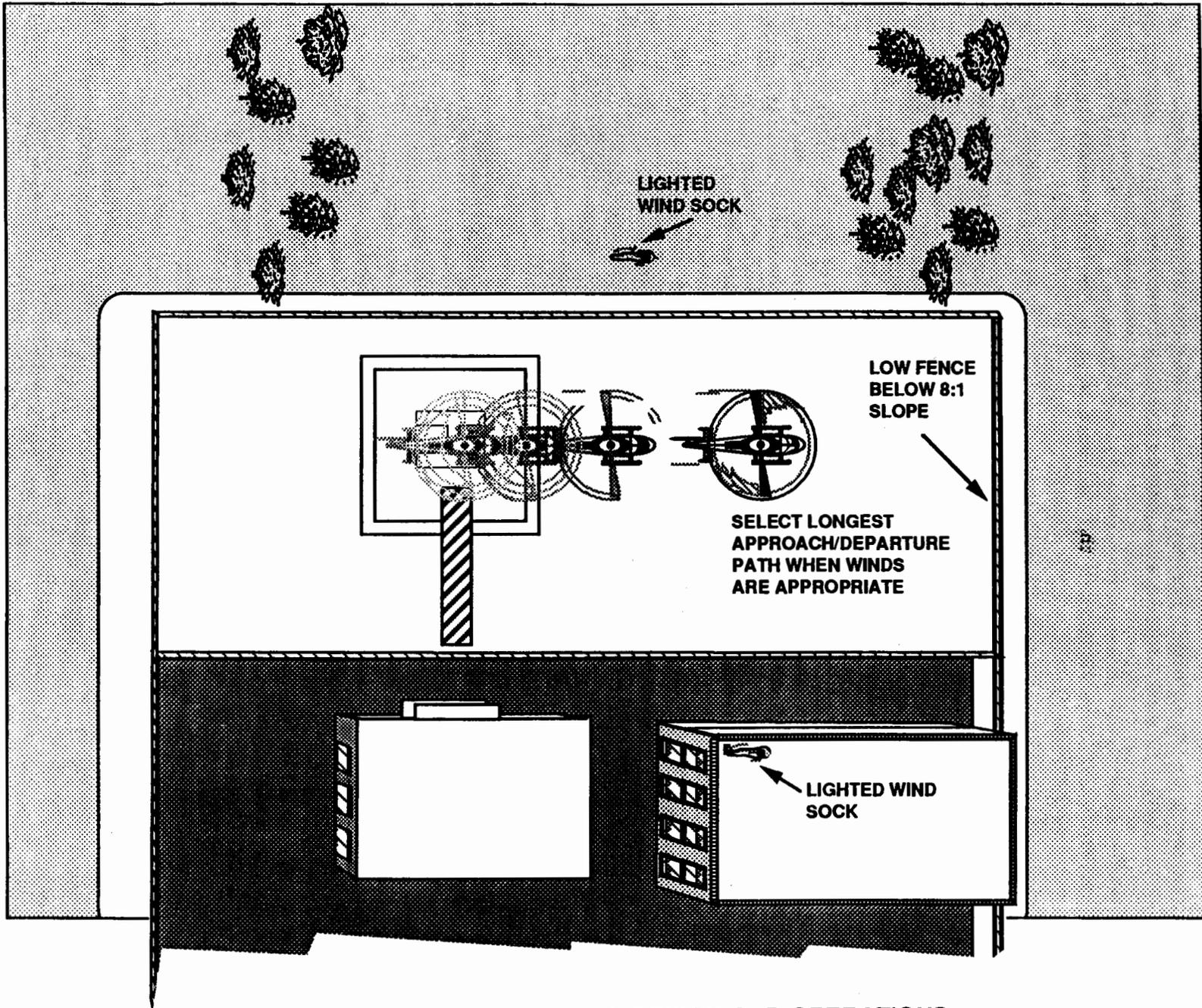


FIGURE 23 IMPROVED HELIPORT DESIGN AND OPERATIONS

COMPOSITE #12

MISHAP TYPE: INSUFFICIENT POWER - DOWNWIND LANDING

DESCRIPTION: The experienced corporate pilot called a flight service station for a weather briefing before leaving his house for a sunrise executive transport mission. Since he received a recording saying that the flight service specialists were busy, he decided to go to the airport and make the "fly or drive" decision based on his findings. When he arrived at the airport, the pilot found that visual meteorological conditions prevailed with 4 miles visibility in early morning haze. The wind was from 050 degrees at 7 to 10 knots with gusts light and variable. After the passengers were boarded, the helicopter departed in a normal manner and the pilot monitored local approach control frequencies for traffic advisories. When the helicopter was 15 miles from the destination, the pilot monitored the heliport automated weather station frequency to obtain the wind.

The pilot began the final approach leg 2 miles from his destination helipad, on a heading of 190 degrees at 700 feet AGL and 70 knots. The voice broadcast from the automated weather station indicated light winds from a southerly direction. While descending through approximately 75 feet AGL, the aircraft experienced a high sink rate with increasing vertical velocity from 500 feet per minute to 2,500 feet per minute. The pilot reported increasing power from 38 percent to 70 percent with no apparent impact on the rate of descent. He attempted to flare at about 10 feet but the aircraft impacted the ground, became airborne again, traveled about 15 feet, impacted the ground again, and slid about 7 feet (see figure 24).

The weather station was located on the leeward side of a 10-story building adjacent to the heliport. Observations made on the pad within 1 hour of the mishap revealed a variable wind from the northeast at approximately 25 to 30 knots. Mishap investigators determined that the wind sensors were not accurately reflecting the actual wind on the helipad at the time of the mishap.

DESIGN ISSUES:

Wind Indicator Placement - This mishap may have been prevented by adhering to the recommendations of the Heliport Design Advisory Circular (reference 3) regarding wind indicator placement. The advisory circular states that the wind indicator should be located "adjacent to the takeoff and landing area, but not interfere with helicopter operations or be shielded by buildings or other objects that prevent it from showing a true indication of the wind's relative direction and magnitude." Several accidents and incidents analyzed were characterized by helicopters not being able to achieve translational lift, and, in general, not being able to attain/maintain sufficient rotor rpm to continue the intended maneuver. These mishaps frequently resulted in collisions with buildings, porches, light stanchions, fences, etc. in the vicinity of the heliport or airport helicopter facility. A document entitled "Evaluating Wind Flow Around Buildings on Heliport Placement," DOT/FAA/PM-84/25 (reference 6)

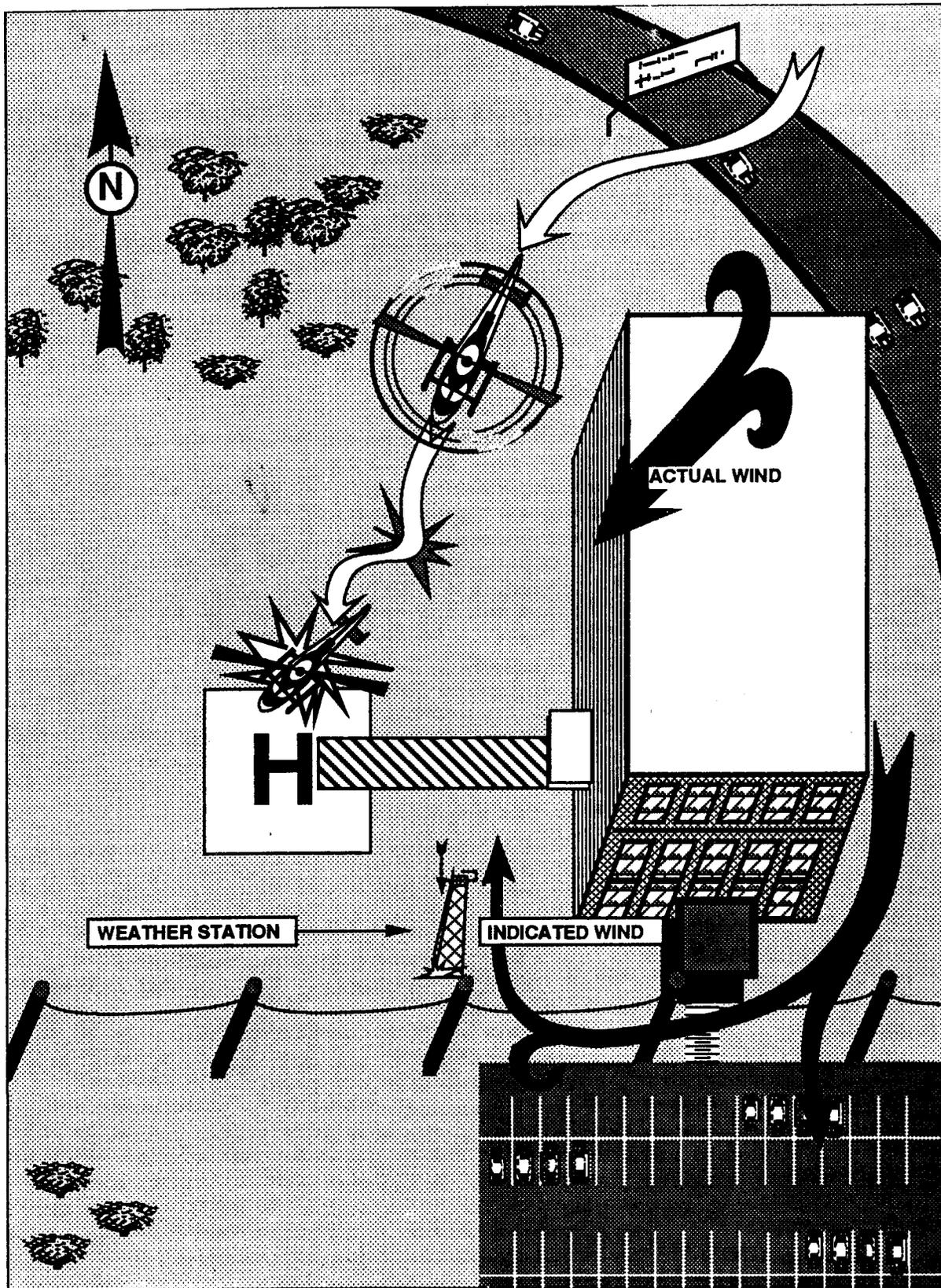


FIGURE 24 INSUFFICIENT POWER - DOWNWIND LANDING

addresses the subject of wind flow around buildings and provides guidance on location of heliports and wind indicators with respect to obstacles. Whenever heliports must be located near large obstacles, a minimum of two wind indicators should be used; one adjacent to the FATO, the other on top of the tallest structure.

Approach Paths - The normally used, obstacle-free approach paths should be located and oriented so that maximum usage can be made of prevailing winds in the geographic area where the facility is located. If the helicopter landing site at an airport or heliport precedes the construction of hangars, terminal buildings, offices, maintenance hangars, etc., consideration of normal helicopter flight paths should be included in the building site selection, as well as the building's height relative to the obstacle-free surface requirements of 14 CFR, Part 77. In addition, common design practices and the historical mishap database dictate careful consideration of the effect of windflow around obstacles and their subsequent effect on helicopter operations.

Observable Wind - Whenever additional sources of wind information are available to pilots, they should be considered. In this circumstance, the mishap description does not mention flags, trees, smoke, or water nearby to aid the pilot in determining the wind. However, since the pilot approached the heliport in a tail wind situation, it can be concluded that the ground speed was greater than the air speed, in this instance, by up to 30 knots. It is important for the pilot to be aware of all environmental cues. In this case, the difference in ground speed versus airspeed was large.

Automated Weather Station - Automated weather stations offer voice broadcast of weather conditions that will be of great benefit to pilots. However, automated weather stations may not satisfy operational needs at all facilities for several reasons. The first consideration is that the visual cues that are available by using wind socks are not available with automated weather stations. Other concerns include the fact that not all automated stations have voice broadcasts, and even when they are offered, some aircraft may lack the capability to receive them. Since wind socks do provide visual cues of both wind speed and direction, heliport operators should use wind socks even when automated weather stations are in use at their facility. Figure 25 depicts the heliport with design improvements that enhance safety.

OPERATIONAL SAFETY ENHANCEMENTS:

Approach Procedures - When pilots find it necessary to use facilities not optimally located or without adequate wind indicators, they should take all possible sources of wind information into consideration, such as trees in the vicinity of the facility, ripples on nearby ponds or lakes, flags near office buildings, etc. If possible, a low reconnaissance orbit should be performed, especially when reported winds indicate a tentative situation or an undesirable one. The safe pilot is one who uses superior judgment to avoid situations which might require the use of skill beyond his/her or the aircraft's capabilities.

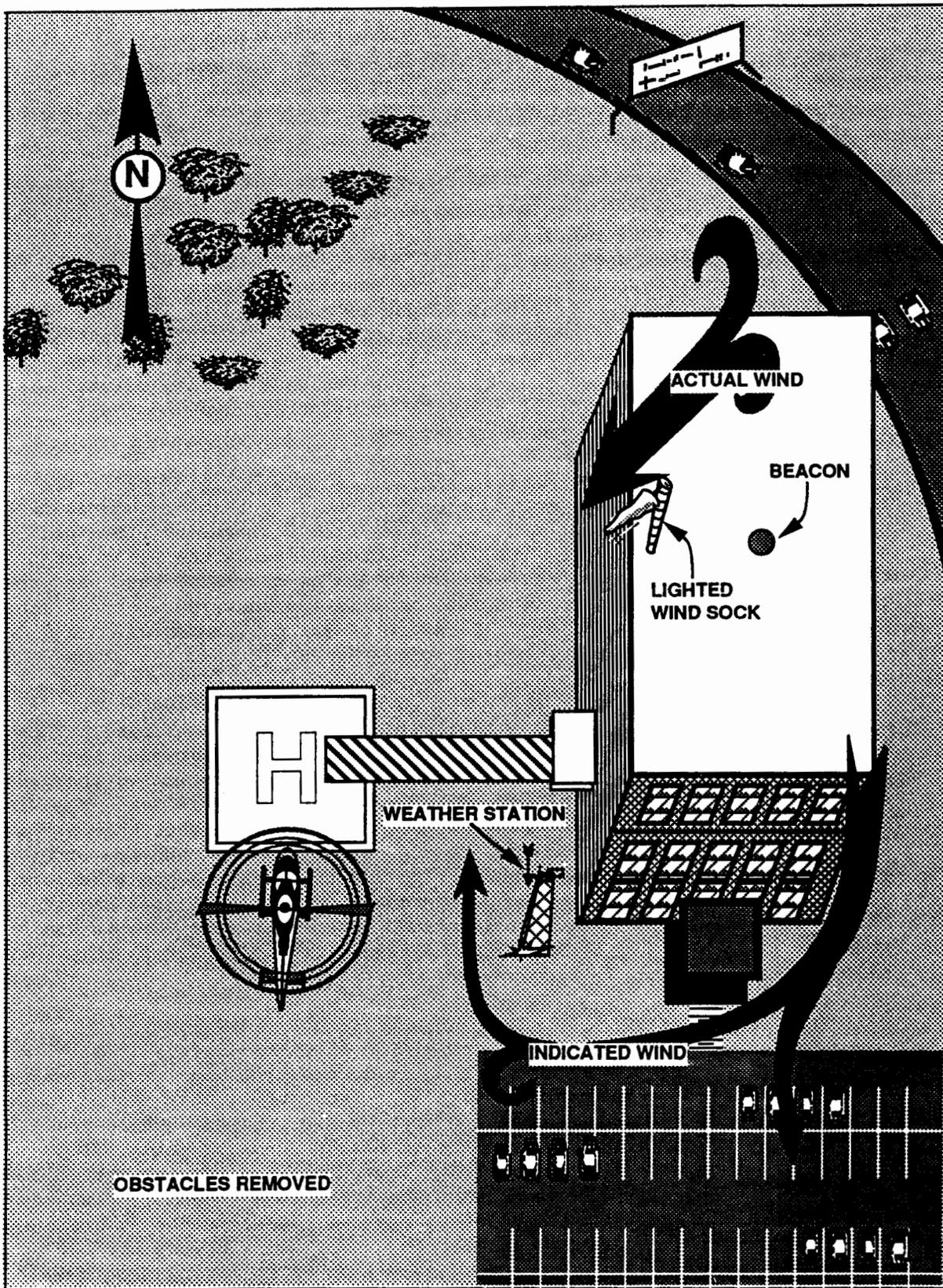


FIGURE 25 IMPROVED HELIPORT DESIGN - ADEQUATE WIND INDICATORS

COMPOSITE #13

MISHAP TYPE: OBSTACLE STRIKE - PARAPET

DESCRIPTION: The single-engine, corporate helicopter was making an approach to a rooftop heliport into the sun during VFR conditions. The wind at the time of the mishap was from 260 degrees at 20 to 25 knots. The pilot indicated that his approach was from the east with a quartering head wind during the final approach segment. The time of day, 6:45 p.m., placed the sun at an angle where the pilot was looking directly into it during the approach. The pilot decided to make a slow/flat approach to the heliport in an effort to use the 8-story building to shade the sun. During the final phase of the approach, the bottom of the vertical stabilizer struck a parapet which surrounded the landing area. After striking the parapet, the helicopter pitched up and away from the heliport (see figure 26).

The pilot was able to regain control of the helicopter about 10 to 20 feet below the level of the heliport and then flew the helicopter back up to the pad and landed. During the recovery, the pilot estimated that the main rotor blades were rotating within a few feet of the building.

DESIGN ISSUES:

FATO Obstacles - The final approach and takeoff area for a rooftop heliport is frequently surrounded by parapets, safety railings, or netting to prevent injury and/or damage to the public or property below. Additionally, rooftop equipment, e.g., environmental control units, vents, antennas, etc., may interfere with operations if allowed to extend into the protected airspace. It is necessary to minimize the impact of rooftop hazards when installing parapets, safety railings, netting, etc. Safety enhancements for the protection of the general public should not be installed in such a manner that they could be a hazard to helicopter operations. Installation should include careful consideration of the range of approach angles, sun angle, wind considerations, and approach paths for ingress and egress. Heliports should also be located away from protrusions on the rooftop surface so that they do not interfere with safe helicopter movement.

Visual Guidance - At heliports where the landing area is constrained, such as on rooftops, the pilot's attention can be diverted by peripheral cues such as environmental conditions, rooftop equipment, other obstacles, or moving vehicles. Visual guidance can be supplied in several ways:

- o groundside equipment such as visual approach slope indicators (VASI),
- o marking(s) on the heliport, and
- o marking(s) or lighting on adjacent buildings (obstacles).

In this mishap, the pilot did not have a VASI-type guidance system to assist him in executing an approach at the proper angle. Visual guidance

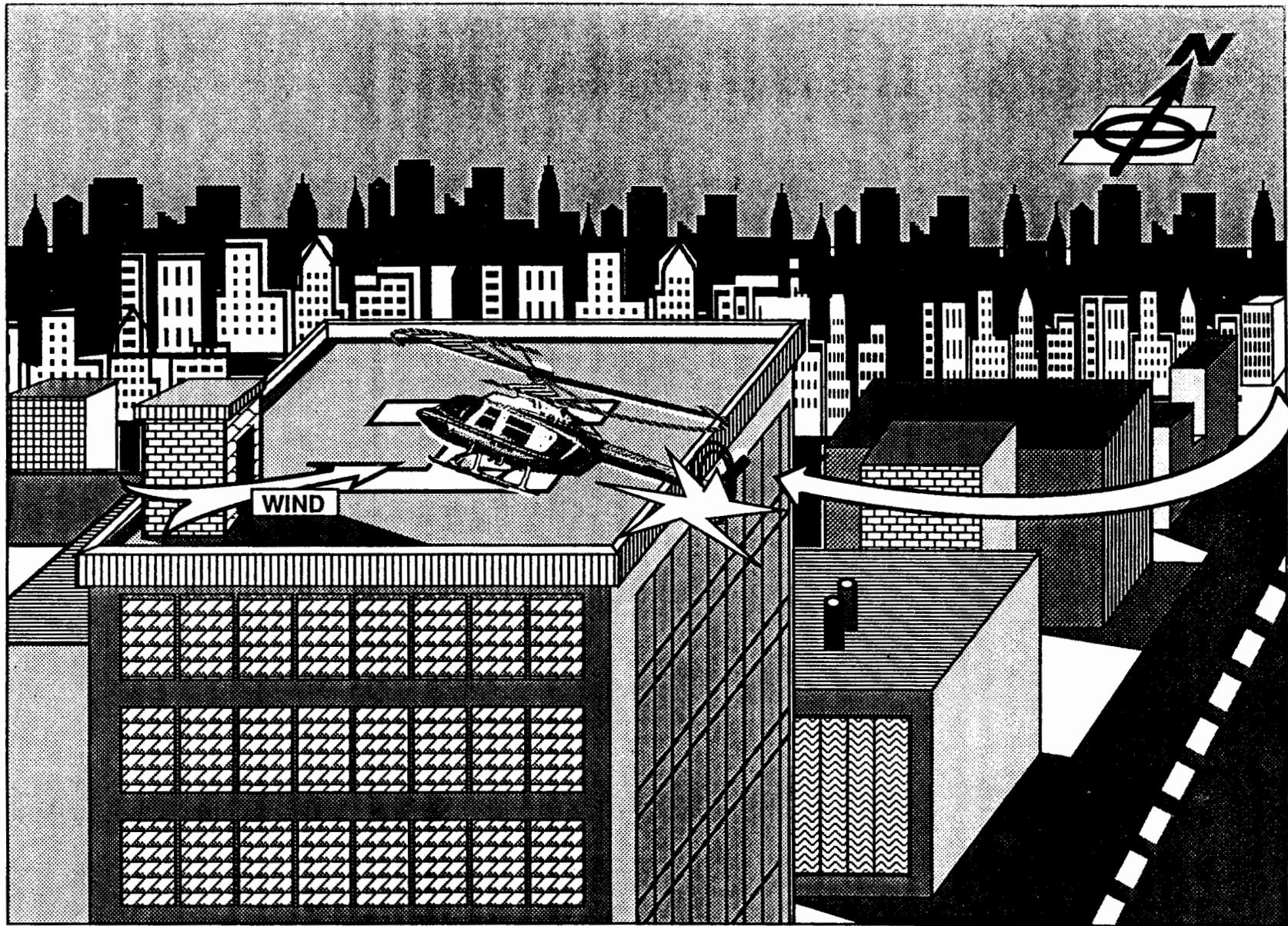


FIGURE 26 OBSTACLE STRIKE - PARAPET

equipment (which should be used by the pilot if installed and operational on-site) would assist the pilot in making safe approaches by bringing the helicopter in at angles above potential obstacles. In this case, a stationary VASI may not have been adequate.

Approach/Departure Path Selection - Approach and departure paths at heliports are established to consider a variety of conditions, such as prevailing wind, spatial orientation, proximity of buildings/obstacles around the landing area, noise, objects, and the population underlying the paths. Also, heliports may be marked or lighted to indicate the general direction for landing. In circumstances such as the one presented here, choosing an alternate approach path might be preferable. Figure 27 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

Sun Angle - The obvious contributing factor in this mishap was the fact that the setting sun was directly ahead of the pilot's approach path. Sun glare has been a contributing factor in a number of mishaps and will continue to be a factor in some approach/departure situations. Pilot vigilance is of utmost importance in these situations. Alternatives at these locations must be considered.

Windscreen Condition - Another consideration in this instance is the condition of the windscreen. Although it was not mentioned in the description, the condition of and visibility through the windscreen is extremely important. Degradations to the windscreen, such as nicks, bumps, dirt, and smoke on the inside of the windscreen, may seriously limit a pilot's ability to see, especially when looking into the sun.

Pilot Technique - The approach angle to the heliport that the pilot used was definitely too shallow. A steep approach angle is more desirable in these situations, since it will generally allow safe approaches while avoiding the chances of striking objects that may be hazardous during shallow approaches.

OPERATIONAL SAFETY ENHANCEMENTS:

Environmental Considerations - It is sometimes impossible to avoid conditions that may affect the method employed by a pilot to operate to or from a facility. Early morning and evening ground fog, mountainous terrain bordering the facility, man-made obstacles, unusual wind conditions, and sun angle can all affect safety. If possible, pilots should routinely be reminded of these circumstances where they exist, possibly via radio. If direct communications are not available, safety bulletins, posters, and other "awareness" efforts would be helpful.

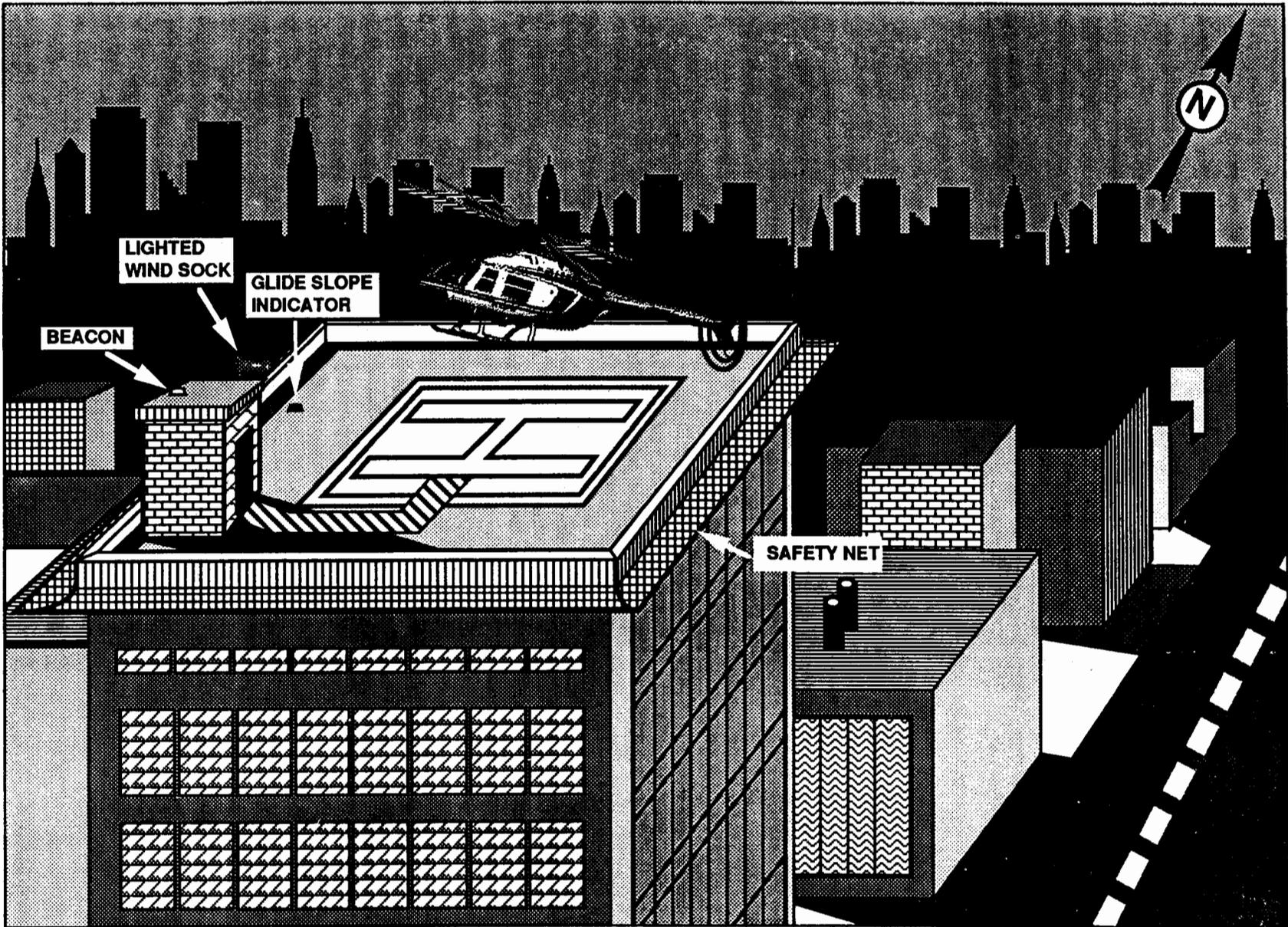


FIGURE 27 IMPROVED HELIPORT DESIGN - VISUAL GUIDANCE AIDS

COMPOSITE #14

MISHAP TYPE: REFUELING FIRE

DESCRIPTION: The pilot landed his light, piston helicopter at the small airport 10 minutes late for his 8:00 a.m. passenger pick up. He waited in the helicopter at the fuel pump until line service personnel arrived so that he could purchase fuel. Upon arrival of the line personnel, the pilot shut down the aircraft engine, but left an electric cooling fan running. The line personnel were unusually busy and the pilot volunteered to refuel his aircraft. As the pilot began to refuel the helicopter, he engaged the hold-open rack feature on the fuel nozzle. When the tank was full, the automatic fuel shut-off failed and fuel began to run out of the fuel tank and onto the ground. The pilot quickly removed the fuel nozzle from the tank and unlatched the hold-open rack. The fuel was ignited and a fire began to burn the aircraft and the tarmac ramp (see figure 28). Since there was no fire extinguisher available near the stationary fuel pump, the line personnel went to get one. Two fire extinguishers were dispensed onto the fire; however, the aircraft and ramp area continued to burn until the local fire department arrived to extinguish the fire. The helicopter was totally destroyed by the fire. There were no injuries to the pilot, line personnel, or any other individuals.

DESIGN ISSUES:

Firefighting Services and Equipment - Requirements for fuel area firefighting equipment have been established by the National Fire Protection Association (NFPA). Guidance on the type and amount of firefighting equipment required to support heliport operations should be obtained through NFPA documents. Advisory circular 00-34A (reference 10) also addresses aircraft fuel services and should be considered in heliport design.

CONTRIBUTING FACTORS:

Availability and Location of Fire Extinguishers - The absence of easy access fire extinguishers at the refueling pump location probably contributed to the severity of damage to the helicopter. A quicker response to the fire may have limited the amount of damage.

Fuel Nozzle - The pilot engaged the hold-open rack feature during refueling. Advisory Circular No. 00-34A (reference 10) addresses the subject of "Aircraft Ground Handling and Servicing." It states that fuel nozzle lever stop notches (hold-open racks) should be removed to avoid the possibility of an inadvertent blocking-open of the valve. The advisory circular further states "...never block the nozzle lever in the open position." Even if these nozzles have automatic fuel shut-off features there is no guarantee that it would preclude a fuel spill. The advisory circular states that: "Fuel-dispensing vehicles and stationary facilities should be equipped with appropriate fire extinguishers, fire blankets, static grounding cables, explosive proof flashlights, and ladders. Fire

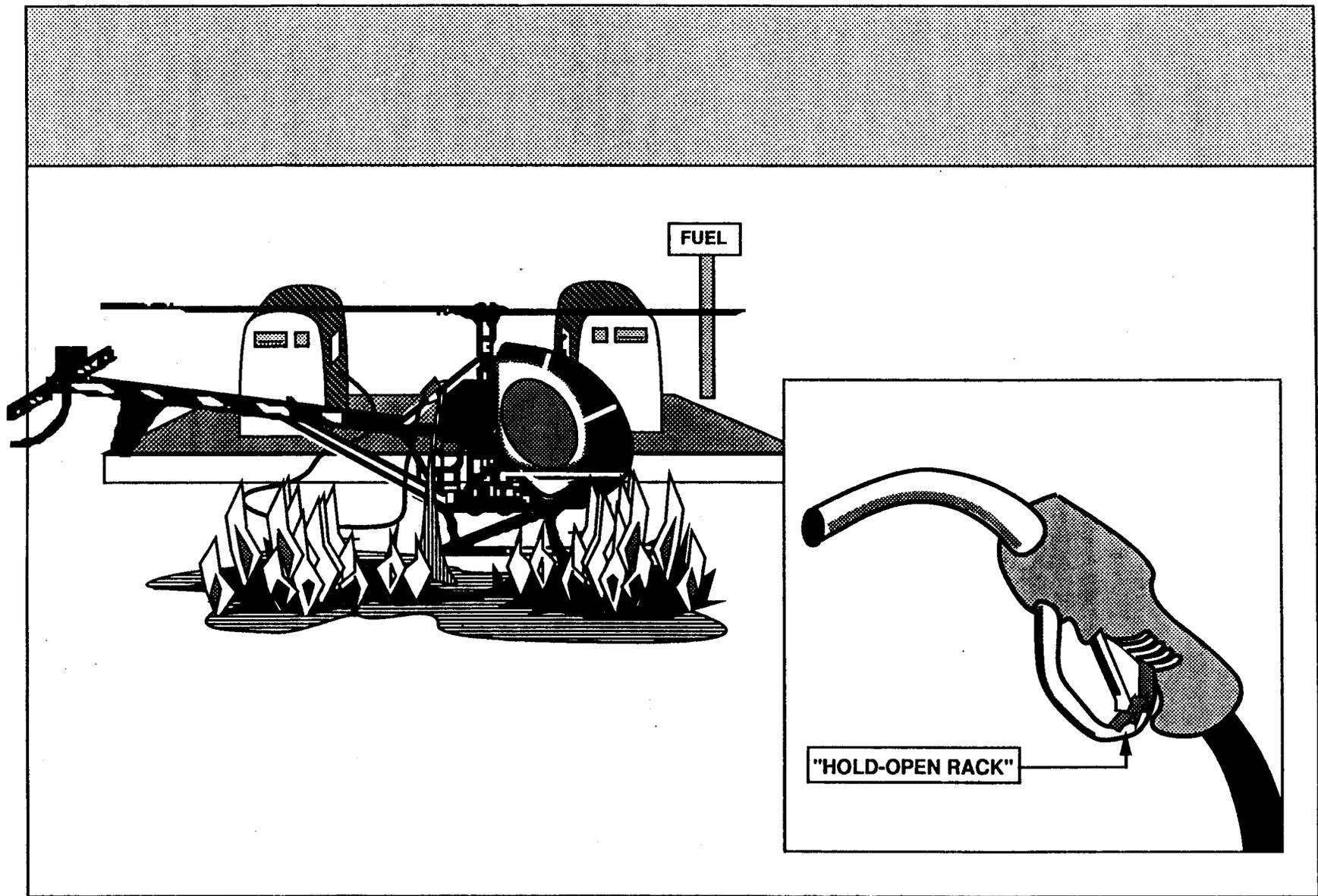


FIGURE 28 REFUELING FIRE

extinguishers should be located so they are accessible from either side of the vehicle (or stationary pump, etc.) and remote from the probable fire hazard."

OPERATIONAL SAFETY ENHANCEMENTS:

Facility/Operator Responsibility - Ensuring proper refueling procedures is the responsibility of the facility operator. Fuel nozzles should not contain features that would allow them to automatically dispense fuel. Also, it should be stressed to employees that the nozzle should never be rigged to automatically dispense fuel, such as using a piece of wood to hold open the release lever. See insert on figure 29 for safety enhanced fuel nozzle.

Pilot Procedures - Pilots should set all switches to the "off" position following engine shutdown. Also, whenever possible, pilots should watch over refueling procedures to contribute to safety in refueling operations.

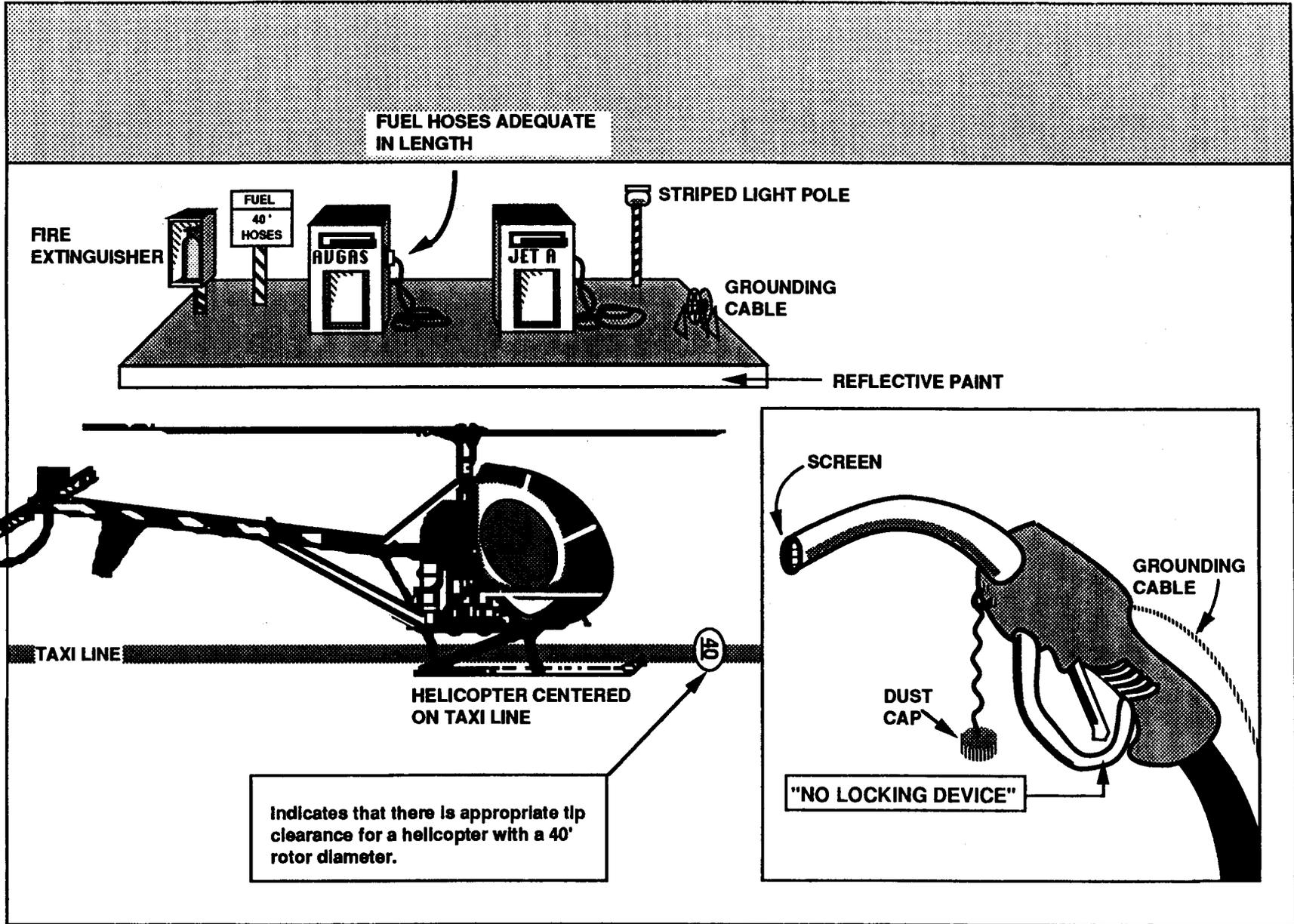


FIGURE 29 IMPROVED HELIPORT DESIGN - REFUELING FACILITY

COMPOSITE #15

MISHAP TYPE: OBSTACLE STRIKE - PERIMETER LIGHT

DESCRIPTION: The pilot met two of the company's vice presidents at the general aviation ramp. They then boarded the helicopter for the 45-minute flight back to their corporate headquarters. The visibility en route was unrestricted which provided a pleasant trip for the two passengers. As the helicopter approached the corporate headquarters, the passengers were quite impressed by the site of the brand new rooftop heliport. In just 5 years, the company had expanded sufficiently to afford the expense of installing a rooftop heliport and this was the first trip to the heliport for the pilot and his passengers. The approach to the helipad was normal and the landing was smooth.

After discharging the passengers, the aircraft was picked up to a hover and the pilot felt the aircraft shudder, followed by a severe vibration. The tailrotor separated from the aircraft and the aircraft rotated to the right (see figure 30). Throttles were reduced to stop the rotation and the aircraft settled back down to the helipad. The aircraft bounced from side to side, rolled off the helipad, and came to rest on its left side. The pilot exited and extinguished a small fire that had started near the engine exhaust.

After extinguishing the fire, the pilot discovered that the tailrotor had struck the glass cover of a heliport perimeter light. The helicopter was substantially damaged; however, the pilot was not injured. The pilot did not report any system malfunction prior to the impact and did not have any reason for landing near the side of the heliport rather than in the center.

DESIGN ISSUE:

Heliport Lighting Design - The Heliport Design Advisory Circular (reference 3) discusses the use of perimeter lighting. The advisory circular recommends using flush-mounted lights whenever practical. If elevated lights are needed, for instance in locations where heavy snow is anticipated, the advisory circular discusses safety considerations and recommends using low impact resistance lights.

Mishap reports contain a number of cases where perimeter lights have been hazardous to safe operations in landing, takeoff, and hover flight phases. Perimeter light strikes have occurred on rooftop heliports. The advisory circular does consider these limited real estate heliport configurations and allows for the placement of the lights on the periphery of the rooftop or safety netting support structure where available. Figure 31 depicts the heliport with design improvements that enhance safety.

CONTRIBUTING FACTORS:

Publicized Information - Several perimeter light strikes have involved operations to new heliports or first time operations to an unfamiliar location. Considering the need for lighting and the fact that these occurrences do happen, it is recommended that both pilots and heliport

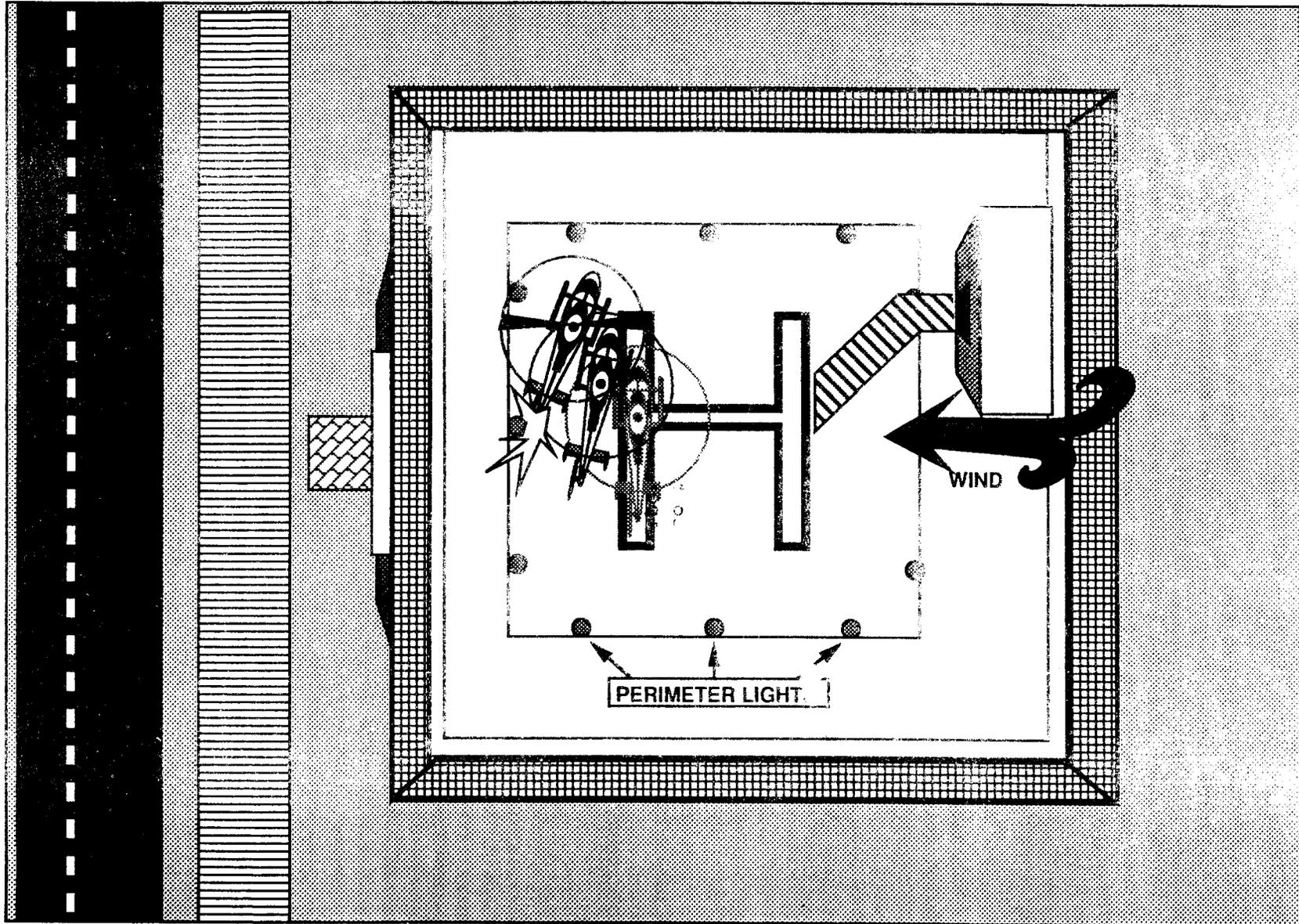


FIGURE 30 OBSTACLE STRIKE - PERIMETER LIGHT

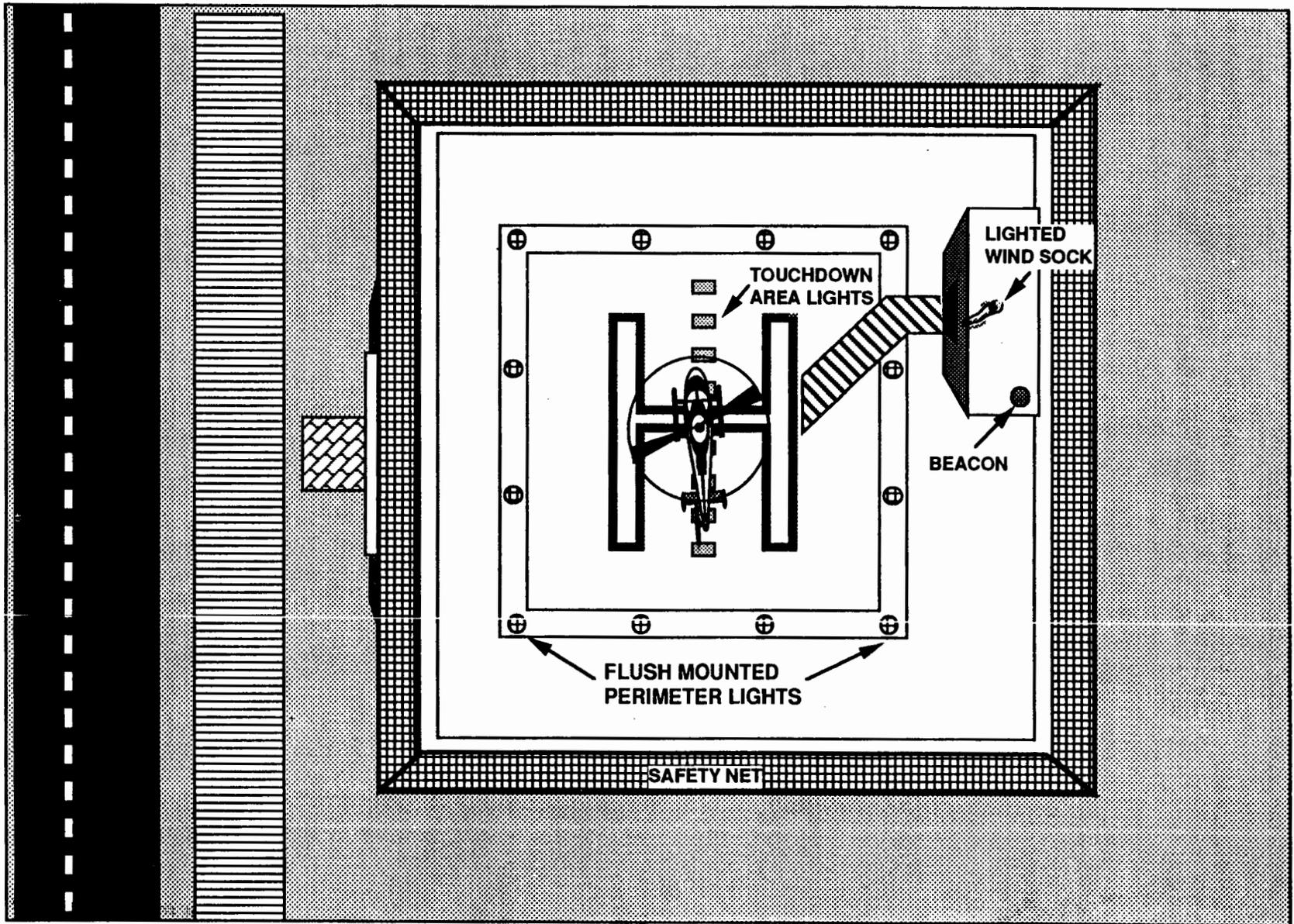


FIGURE 31 IMPROVED HELIPORT DESIGN - HELIPORT LIGHTING EQUIPMENT

operators make efforts to publicize specific information regarding lighting type, location, and height above ground.

Landing Spot - The pilot elected to land to one side of the landing area rather than in the center. This choice reduced the amount of obstacle clearance, thereby reducing the margin of safety.

COMPOSITE #16

MISHAP TYPE: TAIL ROTOR STRIKE - PERSONNEL

DESCRIPTION: A man and his wife arrived from France for three days of sightseeing in Boston. On the night of their arrival, they saw a coupon in a local newspaper that was good for 5 dollars off on a helicopter sightseeing ride. Neither the man or his wife had previously flown in a helicopter. They decided that this would be an excellent way to get an overall view of the city and a great opportunity for taking some photographs. The following day the couple took a taxi to the airport for their sightseeing ride.

After purchasing their tickets for the flight, the couple talked about how clear the sky was and that it looked like a great day for sightseeing. When the flight was announced, the couple, along with two other passengers, met a ticket agent at the gate. The agent told them they would soon be led out to the helicopter and then proceeded to caution them about the potential danger of walking near the helicopter while the rotors were turning. The helicopter was kept running during passenger loading and unloading. The couple from France could not understand much of what the agent said because of their unfamiliarity with the English language. While they were being briefed, another group of passengers was off-loaded from the helicopter.

When the time came for the couple to board the helicopter, they were escorted by an agent, entered on the right side, and slid over to the left side to make room for the other passengers. While they were fastening their seat belts, the pilot told them that there would be a couple of minutes delay while they waited for one more passenger. The French couple talked about the great pictures they would take on the flight. The man suddenly remembered that he had left the extra roll of film in their hotel room. He told his wife that he had to get more film and that he would be right back. He then exited the aircraft on the left side without informing the pilot and before his wife could stop him. As he walked around the rear of the helicopter, he walked into the tail rotor (see figure 32).

DESIGN ISSUES:

Ground Marking - Mishap reports show that even passengers who have ridden on helicopters on a number of occasions may walk into a turning tail rotor. The seriousness of this type of mishap requires that every effort be made to ensure its prevention. When helicopter flights carrying passengers occur on a regular basis from a location, specific ground markings to guide passengers should be considered. Ground marking guidance is provided in the Heliport Design Advisory Circular (reference 3). Figure 33 depicts the ground markings which enhance the safety of embarking and disembarking passengers.

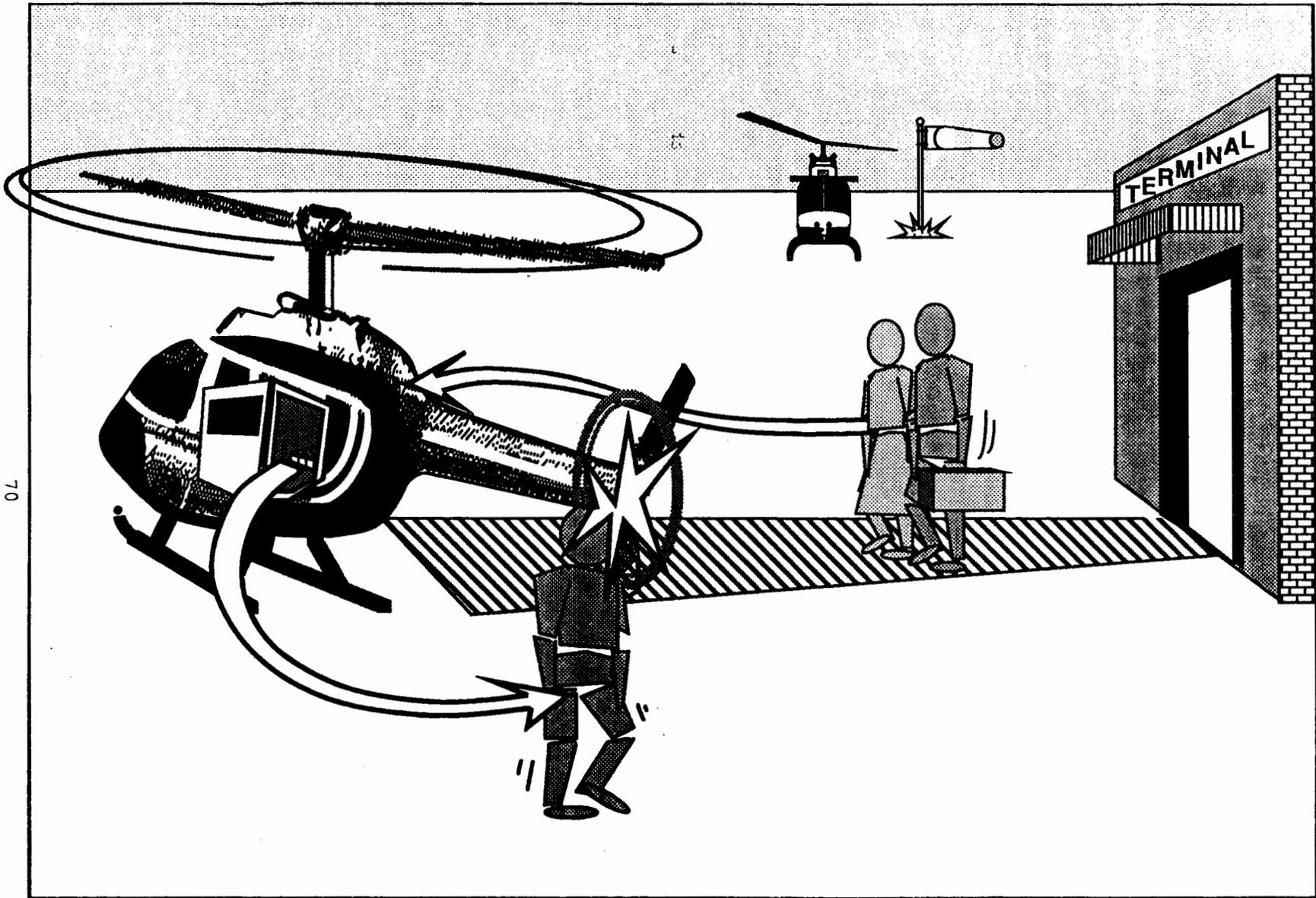


FIGURE 32 TAIL ROTOR STRIKE - PERSONNEL

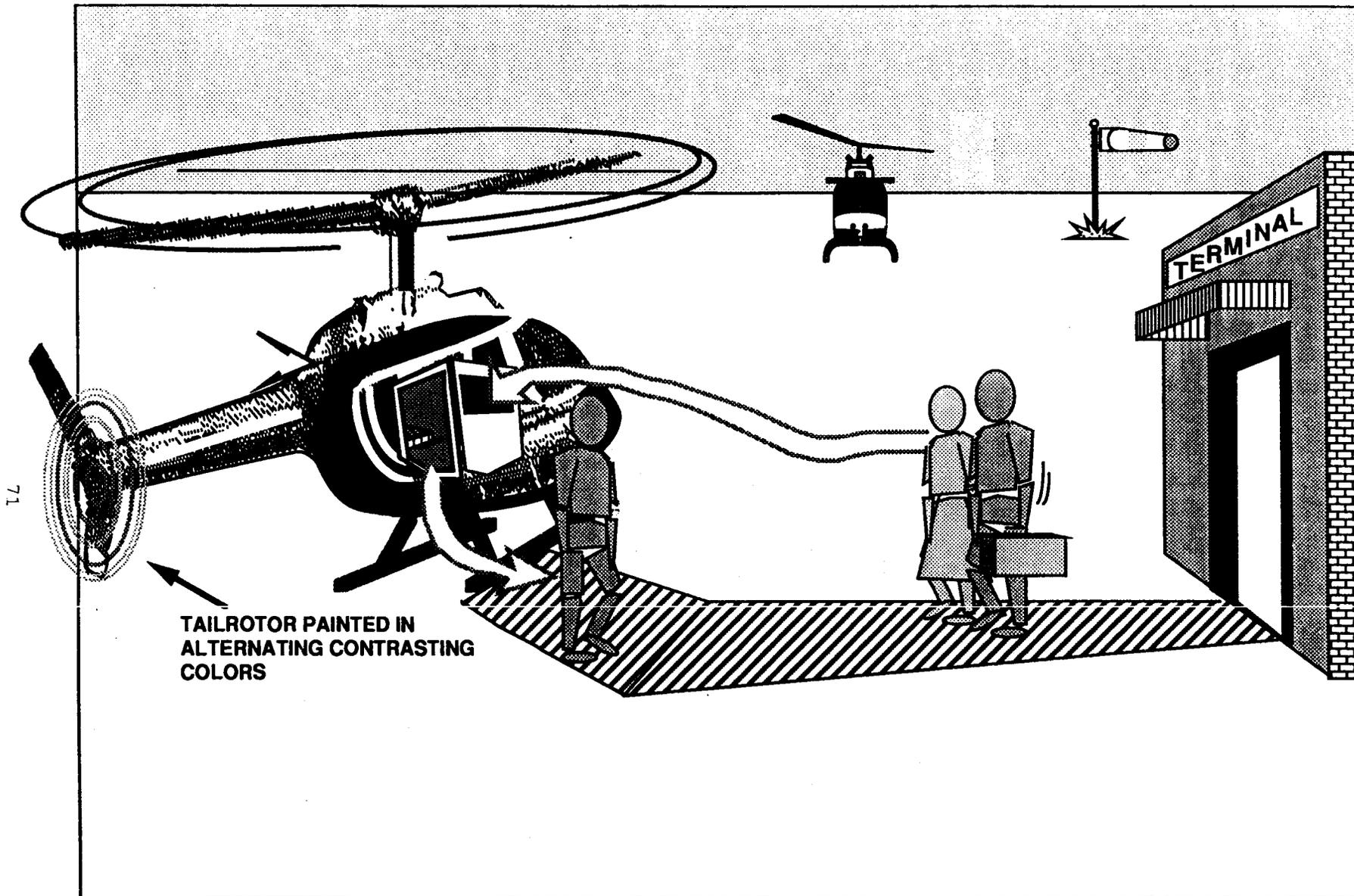


FIGURE 33 IMPROVED HELIPORT DESIGN - PASSENGER WALKWAY MARKING AND IMPROVED HELICOPTER DESIGN - TAILROTOR MARKINGS

CONTRIBUTING FACTORS:

Tail Rotor Paint Scheme - A turning tail rotor may be hard to see under certain conditions. This may be especially true when the helicopter is between the passenger and the light source (sun, moon). Studies have shown that certain paint schemes can make a turning tail rotor more visible (reference 11). Both individuals and manufacturers should ensure that the helicopter's tail rotors are painted for maximum visibility when rotating.

Passenger Briefing - Although the passengers were briefed on the dangers of walking near tail rotors, the French couple did not understand the briefing because of their unfamiliarity with the language. Passenger briefing is a very important aspect of every flight, and it is extremely important that passengers understand safety briefings. One possibility is the use of symbolic briefing materials to aid in briefings. Drawings of hazardous areas and emergency procedures could be very valuable to foreign passengers.

Passenger Perception - The most dangerous component of a helicopter for individuals walking near an operating helicopter is the tail rotor. The main rotor of many helicopters operates at a height above the average person, while many tail rotors do not. Ironically, the most obvious component that an individual unfamiliar with helicopters will be aware of is the main rotor area. The main rotor size and the noise associated with an operating turbine engine will attract the most attention. For these reasons, the tail rotor does not receive the attention and caution that a main rotor receives and is therefore inherently more dangerous to passengers. It is imperative that passengers fully understand the potential hazards of walking near tail rotors.

Aircraft Parking - Pilots should, whenever possible, position their aircraft in the direction from which the passengers will be loaded or unloaded. In this particular case, had the helicopter been facing the terminal, the incident may not have occurred. Figure 33 depicts the proper positioning of the helicopter for passenger safety.

3.0 HELIPORT DESIGN

The purpose of this report is to provide examples of how facility design may contribute to mishaps. This report is offered to promote safety in the design and operation of helicopter landing sites. The composite scenarios were meant to present examples of design practices which have the potential for contributing to mishaps. Discussions concerning heliport design followed each scenario. The discussions addressed many of the design factors which have contributed to facility mishaps in the past.

The historic mishap database shows that the most likely type of helicopter mishap that occurs at landing facilities is an obstacle strike. Main rotor, tail rotor, and landing gear strikes involving a variety of obstacles have occurred. This fact confirms the importance of heliport design in promoting safety in helicopter operations. Helicopters differ from fixed-wing aircraft in obvious ways. Facility designers and operators must take the special needs of helicopters into account whenever operations at facilities include helicopters. In addition to design considerations, operational considerations also play an important role in facility safety. Section 3.2 looks at factors that may affect pilots during operations.

3.1 HELIPORT OPERATOR'S CHECKLIST

Pilots have been using checklists since the early days of aviation. Checklists are used primarily for safety purposes to ensure that important items and procedures have been completed before various phases of flight are undertaken. Since this report addresses heliport design, operations, and safety, a checklist written for heliport operators is appropriate. Figure 34 presents a checklist that heliport operators could use for their facilities.

Including all of the specific items that would need to be considered for each operational area is beyond the scope of this effort. Therefore, the items contained in the checklist are not written for specific operational areas, nor do they represent all of the many details that need to be considered. The items presented represent very general safety aspects and are intended primarily to remind heliport operators of general concepts.

3.2 OPERATIONAL CONSIDERATIONS

As previously mentioned, the hypothetical mishap scenarios presented in section 2.2 were based upon actual mishap reports. The thrust of this report is to address safety from a heliport design perspective. However, in reading through actual mishap reports, some insight concerning pilot situational awareness and the role it plays in safe heliport operations has been gained. The following discussion addresses factors which may affect a pilot's capabilities and suitability for flight.

3.2.1 Situational Awareness

Situational awareness implies that one is aware of the "big picture." In the context of flying a helicopter, this implies that the pilot is aware of all

Heliport Operator's Safety Checklist

- ✓ *Clean and flat operating surfaces
(no cracks, ridges, indentations)*
- ✓ *Obstructions well marked
for day and night use*
- ✓ *Flush mounted lights,
tie-downs, grounding rods*
- ✓ *Adequate wind sensors*
- ✓ *Obstruction-free approach
and departure surfaces*
- ✓ *Adequate drainage*
- ✓ *Sufficient ground markings
(including parking area)*
- ✓ *Adequate clearance from poles
(light, sign, ventpipes) and
other obstacles*

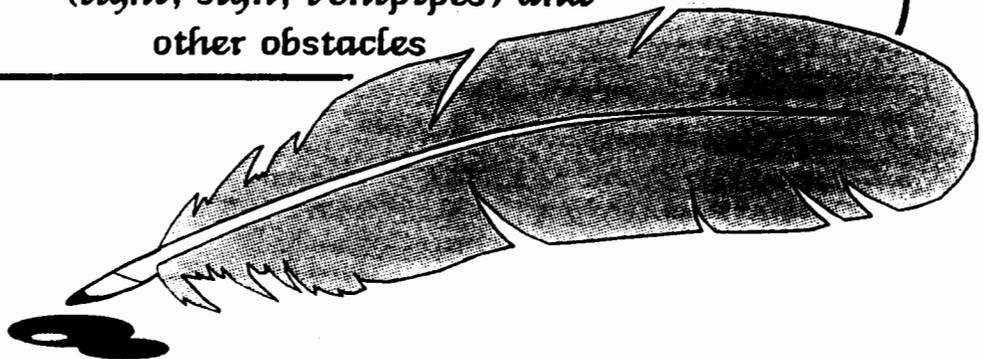


FIGURE 34 HELIPORT OPERATOR'S SAFETY CHECKLIST

aspects of the situation, including aircraft performance and capabilities, environmental factors, his/her flying capabilities, and his/her overall physical and mental well-being. One aspect of situational awareness that is critical when operating at a heliport is pilot vigilance.

3.2.2 Pilot Vigilance

Vigilance may be described as being alert to a situation, especially to potential danger. As previously mentioned, pilot vigilance is extremely important when operating at heliports. Heliports should be designed with safety as the primary consideration. However, the overall responsibility for safety still rests with the pilot. Being vigilant requires the pilot to constantly be aware of what is happening during all phases of an operation. However, being human, pilots are influenced by factors which tend to reduce their vigilance. These factors include fatigue, stress, distractions, and complacency. Often quoted statistics claim that nearly two-thirds of the total number of mishaps are due to pilot error. The number of mishaps that may be directly attributed to pilot fatigue, stress, distractions, or complacency are unknown. However, it is highly probable that one or more of these factors play a role in the majority of landing site mishaps where pilot error is cited as one of the contributing causes. It is important that pilots be aware of factors that may reduce vigilance.

The following mishap scenario was developed to help illustrate factors which tend to reduce pilot vigilance. The scenario will be referenced in the discussions that follow.

MISHAP DESCRIPTION: The pilot and copilot were returning to their home base, at night, after a 10-hour day that involved six separate flights. The pilot was flying the aircraft and he maintained an altitude of 1,000 feet MSL en route to the corporate headquarters. Approximately 30 miles from their destination, the copilot tried to contact a security guard at their corporate facility to obtain a local weather update. However, both communication radios seemed to be malfunctioning. The pilot then suggested calling a flight service specialist on another frequency. When that did not work, the pilot attempted to solve the problem himself. Both pilots were concerned because there was a good chance of fog at their destination. In addition, they were concerned about their low fuel status. Suddenly, a warning light on the annunciator panel lit up. As the pilot and copilot worked on their problems, the pilot failed to maintain altitude and the aircraft began a gradual descent. Both pilots failed to notice that the aircraft was descending at 150 feet per minute. Two minutes later the aircraft struck a 500-foot tower that was located on a hill.

3.2.3 Pilot Fatigue

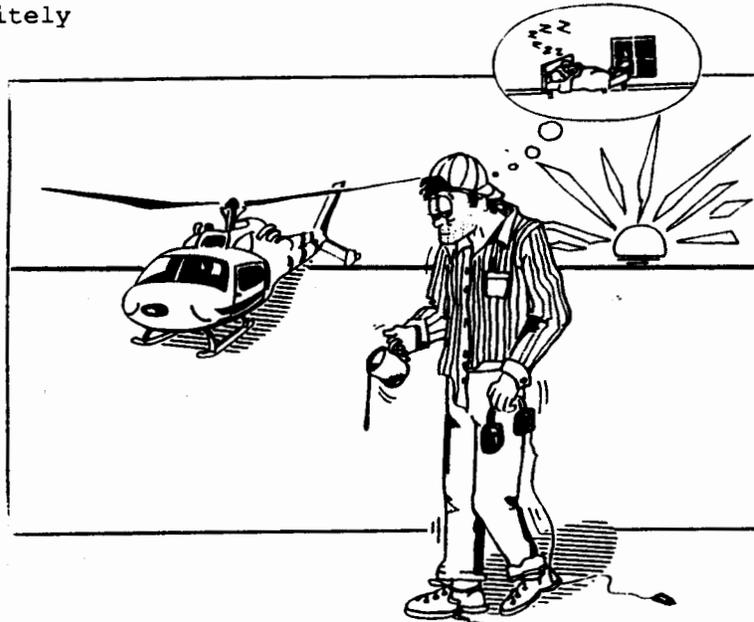
Everyone understands that the term fatigue, when applied to an individual, is used to imply that a person is tired. However, people often do not realize the onset of fatigue or fully appreciate its effects.

Fatigue is brought on by any number of factors including: lack of rest, lack of food, improper diet, stress, demanding workloads, or lack of regular

exercise. Fatigue has several effects on a pilot. It increases the amount of time it takes a pilot to mentally process information and react to a situation. Fatigue tends to reduce the pilot's overall situational awareness. This has the effect of limiting the pilot's view of his surroundings. Reducing situational awareness limits options available to pilots and may result in his/her making decisions that are inappropriate and dangerous. In the worst case, fatigue can lead to extreme focus of a pilot's attention on one specific problem or task, "tunnel vision." "Tunnel Vision" is an extreme loss of situational awareness and a degradation in safety, especially near obstacles on the ground.

In the mishap scenario presented above, the pilots had been working for 10 hours. Long work days can definitely lead to fatigue. Even if the job is not physically demanding, mental fatigue will begin to influence the individual; for example, individuals who have "desk jobs," which are basically not physically demanding, are often fatigued by the end of the work day. Fatigue was undoubtedly a factor in the above scenario. Tired individuals tend to think slower, are more easily distracted, have lapses in thinking, and react more slowly than under normal circumstances. Both the pilot and copilot in the scenario allowed themselves to become

involved in the process of trying to determine why the radios were malfunctioning, and dealing with the cause of the warning light. Both pilots forgot the basic rule of flying: fly the aircraft first, then deal with problems. This is more likely to happen when pilots are fatigued.

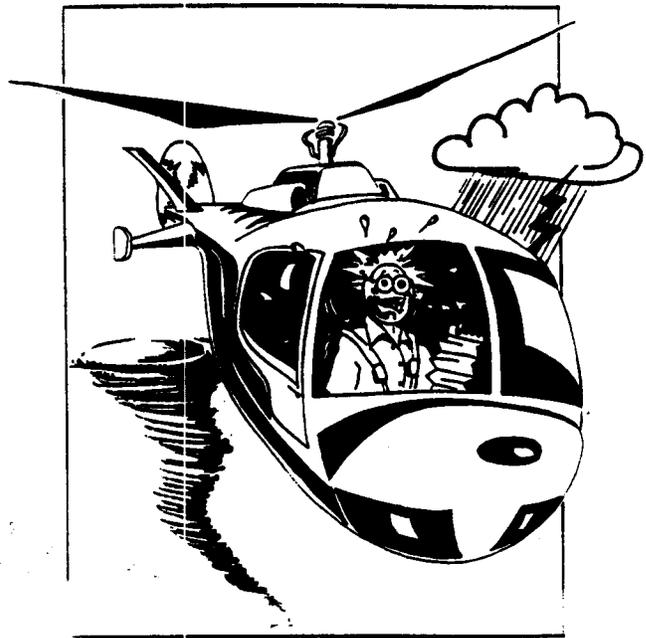


There is one underlying aspect of fatigue that is particularly menacing, its ability to affect a pilot without him/her being aware of its presence. Pilots must ensure that they get sufficient rest before flying. In addition to monitoring the aircraft, pilots must monitor themselves and realize when fatigue is affecting their performance.

3.2.4 Pilot Stress

Stress is defined in part as pressure or strain exerted on an object. The "object" in this discussion is the pilot. Stress can have both positive and negative effects. In times of crisis, stress can increase one's ability to cope with a situation. However, it is generally recognized that stress can have deleterious effects on individuals. This discussion will focus on negative effects.

Stress can result from a variety of sources and it effects individuals physically and/or psychologically. In our society most people have the basic necessities of life including food, clothing, and shelter. Therefore, the majority of stress today comes from psychological factors. The pressures that society presents are indeed many. Major stresses may originate from job, family, or financial circumstances. Like everyone else, pilots must learn to recognize stress and how it affects them. Flying can offer the pilot a variety of stressful situations. A warning light, engine failure, instrument failures while flying in instrument meteorological conditions, and flying in the vicinity of thunderstorms are examples of stressors that pilots may encounter at one time or another in their career.



Malfunctioning equipment such as that presented in the mishap scenario above can certainly raise the level of stress for pilots. Depending on the circumstances, the level of stress can range from minor to debilitating. In the scenario presented, stress was definitely a factor for the pilots as they approached their destination. They were proceeding to a destination where there was a good chance of encountering fog, they were low on fuel, and they had to deal with the problem causing the warning light. This scenario would definitely lead to concern in most individuals. Such concern may lead to concentrating on one item rather than the entire situation at hand. Again, in the scenario above, the pilots failed to monitor the "big picture" while they tended to their concerns. Pilots must be alert to stressful situations and understand how they tend to react at such times.

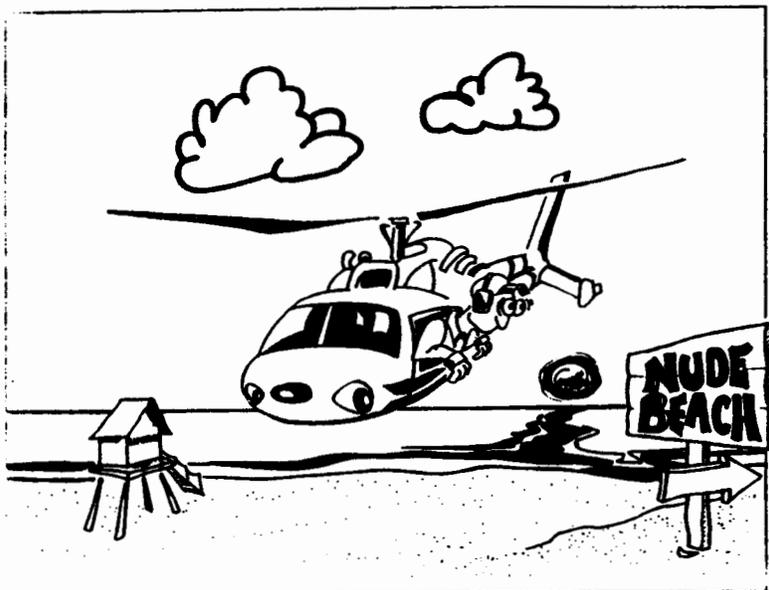
3.2.5 Pilot Distraction

Distractions tend to draw attention away from the task at hand. For pilots, distractions may draw attention away from their job of safely operating the aircraft. Pilot distractions may come from a large variety of sources. For example, warning lights in the cockpit are intended to gain the attention of the pilot. However, pilots can allow warning lights to become too much of a distraction, thereby drawing too much attention away from the pilot's primary mission of keeping the aircraft under control.

The distraction caused by malfunctioning radios was obviously one of the contributing factors in the above scenario. At first, the pilot allowed the copilot to try and resolve the problem. After a few minutes, the pilot then tried to solve the problem himself. Not only did he stop monitoring the aircraft's en route progress, but he failed to tell the copilot to fly the aircraft while he worked on the radios. In addition, a warning light came on in the cockpit. Eventually, both crew members became distracted by the

problems at hand and failed to keep the situation under control.

Besides the on-board distractions that aircraft may offer, heliports also offer any number of distractions. Personnel movements on heliports certainly gain the attention of pilots. Stationary obstacles such as poles, parked aircraft, fences, fuel pumps, etc., may distract pilots, especially in tight operating areas. Being aware of the effect of distractions and guarding against becoming too distracted will result in a safer pilot.



3.2.6 Pilot Complacency

Complacency can be defined in part as a feeling of self-satisfaction while being unaware of dangers that may exist. When piloting an aircraft, a complacent attitude is a dangerous attitude. This factor can be cited in the mishap scenario above. As the crew was flying en route to their destination, a problem with the aircraft's radios developed. After a few minutes, the pilot became involved in trying to resolve the problem. The crew obviously felt comfortable in the pilot's ability to fly the aircraft while attending to the problems at hand. However, they disregarded the danger of allowing themselves to focus on their problems without their monitoring the entire situation. This complacent attitude contributed to the mishap.

Although heliports are generally designed with safety in mind, a complacent pilot or one who tends to forget about the potential for mishaps can be a dangerous pilot. While a pilot should not constantly be worried that a mishap will occur, he should continually be aware of the potential for a mishap when operating an aircraft. This is particularly true at a heliport where the operating environment may not be very forgiving of mistakes. Heliport operational areas are usually thought of as being fixed, stable, and non-dynamic areas. However, this is not true. Each operation at a heliport is unique. Circumstances surrounding operations change. People, debris, aircraft movements, environmental factors, and the pilot's frame of mind all work in concert to make each operation unique. Because each operation is unique, pilots must be alert to the situation. No matter how familiar a particular location is or how familiar a particular operation seems, pilots must guard against becoming complacent.

Complacency is brought on most often by familiarity. When a pilot first flies into a heliport, he/she tends to be very alert and aware of the situation. However, as a pilot flies into the same heliport for the 100th time, he/she may tend to have grown somewhat complacent about the operation and may not be as alert as on the first trip. It is relatively easy to become complacent when operating in familiar surroundings. However, pilots must be aware of this attitude and guard against becoming too lax.



3.2.7 Vigilance at Heliports

Vigilance is important throughout all phases of flight. However, it is particularly important when operating at a landing site. Depending upon the heliport design, operational areas may be small, numerous obstacles may exist, and approach/departure paths may present a variety of potential hazards. Even when all efforts are made to design safe heliports, pilots must realize that they are still a major factor in the safety equation. They must remain vigilant, not only to the aircraft and the situation, but also to themselves. Their mental and physical state plays a major role in safety. Safety is the primary objective in aviation, and the pilot is certainly a key factor.

3.3 HELIPORT DESIGN EXERCISE

In this section, the reader is challenged to use ones' knowledge of heliport design. A diagram of a heliport is presented and the reader is asked to decide what design factors may be inappropriate based upon safety considerations. The inappropriate design features are similar to those discussed in the mishap scenarios presented in section 2.2.

SAFETY EXERCISE

Mr. Joe Entrepreneur built a resort in Fun Times, Florida. Mr. Entrepreneur recently decided that he wants to add a heliport to his resort. However, he must first file Form 7480-1 with the FAA and also obtain permission from the county commission before installing the heliport. Mr. Entrepreneur recently submitted plans for the heliport to the county commission. Since the commission knows very little about helicopters or heliports, they have contracted your aviation engineering

firm to review Mr. Entrepreneur's heliport design from a safety standpoint. Your boss has assigned you and your assistant the task of reviewing the heliport design.

Figure 35 is a diagram that was submitted with the heliport approval application. Your assistant has numbered the design features that she thinks may be safety hazards. She also developed table 2 which includes the corresponding number of the items, as well as the items themselves that are of concern to her. Your task is to fill in the description column in table 2 for those items that you feel represent safety hazards. You must also fill out the recommendation letter (figure 36) that your company will send to the county commission. The correct answers are provided in appendix A and appendix B. Good luck!!

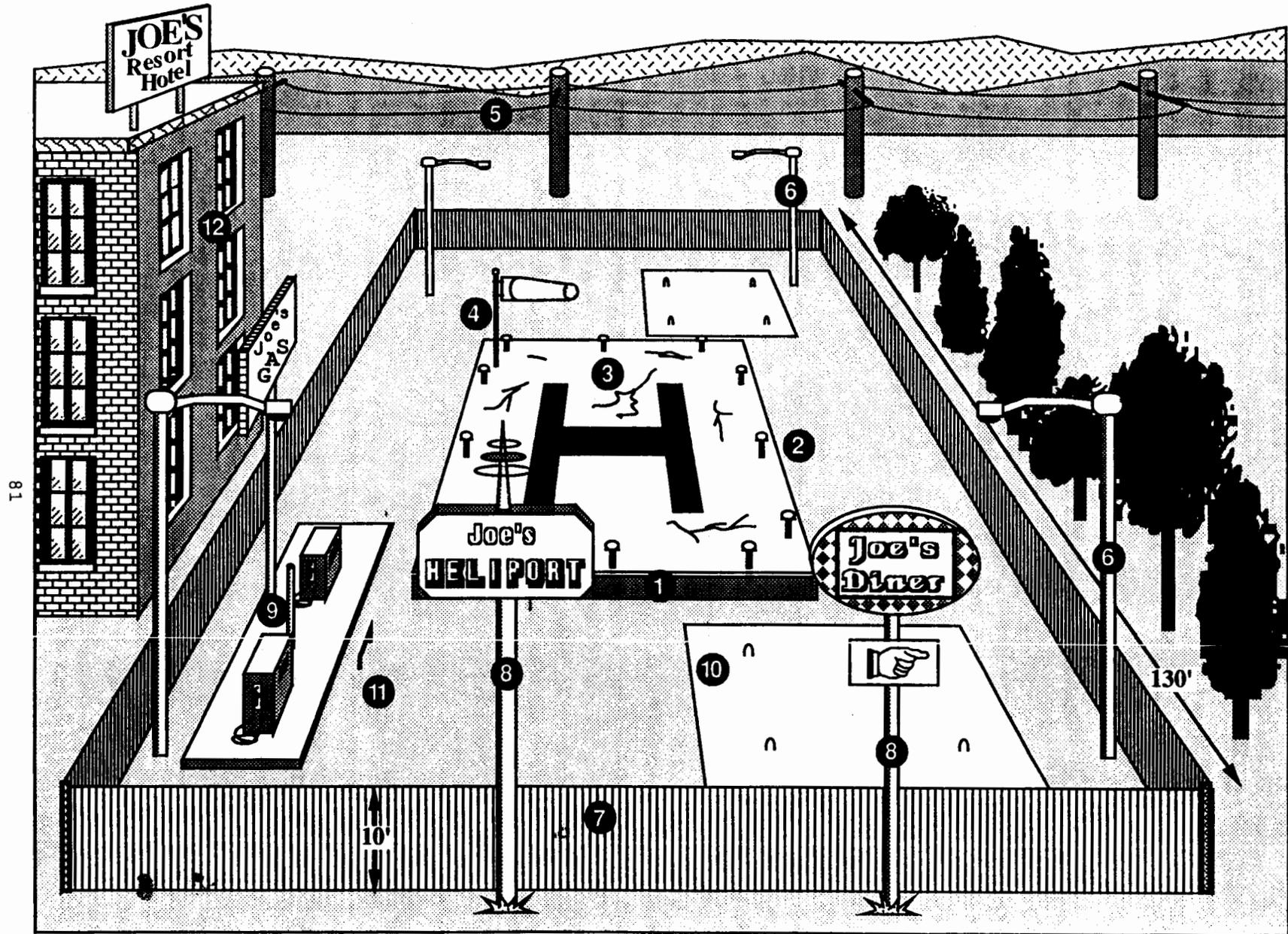


FIGURE 35 PROPOSED HELIPORT DESIGN

TABLE 2 LIST OF POTENTIAL DESIGN PROBLEMS

ITEM NO.	DESIGN	DESIGN PROBLEM DESCRIPTION
1	Elevated Helipad	
2	Elevated Perimeter Lights	
3	Ruts (Indentations) in Asphalt	
4	Wind Sock Placement	
5	Telephone Poles and Wires	
6	Light Poles	
7	10 Foot High Fence	
8	Signs	
9	Vent Pipe and Sign	
10	Tie-down Anchors	
11	Grounding Rods	
12	Building	
13*	* ± Heliport Size	

* Number not depicted in figure 35.

Unusual Aviation Engineering Services
1000 Strain Gage Road
Slide Rule, Florida 00000-0000

February 30, 2000

Mr. John H. Somebody
County Commissioner
1000 Resort Road
Snowbelt, Florida 00001-0000

Dear Mr. Commissioner:

Unusual Aviation Engineering Services has reviewed the heliport design submitted by Mr. Joe Entrepreneur. We realize that Mr. Entrepreneur's heliport represents a potential revenue source for the county. However, our primary task was to review the heliport design based upon safety considerations. Therefore, based upon our review, we recommend

_____ Approving

_____ Disapproving

the heliport design.

Sincerely,

Civil Engineer

FIGURE 36 RECOMMENDATION LETTER

LIST OF REFERENCES

1. "Analysis of Helicopter Mishaps at Heliports, Airports, and Unimproved Sites," DOT/FAA/RD-90/8, Federal Aviation Administration, Washington, D.C., January 1991.
2. "Analysis of Helicopter Accident Risk Exposure at Heliports, Airports, and Unimproved Sites," DOT/FAA/RD-90/9, Draft Report, Federal Aviation Administration, Washington, D.C., December 1990.
3. "Heliport Design Advisory Circular," AC 150/5390-2, Federal Aviation Administration, Washington, D.C., January 1988.
4. "Helicopter Physical and Performance Data," DOT/FAA/RD-90/3, Federal Aviation Administration, Washington, D.C., November 1990.
5. "Helicopter Rejected Takeoff Airspace Requirements," DOT/FAA/RD-90/7, Federal Aviation Administration, Washington, D.C., October 1990.
6. "Evaluating Wind Flow Around Buildings on Heliport Placement," DOT/FAA/PM-84/25, Federal Aviation Administration, Washington, D.C., October 1984.
7. "Investigation of Hazards of Helicopter Operations and Root Causes of Helicopter Accidents," DOT/FAA/PM-86/28, Federal Aviation Administration, Washington, D.C., July 1986.
8. "Heliport Surface Maneuvering Test Results," DOT/FAA/CT-TN88/30, Federal Aviation Administration, Washington, D.C., June 1989.
9. "Aircraft Ground Handling and Servicing," Advisory Circular 00-34A, Federal Aviation Administration, Washington, D.C., July 1974.
10. "Evaluation of a Prototype Lighted Ball Marker for Powerline Obstructions," DOT/FAA/CT-TN90/12, Federal Aviation Administration, Washington, D.C., March 1990.
11. Welsh, Kenneth W.; Vaughan, John A.; and Rasmussen, Paul G., "Conspicuity Assessment of Selected Propeller and Tail Rotor Paint Schemes," FAA-AM-78-29, Federal Aviation Administration, Washington, D.C., August 1978.
12. "Airman's Information Manual," Federal Aviation Administration, Washington, D.C., April 4, 1991.

LIST OF ACRONYMS

AAC	Advanced Aviation Concepts
AC	Advisory Circular
AGL	Above Ground Level
AIM	Airman's Information Manual
ATIS	Automatic Terminal Information Service
ATP	Air Transport Pilot
CEB	Commercial Engine Bulletin
CEO	Chief Executive Officer
CFR	Code of Federal Regulations
EMS	Emergency Medical Service
FAA	Federal Aviation Administration
FATO	Final Approach and Takeoff Area
FBO	Fixed-Base Operator
HIGE	Hover In-Ground Effect
HOGE	Hover Out-of-Ground Effect
MSL	Mean Sea Level
NFPA	National Fire Protection Association
NTSB	National Transportation Safety Board
PAPI	Precision Approach Path Indicator
PLASI	Pulsating Light Approach Slope Indicator
RPM	Revolutions Per Minute
SCT	Systems Control Technology
VASI	Visual Approach Slope Indicator
VFR	Visual Flight Rules
WSPS	Wire Strike Protection System

**APPENDIX A
ANSWERS TO TABLE 2**

ITEM NO.	DESIGN	DESIGN PROBLEM DESCRIPTION
1	Elevated Helipad	Operational areas should be flat if possible. Landing gear may catch on sides of the raised helipad.
2	Elevated Perimeter Lights	Weather permitting, lights should be flush mounted. Landing gear and tail rotors may strike elevated lights.
3	Ruts (Indentations) in Asphalt	Skids may get caught in cracks resulting in dynamic rollovers. Concrete is preferable to asphalt.
4	Wind Sock Placement	The wind sock is located in the FATO. Wind indicators should provide accurate information without interfering with operations.
5	Telephone Poles and Wires	These obstructions violate the 8:1 approach/departure surface.
6	Light Poles	The light poles are too close to parking pads. They should be marked for visibility under all weather conditions.
7	10 Foot High Fence	The fence violates the 8:1 approach/departure surface and creates wind turbulence.
8	Signs	The signs violate the 8:1 approach/departure surface.
9	Vent Pipe and Sign	These obstructions are a hazard to helicopters operating close to the fuel pumps.
10	Tie-down Anchors	Tie-downs should be flush mounted or recessed. Skids may get caught on tiedowns that are above ground level.
11	Grounding Rods	Grounding rods should be flush mounted or recessed. Skids may get caught on grounding rods that are above ground level.
12	Building	Hangars, buildings, or large obstructions near heliports can seriously affect the wind flow pattern near operational areas.
13*	Heliport Size	The overall size of the heliport is small. The helipad and parking pads are small and limit heliport use.

* Number not depicted in figure 35.

**APPENDIX B
ANSWER TO FIGURE 36**

Unusual Aviation Engineering Services
1000 Strain Gage Road
Slide Rule, Florida 00000-0000

February 30, 2000

Mr. John H. Somebody
County Commissioner
1000 Resort Road
Snowbelt, Florida 00001-0000

Dear Mr. Commissioner:

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Approving
 Disapproving

the heliport design.

Sincerely,

Civil Engineer