

UNITED STATES AIR FORCE
GROUND ACCIDENT INVESTIGATION
BOARD REPORT



TYPE OF ACCIDENT: SUN SHELTER COLLAPSE
LOCATION: NELLIS AFB, NV
DATE OF ACCIDENT: 8 SEPTEMBER 2011



Conducted IAW Air Force Instruction 51-507



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR COMBAT COMMAND
JOINT BASE LANGLEY-EUSTIS VA

OFFICE OF THE VICE COMMANDER
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FEB 22 2012

MEMORANDUM FOR ACC/JA

SUBJECT: AFI 51-507, Ground Accident Investigation Report – 8 September 2011, Sun Shelter Collapse, Nellis AFB, NV

I have reviewed the Ground Accident Investigation Board Report regarding the Class A ground mishap wherein a 2,500' long, 75' wide revetment sunshade collapsed at Nellis AFB, NV, on 8 September 2011. The report prepared by Colonel David J. Crow complies with the requirements of AFI 51-507 and is approved.

A handwritten signature in black ink, appearing to read "William J. Rew".

WILLIAM J. REW
Lieutenant General, USAF
Vice Commander

Attachment:
Ground Accident Investigation Board Report

United States Air Force Ground Accident Investigation Board Report
Sun Shelter Collapse
Nellis AFB, NV
8 September 2011

EXECUTIVE SUMMARY

On Thursday 8 September 2011, the 57th Wing and two TDY units, the 388th Fighter Wing from Hill AFB and the 23^d Wing from Moody AFB, were conducting live ordnance flying operations from the revetments area on the south side of the Nellis AFB ramp. The revetment parking spaces were covered by a sunshade installed between 2000 and 2004. Cable bracing required for structural stability of the sunshade was loose, damaged or missing in several areas. The cables had not been inspected or maintained since the sunshade had been installed.

At 1500 hours, the 57th Aerospace Maintenance Squadron swing shift came on duty and prepared to launch F-16 sorties. At 1631 hours, a high wind advisory was issued for winds between 25 to 35 knots until 2000 hours. Maintenance personnel at the revetments took precautions to close aircraft canopies and remove equipment from the aircraft. At 1655 hours, the weather advisory was updated to reflect potential winds between 35 and 50 knots until 1900 hours.

At approximately 1657 hours the tower noted that a gust front hit the airfield reducing visibility to zero. A wind gust of 56 knots was recorded at 1658 hours on the Nellis AFB airfield. Between 1658 and 1700 hours, the 2,500 foot long, 75 foot wide revetment sunshade collapsed. Without the necessary lateral support from the cables, the strong wind gusts cause the sunshade to collapse suddenly. The collapse was described as occurring in a manner similar to a sheet of ice sliding off of a roof. Other personnel on scene but not underneath the structure could not see the collapse due to severely reduced visibility.

Immediately after the sunshade collapsed, maintenance and security personnel searched the site and identified approximately 40 personnel on scene but none were severely injured. Eight personnel were identified as having sustained injuries warranting medical attention. All personnel were subsequently treated and released.

Ten F-16 and two A-10 aircraft sustained damage from the collapsed sunshade. In addition, four AIM-120 missiles mounted on the aircraft sustained damage. Twenty-one pieces of aerospace ground equipment and nine government-owned vehicles were also damaged in the collapse. The estimate of damage was \$7.4M. No other individuals, aircraft, equipment or facilities were injured or damaged.

After shutting down power and shutting off the in-ground aircraft refueling system for the area, Explosive Ordnance Disposal personnel safed the munitions. Maintenance and civil engineer personnel used cranes to lift the portions of the collapsed structure resting on each aircraft and then manually push each aircraft out of their parking locations.

COMMONLY USED ACRONYMS & ABBREVIATION

ACC	Air Combat Command	GOV	Government Owned Vehicle
AFB	Air Force Base	IAW	In Accordance With
AFI	Air Force Instruction	L	Local Time
AFMAN	Air Force Manual	Lt Col	Lieutenant Colonel
AFPAM	Air Force Pamphlet	MAJCOM	Major Command
AFSC	Air Force Specialty Code	MSgt	Master Sergeant
AIM	Air Intercept Missile	OI	Operating Instruction
AMOS	Automated Meteorological Observation Sensor	S/N	Serial Number
AMU	Aircraft Maintenance Unit	SNCO	Senior Non-Commissioned Officer
AMXS	Aerospace Maintenance Squadron	SrA	Senior Airman
CMSgt	Chief Master Sergeant	SSgt	Staff Sergeant
CES	Civil Engineer Squadron	SOF	Supervisor of Flying
FAR	Federal Acquisition Regulation	TDY	Temporary Duty
MOC	Maintenance Operation Center	TO	Technical Order
MSG	Mission Support Group	TSgt	Technical Sergeant
MXG	Maintenance Group	USAF	United States Air Force
EOD	Explosive Ordnance Disposal Center	USAFWC	United States Air Force Warfare Center
GAIB	Ground Accident Investigation Board	Z	Zulu or Greenwich Meridian Time (GMT)
GSA	General Services Administration		

The above list was compiled from the Summary of Facts, the Index of Tabs, and witness testimony (Tab V).

United States Air Force Ground Accident Investigation Board Report
Sun Shelter Collapse
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SUMMARY OF FACTS

1. AUTHORITY, PURPOSE, AND CIRCUMSTANCES

a. Authority

On 4 November 2011, the ACC Vice Commander, appointed a Board President to conduct a ground accident investigation of the 8 September 2011 Sun Shelter Collapse which occurred at Nellis AFB, NV. The investigation took place at Nellis AFB, from 9 November 2011 through 29 November 2011. Technical advisors assigned included a Legal Advisor, Engineer Advisor, Weather Specialist, Contracting Officer, and Recorder (Tab X-3 – 4).

b. Purpose

This ground accident investigation was convened under Air Force Instruction (AFI) 51-507. The purpose of the investigation is to inquire into the facts surrounding the ground accident, to prepare a publicly releasable report, and to gather and preserve all available evidence for use in claims, litigation, disciplinary actions, adverse administrative proceedings, and for other purposes. This investigation is separate and apart from the safety investigation, which is conducted pursuant to AFI 91-204 for the purpose of mishap prevention. The report is available for public dissemination under the Freedom of Information Act (5 United States Code (U.S.C.) Section 552, as amended), DoD 5400.7-R and AFMAN 33-302.

2. ACCIDENT SUMMARY

On Thursday 8 September 2011, Nellis AFB conducted a routine flying schedule. The 57th Wing and two TDY units, the 388th Fighter Wing from Hill AFB and the 23rd Wing from Moody AFB, were conducting live ordnance flying operations from the revetments area on the southwest side of the Nellis AFB ramp (Tab V-1.2).

At 1631 hours, a high wind advisory was issued for Nellis AFB (Tabs B-2, BB-22). Maintenance personnel at the revetments took precautions to close aircraft canopies and remove equipment from the aircraft (Tabs V-1.3, V-9.2, and V-12.3). Between 1658 and 1700 hours, severe winds caused the sunshade at the revetment area to collapse (Tabs BB-15, DD-3).

Immediately after the sunshade collapsed, maintenance and security personnel searched the site and identified approximately 40 personnel were on scene and none were severely injured (Tab V-1.4). Eight personnel were identified as having sustained injuries warranting medical attention (Tabs V-1.6, V-2.3, and C-2). All personnel were transported in privately owned vehicles to the installation medical facility (Tab V-2.3, V-5.3, V-9.5, and V-10.3).



Figure 1. Nellis AFB

Ten F-16 and two A-10 aircraft sustained damage from the collapsed sunshade. In addition, four AIM-120 missiles mounted on the aircraft sustained damage. Twenty-one pieces of aerospace ground equipment and nine government-owned vehicles were also damaged in the collapse. The estimate of damage was \$7.4M (Tab P-3 – 5). Maintenance and civil engineer personnel then secured the scene and removed the collapsed structure from each aircraft and had to manually push each aircraft out of the parking locations (Tabs V-1.9, V-12.5). Operations continued throughout the night and following day (Tabs V-1.9, V-4.3). No other individuals, equipment or property were injured or damaged in this mishap.

3. BACKGROUND

The various military units relevant to the accident and their relationship are as follows: The 57th Aircraft Maintenance Squadron is a squadron within the 57th Maintenance Group. The 57th Maintenance Group is a part of the 57th Wing. The 57th Wing is part of the U. S. Air Force Warfare Center, which is, in turn, a direct reporting unit under Air Combat Command.

a. MAJCOM

Air Combat Command's (ACC) primary mission is to provide combat airpower to America's warfighting commands. ACC operates fighter, bomber, reconnaissance, battle-management, and electronic-combat aircraft and also provides command, control, communications and intelligence systems, and conducts global information operations. As a force provider, ACC organizes, trains, equips and maintains combat-ready



forces for rapid deployment and employment (Tab CC-3 – 6).

b. Direct Reporting Unit

The U. S. Air Force Warfare Center (USAFWC) at Nellis Air Force Base, Nev., reports directly to Air Combat Command. Founded on 1 September 1966, the USAFWC ensures deployed forces are well trained and well equipped to conduct integrated combat operations. From testing and tactics development programs to training schools and venues, USAFWC provides Airmen with proven and tested technology, the most current tactics, superb academic training and a unique opportunity to practice integrated force employment. To execute its mission, the USAFWC oversees the operations of five Wings, including the 57th Wing at Nellis AFB, NV (Tab CC-13 – 14).



c. 57th Wing

The 57th Wing is the largest composite wing in the United States Air Force. It provides advanced aerospace training to world-wide combat air forces and showcases aerospace power to the world while overseeing the dynamic and challenging flying operations at Nellis. It oversees all flying operations at Nellis Air Force Base and conducts advanced aircrew, space, logistics and command and control training through the USAF Weapons School, "RED FLAG" and "GREEN FLAG" exercises. The wing additionally supports the USAF Warfare Center's test and evaluation activities and showcases US air power through the USAF Air Demonstration Squadron (Tab CC-9 – 12).



d. 57th Maintenance Group

The 57th Maintenance Group is the Air Force's most diverse maintenance group, providing on- and off-equipment maintenance for over 140 assigned A-10, F-15, F-16, and F-22A aircraft to support 10 flying programs, Air Force Special Operations Command, and all visiting Red Flag, Green Flag, and operational test and evaluation aircraft (Tab CC-10 – 11).

e. 57th Aircraft Maintenance Squadron

The 57th Aircraft Maintenance Squadron accomplishes on-equipment maintenance of assigned aircraft, to include aircraft servicing, before and after flight inspections, launch and recovery, munitions loading, and any unscheduled maintenance requirements that occur during the course of the flying day. The squadron includes the F-22 Raptor Aircraft Maintenance Unit (AMU), F-16C/D Tomahawk AMU, and F-16C/D Viper AMU (Tab CC-11).

f. 99th Air Base Wing

The 99th Air Base Wing is the host wing for Nellis Air Force Base, NV. The wing oversees base day-to-day operations and provides support for more than 10,000 personnel assigned to Nellis AFB, Creech AFB and the Nevada Test & Training Range (Tab CC-15).



g. 99th Mission Support Group

The 99th Mission Support Group provides civil engineer, communications, contracting, logistics readiness, personnel, and services

support for Nellis and Creech AFBs (Tab CC-15).

h. 99th Civil Engineer Squadron

The 99th Civil Engineer Squadron provides maintenance, repair, design and construction support for facilities and infrastructure, fire protection and crash rescue, disaster preparedness, environmental compliance, explosive ordnance demolition and oversight for privatized military family housing (Tab CC-15).

i. 99th Logistics Readiness Squadron

The 99th Logistics Readiness Squadron provides motor vehicle operations and maintenance, traffic management, fuels management and supply orders (Tab CC-15).

4. SEQUENCE OF EVENTS

On the day of the mishap, Thursday 8 September 2011, Nellis AFB conducted a routine flying schedule. The 57th Wing and two TDY units, the 388th Fighter Wing from Hill AFB and the 23rd Wing from Moody AFB, were conducting live ordnance flying operations (Tab V-11.6). Aircraft operations using live ordnance are launched and recovered from the revetments area because the revetments provide the appropriate explosive safety separation between armed aircraft and because their remote location on the base affords the opportunity to point forward firing munitions away from populated areas (Tab V-11.6).

The 57th Wing launched 10 sorties that morning between 0915 and 0950 hours and all were successfully recovered at Nellis AFB (Tab T-3).

At approximately 1430 hours the Supervisor of Flying (SOF) for the swing shift came on duty at the control tower and saw a weather forecast for unremarkable winds of approximately 16 knots from the north (Tab R-4).

At 1500 hours the 57th AMXS swing shift came on duty and began preparations to launch 8 sorties with planned departure times between 1600 and 1635 hours (Tab T-3). By 1610 hours, the AMXS AMU superintendent entered the maintenance facility and expressed concern about the changing weather (Tab V-1.3). He directed the production superintendent to return to the revetments area to ensure that maintenance personnel took appropriate actions to protect the aircraft from dust and debris (Tab V-12.3). Maintenance personnel then commenced closing aircraft canopies, removing aircraft access ladders, installing aircraft engine intake and exhaust covers and other related tasks (Tab V-1.3).

Maintenance leadership was particularly concerned about aircraft tail number 89-2048 (2048) since it had been placed on aircraft jacks and the engine had been removed for maintenance (Tab V-1.3, V-12.3). Severe weather could shift the aircraft, tip it off the jacks and cause significant damage. For that reason, flight leaders stayed with the operation to ensure personnel safely accomplished the task as the weather deteriorated (Tab V-12.3).

At 1631 hours, a high wind advisory was issued for Nellis AFB (Tabs B-2, BB-22). The advisory was for Phase 1 winds between 25 – 34 knots from 1700 to 2000 hours (Tab BB-17).

The advisory was received at the Maintenance Operations Center (MOC) at 1645 and transmitted to maintenance personnel in accordance with established procedures (Tab V-6.3). The Tower logged the advisory at 1650 hours (Tab BB-15).

At 1655 hours, the weather advisory was updated to a Phase 2 wind advisory indicating potential winds between 35 and 50 knots from 1700 to 1900 hours (Tabs V-6.3, BB-22). The tower logged the advisory at 1655 hours (Tab BB-15). The tower camera video shows an approaching heavy dust cloud (Tab DD-3). The tower log noted at 1658 hours that a gust front hit the airfield reducing visibility to zero while personnel on scene described the approaching dust storm as a “wall of sand” (Tabs BB-15, Tab V-9.5).

The high winds caused a base wide power outage, causing the tower video camera to cut out at 1655 hours (Tabs DD-3, R-7). The tower swayed and tower personnel began evacuation procedures based on an observed 72 knot wind gust (Tab R-7 – 12).

This Phase 2 wind advisory was received by the MOC at approximately 1700 hours (Tab V-6.3). MOC attempted to transmit the message however the base power outage affected the MOC’s radio, preventing them from transmitting in accordance with procedures (Tab V-6.3).

Between 1658 and 1700 hours, the sunshade structure at the revetment area collapsed (Tabs BB-15, DD-3). A ground-level wind measurement device on the Nellis AFB airfield registered a wind gust of 56 knots at 1658 hours (Tab BB-15). Personnel on site saw the collapse happen suddenly and described it as occurring in a manner similar to a sheet of ice sliding off of a roof (Tabs V-1.4, V-12.6). Visibility was so poor that other witnesses on scene but not immediately underneath the structure could not even see the collapse (Tab R-13).

The tower camera returned to operation at 1702 hours, revealing the collapsed sunshades and subsequent recovery effort (Tab DD-3).

Immediately after the sunshade collapsed, on-site leadership sprang into action and began search and recovery operations immediately (Tab V-1.5). The production superintendent called in a ground emergency without delay and the expeditor immediately repeated the call to ensure successful transmission (Tabs R-14, V-1.5, and V-2.3). Maintenance and security personnel quickly searched the site and identified approximately 40 personnel on scene; none were severely injured (Tab V-1.8). Flight leadership initially directed all personnel to recover to the building directly south of the revetment ramp area (Tab V-1.4). However, after observing the fallen structure in contact with live ordnance on the aircraft, personnel were redirected to the golf course since it was the pre-designated rendezvous location for a live ordnance emergency (Tab V-1.6, V-2.3). During this time, a HH-60 also landed near the site, making itself available in the event it was needed to transport injured personnel (Tab V-3.4, V-2.3 – 2.5).

Once they arrived at the golf course, leadership again took accountability for personnel (Tab V-1.6). They identified eight personnel who sustained minor injuries warranting medical attention, made certain they were fit for transport by unit personnel, and ensured that they were taken in privately owned vehicles to the installation medical facility (Tabs V-1.6, V-2.3, and C-2).

After maintenance leadership sent personnel requiring medical attention for treatment, they made preparations for recovery of the aircraft, munitions, vehicles and equipment damaged by the sunshade collapse (Tab V-12.4). Nellis AFB Fire Department personnel had already arrived and established incident command (Tab V-11.3).

The collapsed shelter had trapped (10) F-16 and two (2) A-10 aircraft under its roof (Tabs C-2, P-3). In addition, four (4) AIM-120 missiles mounted on the aircraft, twenty-one (21) pieces of Aerospace Ground Equipment (AGE), and nine (9) vehicles were also under the collapsed sunshade (Tab P-4 – 5). The total dollar value of the damaged aircraft vehicles and equipment was \$7.4M (Tab P-5).

Initial recovery operations included shutting down power and shutting off the in-ground aircraft refueling system that served the revetment area parking spaces (Tab V-11.3). Subsequently, munitions were safed and plans were developed to remove the aircraft trapped under the collapsed sunshade (Tab V-1.8).

Support personnel from the 99th Civil Engineer Squadron brought two large cranes to the site with plans to accomplish the operation the following day (Tab V-1.8). However, after seeing a forecast of high winds, leadership determined the best course of action was to proceed immediately (Tab V-1.8, V-12.4). Maintenance and Civil Engineer personnel then proceeded to free each aircraft and to manually push them out of the parking locations, working through the night until they finished late the next day (Tab V-1.8, V-12.4).

5. MAINTENANCE.

This section is not used. Maintenance of the sunshade will be addressed in Section 6 below.

6. EQUIPMENT, VEHICLES, FACILITIES AND SYSTEMS.

a. Background

The Revetment Sunshade (sunshade) was located on the southwest side of the Nellis AFB flightline. Sunshades are pre-manufactured steel structures which protect aircraft, aircraft maintenance personnel, aircrews and equipment from direct sunlight (Tab U-4, U-13, and U-39 – 40). The area is known as “revetments” because the aircraft parking spaces are separated by 75 feet long by 5.5 feet wide by 10 feet high earthen-filled, concrete-capped, metal bin revetments. The primary mission for the revetments parking area is the launch and recovery of fighter aircraft armed with live ordnance (Tab V-11.6). The revetments were installed to provide explosive safety separation between the aircraft when they are armed with live ordnance. The revetments area was capable of supporting F-15, F-16, F-22 and A-10 aircraft.

Aircraft sunshades are defined as organizational equipment and are therefore purchased and maintained by the using organization (Tab O-19). This definition was staffed at Headquarters Air Force and codified in an Air Force Civil Engineer memorandum dated 29 April 2002 (Tab O-19). The 57th Wing at Nellis AFB identified a need to protect Airmen and aircraft from intense heat during the summer (Tab U-13). The sunshade was originally sited in 2000 and installed by contract in 2000 and 2003 (Tab O-90). The sunshades were procured as commercial

items on five separate task orders against GSA schedule contract GS-07F-0419K (Tab O-90). The vendor for all of the sunshades was AGATE Steel Inc. from Scottsdale, Arizona (Tab O-90).

b. Design of the Sunshade.

The sunshade was a pre-engineered steel frame consisting of 25 linked bays, each 100' wide, 75' deep, and 25' high, for a total dimension of 2500' x 75' x 25' (Tabs Y-3, BB-7). The sunshades and revetments were oriented parallel to the 03-21 runways, though for the purposes of this description, the minor dimension of the structure (75') will be referred to as E-W, and the major dimension (2500') will be referred to as N-S. See Figure 2 below for a picture identifying the major components of the sunshade. The revetments were numbered 1-25 from the south to the north (Tab BB-7).

The primary structure of the sunshade was composed of I-shaped structural steel columns and girders. The columns were in E-W rows, each consisting of 4 columns spaced at 25', and each column row was spaced at 100', offset approximately 6" north of each revetment wall. The columns were oriented with the strong axis N-S. The girders were each 100' long consisting of two 50' members bolted together in the center of each bay. With the exception of the north and south end column rows, all columns supported two girders, one to the north and one to the south (Tab BB-7).

The secondary structure was composed of square hollow structural section purlins, flexural members that bridged the 25' gap between adjacent girders and to which the fabric sunshade was attached. The purlins were oriented E-W and bolted to the girders every 5'. The purlins alternated between two types, level and elevated. Thus the sunshades had a series of open gables along the east and west sides (Tab BB-7).

The sunshade structure was designed to resist wind loads in both the E-W and N-S directions. In the N-S direction, the column-girder joints were braced by double-angle knee bracing. In the E-W direction, the wind bracing consisted of two cable cross-braces, one each in the east and west bays of each column row. Additionally, cable cross-bracing connected across every four purlin spans in the center bay along the entire length of the sunshades, forming a partial structural diaphragm that transferred lateral loads from the roof assembly to the E-W and N-S wind bracing. All cable cross-bracing was steel 5-wire strand connected to the structure using an eye splice and eyebolts held in place using hillside washers (Tab BB-7 – 8).

Any lateral load would have a tendency to cause horizontal movement, or drift, of the elevated structure. In the N-S direction, horizontal movement would have been resisted in tension and compression by the knee bracing on the windward and leeward sides of the column-girder frame, respectively, and by the columns in flexure. In the E-W direction, drift would have been resisted in tension by the cable cross-bracing in the east and west bays of each column row and by the columns in flexure. The low-windward-to-high-leeward cable in each of the two cross-bracings would be engaged in tension while the other two cables would begin to slacken, unable to carry a compression load. The cables in the roof diaphragm would resist in tension any differential E-W widening and any differential N-S drift of the center two of the four column-girder frames, keeping the column rows aligned (Tab BB-8). According to the provisions of the governing code at the time of design, the 1997 Uniform Building Code, the design wind load on the

sunshade was 80 mph with Exposure C. Analysis of the resulting lateral forces and the structural capacity of the sunshade as described shows that the sunshades were adequately designed to resist wind loads in the E-W direction (Tab BB-14).

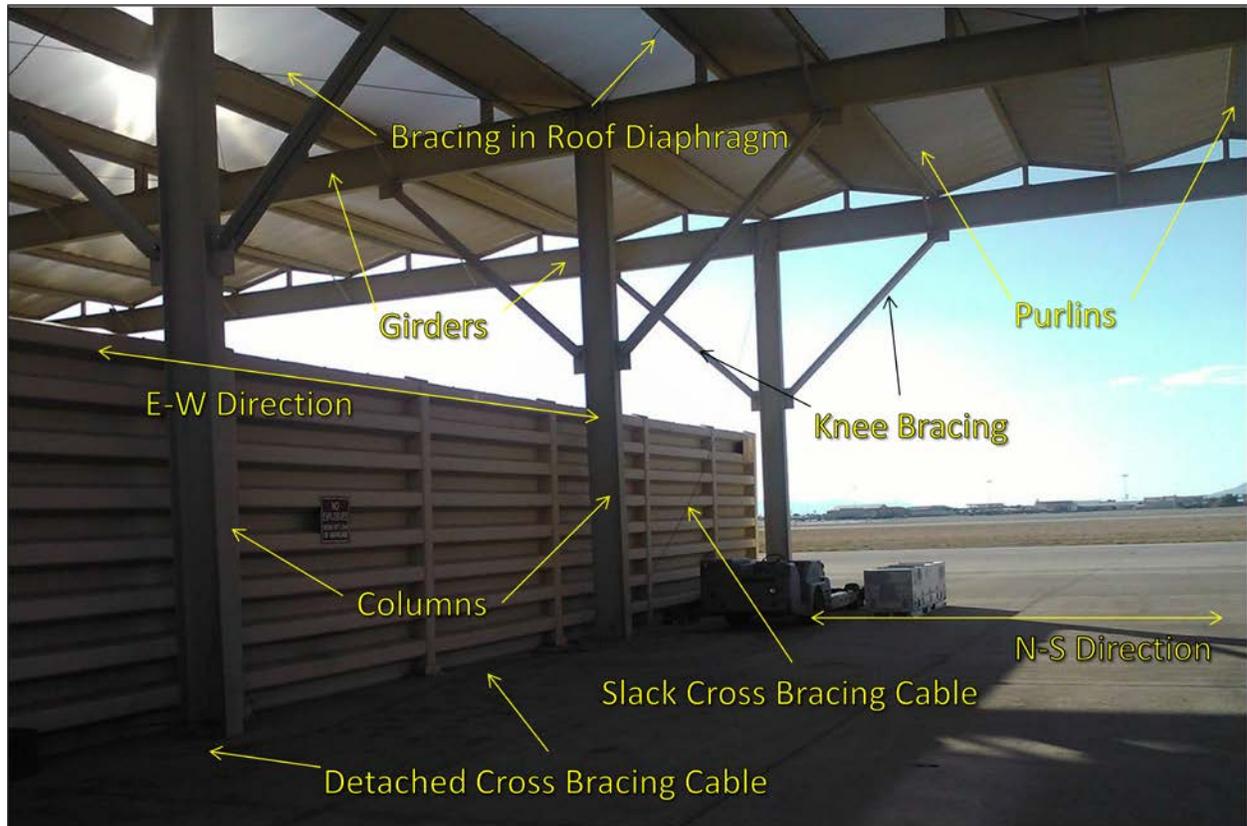


Figure 2. Condition Before Collapse

c. Installation and Acceptance of the Sunshade.

The sunshade structure was installed by the vendor AGATE Steel Inc. incident to the purchase contract (Tab O-90). Contract documents regarding the purchase and installation are no longer available. In accordance with Federal Acquisition Regulation (FAR) Part 4.805 (b)(2), the contract retention period for contracts (and related records or documents, including successful proposals) exceeding the Simplified Acquisition Threshold for other than construction is six (6) years three (3) months after receipt of final payment (Tab O-90). Therefore, all information relating to the acquisition details, including approvals, inspection and acceptance of the sunshades had been disposed of (Tab O-90 – 91). Information available from the Wide Area Workflow and Defense Accounting and Finance Service indicate who accepted the sunshade. For each task order, a member of the 57th Wing Resource Advisor staff accepted the sunshade and the required installation (Tab O-91 – 92).

d. Sustainment/Maintenance of the Sunshade.

The 57th Maintenance Group had not contemplated inspection and maintenance actions for the revetment sunshade subsequent to its installation (Tab V-11.4, V-12.5). Research did not

identify any contract actions for the maintenance of the sunshade except for a \$4,500 task order awarded 28 August 2009 to replace fabric on the structure (Tab O-90).

Over the lifetime of the sunshade, questions arose over the ownership of the sunshade. Contract records clearly indicate 57th Wing personnel accepted the sunshade upon installation (Tab O-91). Maintenance personnel were not certain of the ownership of the equipment (Tabs V-11.4, V-12.5). As further evidence of the lack of ownership of the sunshade, in the summer of 2011, 57th Maintenance Group sought and received approval from ACC/A4 to award a contract for inspection and maintenance of aircraft sunshades at Nellis AFB (Tab U-43). The revetment sunshade was not included in this request for inspection and maintenance (Tab U-43). Maintenance personnel suggested ownership was unclear because the revetment ramp area was used by all Nellis aircraft as well as all TDY aircraft when missions included live ordnance (Tab Tabs V-11.4, V-12.5).

e. Condition of the Sunshade Prior to Collapse.

Photos taken of the sunshades over revetments 16-18, 21, and 23 show examples of the disrepair of the sunshades prior to the collapse. Of the 18 E-W cross-bracing cables visible in the pictures, 6 were slack (all east wind-resisting) and 6 were detached (all west wind-resisting) (Tab Y-6 – 11). Of the 16 structural diaphragm cross-bracing cables, 3 were slack or disconnected (Tab Y-12). Two column base plates showed significant prying deformation and loosening of the nuts on the anchors (Tab Y-13 – 14). Consistent with these failures and deformations, the eastern column in revetment 17 appears to have drifted out of plumb to the east (Tab Y-15). A 57th Wing Safety inspection of the revetment sunshades in February or March 2011 noted at least one damaged, slack, or detached cable in the E-W cross-bracing in each of the column rows in revetments 13-22 (Tabs BB-8, V-7.3).

Given the condition of the sunshade as described above, the structure's resistance to wind loads in the N-S direction would have been slightly reduced due to the condition of the diaphragm cables, but the majority of the capacity would remain due to the knee bracing. In the E-W direction, however, the designed wind resistance came solely from the four cross-bracing cables, and only two of these cables would be engaged in tension by a given direction of wind loading. As the photographic evidence reference above shows, both cables to resist a west wind were missing in each of the column rows of revetments 16, 17, and 18. Thus, the designed west wind bracing was certainly non-existent in those revetments and may have been reduced or non-existent in other revetments (Tab BB-8).

f. Condition of the Sunshade After Collapse.

The entire sunshade structure drifted to the east and fell, coming to rest on the revetments, aircraft parked under the sunshades, GOVs parked in the vicinity of the sunshades, or the ground (Tab Y-16 – 19). The column base plate assemblies generally exhibited a complete tension failure of the adhesive of the windward post-installed anchors, crushing of the concrete surrounding the leeward post-installed anchors, warping of the base plates, and/or failure of the windward column-base plate welds (Tab Y-20 – 22). Most columns also deformed, bending about their weak axis near the midpoint (Tab Y-23). Nearly all west wind cable bracing failed at the eye splice or by eyebolt straightening (Tab Y-24 – 25). The girders exhibited significant torsional warping, (i.e. twisting) though the column-girder joints, girder butt joints, and knee

bracing and respective connections were all intact (Tab Y-26 – 27). The majority the purlin-girder bolts failed in tension, breaking and scattering hundreds of bolt heads and nut-bolt thread assemblies across the surrounding area (Tabs BB-8 – 9, Y-28 – 29).



Figure 3. Condition After Collapse

7. ENVIRONMENTAL CONDITIONS

a. Winds.

The day of the mishap began with mild winds of 10 knots or less (Tabs BB-3, F-9 – 11). The forecast for the day did identify a potential for thunderstorms, but indicated it was likely in central Nevada and not in the Nellis area (Tab V-13.2). At around 1300, thunderstorms started popping up in northern Nevada, north of Indian Springs and Creech (Tab V-13.3). Since the winds were blowing from the southeast, the thunderstorms were pushing away from Nellis and severe weather was not indicated for the area (Tab V-13.3). Likewise, the meteorological forecasting systems, met-watch and radar, did not predict severe weather for Nellis (Tab V-13.3).

Around 1500L rain showers appeared to the northwest of Nellis near Creech but no thunderstorms were detected (Tab V-13.3). Winds did not exceed 30 knots (Tab V-13.3). However, the rain showers became, at some unrecorded time, a thunderstorm and collapsed (Tab V-13.3 – 13.5). The collapse occurred because a storm cell is an air mass that contains up and down drafts in convective loops (Tab V-13.3). As the storm cell suddenly lost energy, its upward drafts ceased (Tab V-13.3). Without upward drafts to keep the dense cold air aloft, the storm cell collapsed with unexpectedly strong and sudden down rush of winds (Tab V-13.3).

Even as the storm cell collapsed, the radar still did not register it as a storm (Tab V-13.3). It only appeared on the radar scan as a storm cell just as Nellis was already hitting warning-level winds (Tab V-13.3). Within four minutes, at 1659L, the Automated Meteorological Observation Sensor (AMOS) reported that the predominant wind speed had increased to 39 knots from the west-southwest, reaching a peak wind speed of 58 knots at 1701L (Tabs BB-3, F-9 – 11).

After the severe gust the winds decreased in strength, dropping to 7 knots by 1709L (Tabs BB-3, F-9 – 11). The wind remained mild until, at 1713L, the AMOS reported a second strong wind gust of 48 knots (Tabs BB-3, F-9 – 11). The winds again dropped to less than 10 knots with no more severe weather activity for the rest of the evening (Tabs BB-3, F-9 – 11).

A rain shower that develops quickly into a storm cell and collapses, causing a highly localized weather event like the one observed on 8 September, is a highly unusual phenomena and not able to be forecasted (Tab V-13.6).

b. Warnings, Restrictions and Procedures.

On 8 September 2011, Nellis AFB issued weather warnings in accordance with established procedures. No issues regarding weather warnings, restrictions or procedures were deemed relevant to this accident.

8. PERSONNEL QUALIFICATIONS.

As discussed in Section 6 above, no inspection or maintenance procedures had been developed regarding the revetment sunshade. Because no procedures had been developed, no specific qualifications had been established.

9. MEDICAL FACTORS.

Due to the nature of the event, no physical or mental health attributes of the personnel involved in the incident were deemed relevant to the accident.

Although emergency responders arrived in a timely manner, there were no life threatening injuries or any requiring treatment at the scene. Eight personnel were seen at the Nellis AFB medical treatment facility. Injuries were minor and included only bruises, sprains, and minor cuts (Tabs C-2, V-1.6, V-5.3, V-9.3 – 9.5, V-10.3 – 10.4, V-12.4).

10. OPERATIONS AND SUPERVISION.

a. Operations.

Interviews did not identify any relevant operations tempo or organizational experience level issues relevant to this accident.

b. Supervision/Oversight.

As previously documented, the revetment sunshade was defined to be organizational equipment (Tab O-19). The 57th Maintenance Group purchased the sunshade with five contract task orders issued in 2000 and 2003 (Tab O-90). The 57th Maintenance Group did not have an active inspection and maintenance program for the revetment sunshade (Tab V-11.6). Over the lifetime of the sunshade, questions arose over the ownership of the sunshade. Contract records clearly indicate 57th Wing personnel accepted the sunshade upon installation (Tab O-91). Maintenance personnel were not certain of the ownership of the equipment (Tab V-11.4, V-12.5). As further evidence of the lack of ownership of the sunshade, in the summer of 2011, 57th Maintenance Group sought and received approval from ACC/A4 to award a contract for

inspection and maintenance of aircraft sunshades at Nellis AFB (Tab U-43). The revetment sunshade was not included in this request for inspection and maintenance (Tab U-43). Maintenance personnel suggested ownership was unclear because the revetment ramp area was used by all Nellis aircraft as well as all TDY aircraft when missions included live ordnance (Tab V-11.4, V-12.5).

11. HUMAN FACTORS ANALYSIS

The board evaluated human factors relevant to the mishap using the analysis and classification system model established by the Department of Defense (DoD) Human Factors Analysis and Classification System (HFACS) guide, implemented by AFPAM 91-204, *USAF Safety Investigations and Reports*, dated 24 September 2008. A human factor is any environmental, technological, physiological, psychological, psychosocial, or psycho-behavioral factor a human being experiences that contributes to or influences his performance during a task. The DoD has created a framework to analyze and classify human factors and human error in mishap investigations. The framework is divided into four main categories: Acts, Preconditions, Supervision, and Organizational Influences. Each category is further subdivided into related human factor subcategories. The main categories allow for a complete analysis of all levels of human error and how they may interact together to contribute to a mishap. This framework allows for evaluation from the unsafe acts that directly are related to the mishap through the indirect preconditions, supervision, or organizational influences that may have led to the mishap. The potentially relevant factors to this accident are discussed below.

a. Acquisition Policies/Design Processes

Acquisition Policies/Design Processes is a factor when the processes through which aircraft, vehicle, equipment or logistical support are acquired allows inadequacies or when design deficiencies allow inadequacies in the acquisition and the inadequacies create an unsafe situation. Contract documents demonstrate the sunshades were purchased as equipment from a GSA schedule contract (Tab O-90). This acquisition process did not require a technical design review, technical government oversight of the installation of the sunshades or require the contractor to provide operation and maintenance documentation (Tab U-39). In addition, no Air Force guidance established an acquisition process for sunshades which forced each installation to develop their own requirement and specifications and purchase their sunshades (Tab O-77).

b. Perceptions of Equipment

Perceptions of Equipment is a factor when over or under confidence in an aircraft, vehicle, device, system or any other equipment creates an unsafe situation. Interviews with personnel from the Maintenance Group demonstrate that personnel did not consider the possibility that the sunshade could collapse (Tab V-11.7). As a result of this over confidence in equipment, no inspection and maintenance procedures were developed and no advice from others was sought regarding the sunshade (Tab V-4.4).

c. Procedural Guidance/Publications

Procedural Guidance/Publications is a factor when written direction, checklists, graphic depictions, tables, charts or other published guidance is inadequate, misleading or inappropriate

and this creates an unsafe situation. Interviews with personnel from the Maintenance Group demonstrated that no inspection procedures or checklists were developed for the sunshade when they were installed (Tab V-11.4, V-12.5). No checklists or procedures existed until summer 2011 when the Maintenance Group sought permission to establish an inspection and maintenance contract for their sunshades (Tab V-11.4, V-12.5). ACC/A4 approved this inspection and maintenance contract on 9 September 2011 (Tab U-43). As was noted previously, the revetment sunshade was not included in this inspection and maintenance contract request (Tab U-43).

12. GOVERNING DIRECTIVES AND PUBLICATIONS.

a. Primary Operations Directives and Publications.

1. Joint Publication 1-02, *DoD Dictionary of Military and Associated Terms*, as amended through Apr 10
2. Air Force Instruction 91-202, *The US Air Force Mishap Prevention Program*, dated 18 Feb 10
3. Air Force Instruction 51-507, *Ground Accident Investigations*, dated 28 May 2010
4. Air Force Manual 15-111, *Surface Weather Observations*, dated 10 March 2009

b. Other Relevant Directives and Publications.

At the time of the accident, no Air Force Instructions governing Aircraft Sunshades were in force. A draft of a proposed AFI was provided for review during the investigation. (Tab O-77)

29 November 2011

, Colonel, USAF
President, Ground Accident Investigation Board