REPORT

OF ACCIDENT TO

PAWAN HANS HELCOPTER LTD Mi-172 HELICOPTER

VT-PHF ON 19TH APRIL 2011 AT

TAWANG, ARUNACHAL PRADESH

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GOVERNMENT OF INDIA
MINISTRY OF CIVIL AVIATION

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Mi-172 HELICOPTER VT-PHF
ON
19TH APRIL 2011 AT
TAWANG, ARUNACHAL PRADESH
BY
COMMITTEE OF INQUIRY
COMPRISING

Air Marshal (Retd) PP RAJKUMAR, PVSM, AVSM	- Chairman
Air Commodore (Retd) RAVI KRISHAN, VM	- Member
Wing Commander (Retd) RABINDER SINGH	- Member
Wing Commander VIPIN SHARMA	- Co-opted Member
Shri MJ SINGH, Deputy Director of Air Safety, O/o DGCA	- Secretary

GOVERNMENT OF INDIA
MINISTRY OF CIVIL AVIATION

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ABBREVIATIONS USED

A

AAI	Airport Authority of India
A/C	Aircraft
ADF	Automatic Direction Finder
AFCME	Air Force Central Medical Establishment
AFSO	Air Field Safety Operator
AME	Aircraft Maintenance Engineer
AMSL	Above Mean Sea Level
ANNEX	Annexure
AP	Arunachal Pradesh
ASC	Air Safety Circular
ATC	Air Traffic Controller
ATM	Air Traffic Management
AUW	All Up Weight

C

CAR	Civil Aviation Requirement
CB	Cumulonimbus Cloud
CG	Centre of Gravity
CHPL	Commercial Helicopter Pilot License
CO	Carbon Monoxide
COI	Committee of Inquiry
CMD	Chairman & Managing Director
CMO	Chief Minister's Office
CN	Cyanide
CNS	Communication and Navigation Surveillance
CRS	Certificate of Release to Service
CRM	Crew Resource Management
CVR	Cockpit Voice Recorder

D

DDAS	Deputy Director Air Safety
Dept	Department
DFDR	Digital Flight Data Recorder
DGCA	Directorate General of Civil Aviation
DGM	Deputy General Manager
DGR	Dangerous Goods

DME	Distance Measuring Equipment
DP	Dew Point
DST	Department of Supply and Transport

E

ED	Executive Director
ELT	Emergency Locator Transmitter
ETA	Estimated Time of Arrival

F

FAR	Federal Aviation Regulation
FDR	Flight Data Recorder
Ft	Feet

G

GM	General Manager
Govt.	Government
Govt. of AP	Government of Arunachal Pradesh
GPS	Global Positioning System

H

HAL	Hindustan Aeronautics Limited
Heptr	Helicopter
HF	High Frequency
HRD	Human Resource Development
HP Cocks	High Pressure Cocks
hPa	Hecta Pascal
Hrs	Hours

I

IAC	Interstate Aviation Committee
ICAO	International Civil Aviation Organization
IGE	In Ground Effect
ILS	Instrument Landing System
IOC	Indian Oil Corporation
IR	Instrument Rating

K

Kgs	Kilograms
Kts	Knots

L

Lat	Latitude
Long	Longitude
Ltr	Litres
L/Min	Litres/Minute

M

Met	Meteorological
MoCA	Ministry of Civil Aviation
M/Mts	Meters
MGB	Main Gear Box
MHz	Mega Hertz

N

NIASS	National Institute for Aviation Safety & Services
NSOP	Non-Scheduled Operator Permit

O

OAT	Outside Air Temperature
OGE	Out of Ground Effect

P

PHHL	Pawan Hans Helicopters Limited
PIC	Pilot In Command
PM	Post Mortem
PWD	Public Works Department

R

Retd.	Retired
RT	Radio Transmission

S

Secs.	Seconds
SHP	Shaft Horse Power
S/No.	Serial Number
SOP	Standard Operating Procedures

V

VFR	Visual Flight Rules
VHF	Very High Frequency
VHT	VT-PHT (Call Sign of Parked Helicopter)
VOR	VHF Omni directional Range
VSI	Vertical Speed Indicator

W

WSO	Watch Supervisory Officer

LIST OF PHOTOGRAPHS

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1. FACTUAL INFORMATION

REPORT OF ACCIDENT TO PAWAN HANS HELICOPTERS LIMITED Mi-172 HELICOPTER VT-PHF AT TAWANG IN ARUNACHAL PRADESH ON 19.04.2011

(a)	Aircraft		
	Type and Model	:	Mi-172 Helicopter
	Nationality	:	Indian
	Registration	:	VT-PHF
(b)	Owner/Operator	:	Pawan Hans Helicopter Limited, New Delhi
(c)	Date of Accident	:	19.04.2011
(d)	Time of last Contact with ATC	:	1352 IST
(e)	Last Point of Departure	:	Guwahati Airport
(f)	Point of intended Landing	:	Tawang Civil heliport (UgyenSangpo Heliport)
(g)	Geographical Location of Accident	:	At the Northern edge of Tawang Helipad Elevation – 8250 feet (2515 m) Lat 27°34’23” N Long 91°51’57” E
(h)	Type of Operation	:	Non-scheduled
(i)	Phase of Operation	:	Landing

(All Timings in the Report are in IST i.e. UTC + 5:30)

SYNOPSIS

Pawan Hans Helicopter Limited Mi-172 helicopter VT-PHF was engaged by the Govt. of Arunachal Pradesh and was operating a flight on sector Guwahati-Tawang on 19.04.2011. The helicopter was carrying a total of 23 persons comprising 4 crew members and 19 passengers including an Aircraft Maintenance Engineer (AME) of PHHL. The flight from Guwahati till approach to Tawang Civil Helipad was uneventful. However during the final approach to the helipad, helicopter descended below the level of the helipad and its left undercarriage impacted with the concrete edge of helipad and it toppled over to left. After rolling to the left, helicopter caught fire. There were 19 fatalities including 2 crew members and an AME.

The accident was immediately notified by Pawan Hans Helicopters Limited and the WSO Guwahati to DGCA. The investigation was ordered with the notification of a Committee of Inquiry appointed by the Government of India, Ministry of Civil Aviation under Rule 74 of Aircraft Rules, 1937 vide order No AV/15013/001/2011-DG dated 23.04.2011 to investigate into the cause of this accident with the following members:

Air Marshal (Retd) P.P. Rajkumar, PVSM, AVSM	- Chairman
Air Commodore (Retd) Ravi Krishan , VM	- Member
Wing Commander (Retd) Rabinder Singh	- Member
Wing Commander Vipin Sharma	- Co-opted Member
Shri M.J. Singh, DDAS, DGCA	- Secretary

As per the obligations under ICAO Annex 13, notification was sent to the Manufacturer and ICAO and the CVR and FDR were sent to Interstate Aviation Committee, Moscow, Russia for readout analysis.

The weather was reported to be fine and the accident occurred during day light hrs at 1354 hrs. Soon after toppling to the left the cabin and cockpit were filled with smoke and later on it caught fire. The portable fire extinguishers which were available at the helipad were ineffective and a fire tender reached the site after about half an hour. The Pilot and the Flight engineer escaped through the Perspex bubble of the cockpit. One passenger came out by breaking the right window in the cabin and the other three passengers came out from the rear exit near the tail boom. The helicopter was totally destroyed by fire.

1.1 History of Flight

The Government of Arunachal Pradesh (Govt. of AP) had signed a wet lease agreement with M/s Pawan Hans Helicopter Limited (PHHL) for airlift of passengers from Guwahati to Tawang as per their requirements in Mi-172 helicopters.

On 18.04.2011, the Mi-172 helicopter VT-PHF had carried out a night halt at Tawang. The co-ordinates of Tawang helipad are 27^{o} 34'23" N and 91^{o} 51'57" E. It is located at an elevation of 8250 ft AMSL. On 19.04.2011, the crew was required to operate a flight Tawang-Guwahati-Tawang.

Tawang was not a designated night halt station. On 18th & 19th April 2011, a Conference on North East Ministers Rural Development Review Meeting was being held at Tawang in which a Union Cabinet Minister and the Chief Minister of Arunachal Pradesh were participating. Hence, the Chief Minister's Office (CMO) had desired that the Mi-172 be utilized for airlift of participants and other passengers for the Conference, involving a night halt at Tawang. This decision was conveyed to the crew after they had reached the helipad at Naharlagon in Itanagar, their home base, on 18.04.2011. This caught them unawares, as they did not have a night kit. The Pilot in Command, therefore, had taken an advance of Rs. 5000/- from the PHHL authorities at Itanagar, towards night kit and warm clothing. The Govt of AP made the accommodation and other arrangements at Tawang, which were adequate.

The crew had attended a social/cultural evening on the invitation of the Chief Minister on the previous day at Tawang. Drinks were also served during the social/cultural evening. The show was only for the dignitaries attending the conference. This was followed by dinner which had finished at about 2100 hrs. The Captain has stated that he had proper sleep for at least 8 hours from about 2200 hrs. They had adequate time before the sortie which was at 1100 hrs on 19th April 2011. Captain had also stated that there were no mental or physical worries during the night.

Since facility for pre-flight medical did not exist at Tawang, the crew did not undergo that test, next morning. The flight plan for the day was filed with ATC Guwahati by fax. The flight plan was filed under VFR.

The helicopter was cleared for flight by the AME at 1000 hrs at Tawang. The total fuel on board was 1400 litres. The flight took off from Tawang at 1100 hrs and landed uneventfully at 1205 hrs at Guwahati Airport.

After landing at Guwahati, the Pilot in Command (PIC) reported NIL snags in the Flight Log of PHF. The Flight Engineer had carried out the post-flight inspection, which included the nose and main oleo extensions, and reported everything to be normal. The helicopter was left with 880 litres of fuel after landing. 1320 ltrs of fuel Jet A1 were uplifted at Guwahati, to make the total fuel carried to 2200 ltrs.

Passenger handling, security check etc. was done by the Govt. of AP officials. The Captain had authority to restrict the number of passengers being carried, to keep the AUW within limits at the destination i.e. Tawang. The AUW limit for Tawang for a temperature of 16 ^{o}C is 10200 Kgs. For the flight from Guwahati to Tawang, 19 passengers were taken on board including two children and an AME (PHHL employee). Thus, the Persons on Board on the flight were 23 (including the flight and Cabin crew).The passengers were briefed by the Cabin Attendant on the use of Emergency Exits and other procedures prior to start up.

The helicopter took off from Guwahati at 1259 hrs. The procedure was to maintain 3000 ft until entry to Bhutan Valley then gradually climb to 7000 ft closer to Tawang the helicopter further climbs to the circuit height for the helipad. The helicopter changed over to Bhutan Valley Route frequency at 1323 hrs and no abnormality was reported. The transcript of the CVR indicates that the crew was friendly and comfortable with each other. Analysis of both the FDR and CVR indicate no abnormality in flight. At 1340 hrs, PHF came in contract with Tango Control i.e. the Air Force ATC detachment located at the Army Helipad, Tawang, which is about 800 ft higher in elevation and 2100 meters away from the heliport. Tango Control has a clear view of the civil helipad from their location. PHF gave the position report and ETA as 1351 hrs. Tango Control gave the temperature as 16^{o}C and QNH 1021 hPa and asked PHF to give a call for left base for 20.

The CVR conversation after this point records the Pilot expressing a desire to sleep for about an hour. The other Pilot agreed with him and said that they should have lunch and go to sleep. There are also comments by the

Flight Attendant on buying a few clothes (for the night halt) and washing the clothes (before the nap).

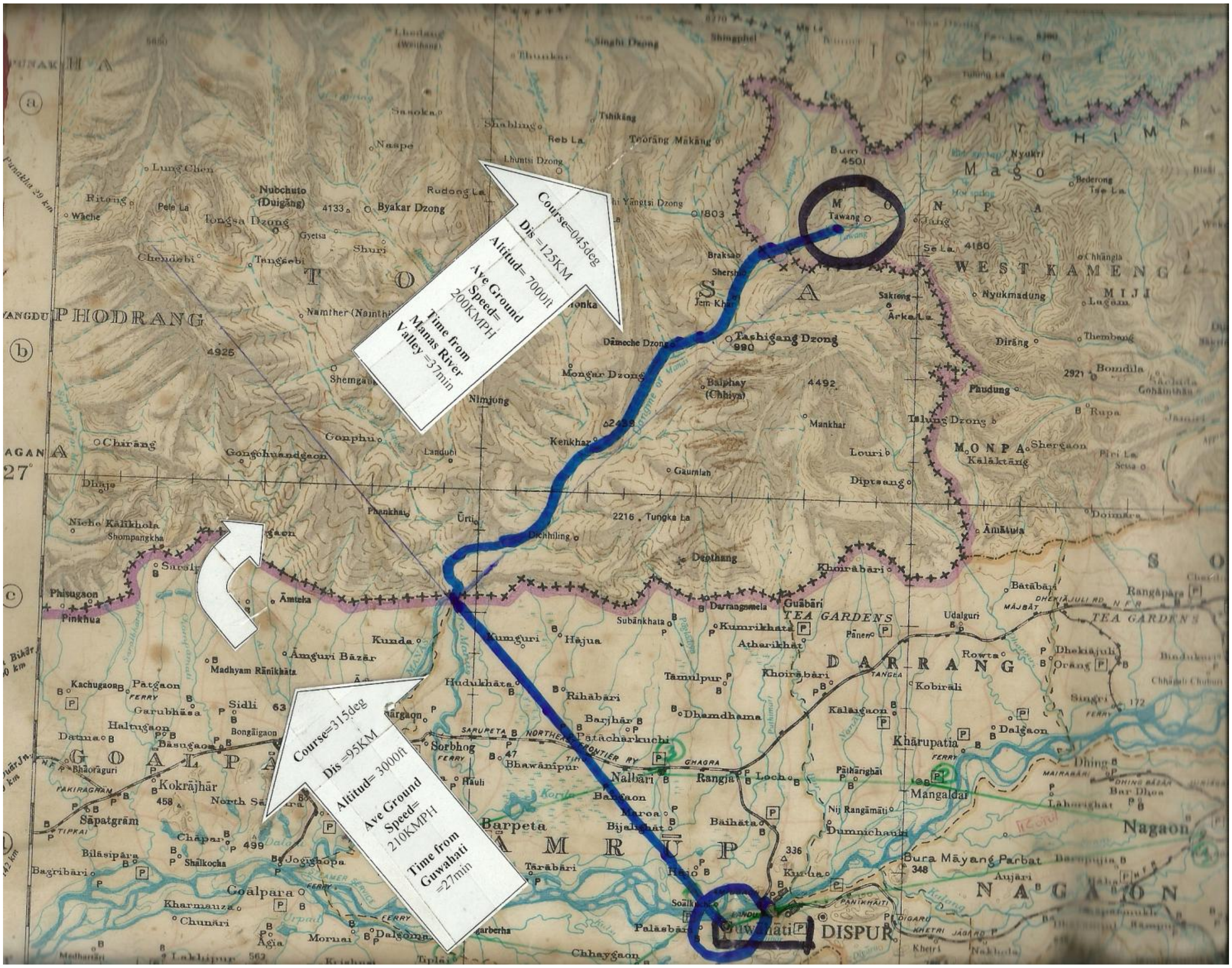


Photo : 1

Route Map : Guwahati - Tawang

As they approached the helipad, the Captain had observed that the winds had picked up. Tango Control passed the winds as 230/04 Kts and informed that another helicopter VHT was parked at the Western edge of the helipad. PHF had thanked Tango Control for this information.

Soon after, the Flight Engineer had carried out the Down Wind checks where the fuel quantity was read out to be 1500 ltrs. Other parameters were normal. The AUW with this fuel and 19 passengers on board works out to be about 10918 Kgs. The stipulated max AUW for Tawang at that temperature

was 10200 Kgs. However, the PIC has stated that since the Tango Control was not co-located with the Civil Helipad, their QNH and temperature readings are not reliable for the Civil Helipad. Hence, he relied on the helicopter Outside Air Temperature (OAT) gauge which was between 5^{o}-10^{o}C. For 10^{o}C, the prescribed AUW was 10600 Kgs. Thus, the helicopter was above the prescribed AUW limit for Tawang.

On finals, the Co-Pilot cautioned the PIC "Sir, check you height Sir". Subsequently, the Flight Engineer had called out "Ground speed 64 Kts, trimming roll to left, auto pilot neutral".

There was no bird hit reported throughout the sortie. Engine and other helicopter parameters were normal throughout this approach. About 1-2 secs before the accident, the last (indistinct) transmission appeared to be "clear up Sir, clear up". Soon after, the left undercarriage impacted on the edge of the helipad with a slight left bank, shallow angle and low speed, and the helicopter rolled over to the left.

Photo : 2 **Front View**

Photo : 3 **Rear View**

The rotors hit the beginning of the helipad and broke.

Photo:4 Rotor Hit Marks on Helipad

Within about 30 secs, the helicopter was enveloped in a thick black smoke. Govt of AP employees at the helipad, along with others who had come to receive the passengers, tried to put out the fire with the available fire extinguishers. It was not effective. People broke a domestic water pipe and tried to use that water to put out the fire. That was also ineffective. Subsequently, a water trailer from Paramilitary Forces and an Army Domestic Fire tender reached the spot after 30 minutes, which were able to suppress the fire. By this time most of the helicopter was destroyed by fire. The tail boom was the only portion which was not totally burnt, though damaged

On that day, there were six survivors from the accident. Two were aircrew and four were passengers. On impact the nose portion of the Perspex had broken. The Flight Engineer, who was initially stunned by the accident, recovered and was the first to exit through the nose. The PIC, had shouted to switch off the engines. He has stated that he tried to switch off the HP Cocks himself but could not do so because

of the smoke and near inverted angle of the helicopter. He also tried to rescue the Co-Pilot who had fallen forward towards the instrument panel by shouting at him to get out. When that proved ineffective, he tried to unbuckle him. The Co-Pilot's lap straps were fully tight and he could not unbuckle him. By this time, he was suffocating himself and losing strength. Therefore, he also went out through the break in the Perspex, gulped some air and again tried to rescue the co-pilot. When that was not possible due to smoke, he left to assist in the rescue work.

One of the passengers, who was sitting nearest to the cockpit, managed to break one of the starboard emergency exit windows with the help of the metal 'chock' (used to stop the wheels from moving after switch off). Three passengers were rescued through the emergency hatch at the rear of the helicopter. Of these three, one passenger succumbed to injuries at Delhi on 08.05.2011. Another, who appeared to be recovering, also succumbed on 09.06.2011, at Mumbai. Thus, 19 persons have died due to the accident and only four have survived.

1.2 Injuries to Persons

INJURIES	CREW	PASSENGERS	OTHERS
FATAL	2	16	NIL
SERIOUS	1	3[#]	NIL
MINOR	1	NIL	NIL

[#]A passenger who succumbed to the injuries after 50 days is included here.

1.3 Damage to Aircraft

The helicopter was destroyed due impact and the post-impact fire. Parts of the rotor blade were found even at 370 m. Other than the main rotor blades, rest of the helicopter and parts had stayed in the shallow depression on the ground close to the Northern edge of the helipad. Most of the tail boom including the intermediate and tail gear boxes and the tail rotor were burnt partially. Though cracked and broken at places, they were more or less together. Some of the debris, including the engines and portions of the main gearbox were shifted using cranes on the day of the accident itself. This was to facilitate recovery of bodies in a narrow space. Therefore the exact wreckage distribution after the accident could not be studied.

1.4 Other Damages

A newly constructed un-inhabited single storey building is located at the bottom of the depression at the Northern edge of the helipad. Some helicopter parts had fallen into the cemented gap between the retaining wall of the slope of the helipad and this building. The burning parts of the helicopter had blackened portions of the wall of this building. Some of the windows were also burnt partially.

1.5 Personnel Information

1.5.1 Pilot in Command (PIC)

License Type	Authorisation under Rule 160
Date of birth	20.12.1950
Date of issue	08.06.2007
Medical Validity	14.09.2011
IR Validity	21.08.2011
Proficiency check done	16.03.2010, 20.08.2010 and 14.04.2011
Route check done	11.03.2011
Hill/Mountain check done	11.04.2011
Last Simulator done	July 2007
Last DGR done	29.11.2009
Last CRM done	22-23.12.2010
Ratings on type	T6-G, DC-3, HT-2, Chetak, MI-8, MI-17 Mi-172
Total flying hours	4800 hrs
Experience on type	1600 hrs
Total Instrument flying	180 hrs

Flying hours

Last one year	451:55hrs
Last Six months	156:00 hrs
Last 30 days	17:00 hrs
Last 07 days	17:00 hrs
Last 24 hours	04:00 hrs

Before Joining Pawan Hans Helicopters Limited the PIC had served in the Indian Air Force from 22.1.1972 to 31.12.2002. In the IAF, he had flown trainer aircraft HT-2 and T6 G, Transport aircraft DC-3 and helicopter Chetak, MI-8 and MI-17. He flew a total of 3378: 05 hours in the IAF. However, as per his service log book, he last flew in the IAF on 13.4.1992. From that day till retirement from Air Force on 31.4.2002 he had not flown. He joined PHHL on 18.6.2007 and was sent to St. Petersburg, Russia in July 2007 by the PHHL for Mi-172 helicopter training. He did his ground training and simulator training on full-fledged simulator in Russia. On return, he did his flying training in September-October 2007 in Itanagar and commenced flying as Co-Pilot on Mi-172 helicopter. He was given command on Mi-172 on 06.01.2009. Thereafter he flew PIC as well as Co-Pilot on Mi-172 Helicopter.

Records (attendance register) also indicate that he did not attend office after 31.01.2011 till 10.04.2011. During this period he had undergone the medical examination at AFCME, Delhi on 1.3.2011 wherein he was detected to have hypertension and was declared unfit for flying for two weeks on account of hypertension. The medical assessment issued by DGCA, in the limitation, it was mentioned that he is fit to fly as PIC along with a qualified and experienced pilot. The pilot started flying from 11.04.2011 and flew continuously from 13.04.2011 to 19.04.2011 for seven consecutive days.

He had operated to Tawang Helipad many times in the past. He had also landed at this helipad, with another helicopter present on it, a few times. He does not recall ever having made an approach to this particular ‘H’ marking on this helipad.

Records indicate that after joining PHHL he was involved in a precautionary landing incident on 01.11.2008 in Bhutan valley as a Co-Pilot, while flying from Tawang-Guwahati, due No. 1 rectifier failure associated with No.1 & No.2 Generators failure and other associated failures. The said incident was investigated and was found to be due to technical failure.

1.5.2 Co-Pilot

License Type	Commercial Helicopter Pilot License
Date of Birth	01.09.1951
Date of issue	6.4.1995(Valid upto 20.03.2013)
Medical Validity	15.05.2011
IR Validity	27.12.2011
Proficiency check done	29.12.2010
Route check done	20.12.2010
Mountain/Hill flying done	28.12.2010
Last simulator done	January 2007
Last CRM done	22.12. 2010
Last DGR done	23.12.2010
Ratings on type	Chetak, Cheetah, B-206 B3, AS-350 BA, Mi-172 Open rating for all helicopters with AUW Not exceeding 1500 Kgs.
Total flying hours	6463:00 hrs
Flying hours as PIC	3200: 00 hrs
Experience on type	1530:00 hrs

Flying hours

Last one year	517:00 hrs
Last Six months	226:00 hrs
Last 30 days	34:15 hrs
Last 07 days	22:10 hrs
Last 24 hours	04: 40 hrs

He served in the Army for 24 years before taking up commercial flying. Prior to joining in PHHL he had flown with Mesco Airlines from 01.01.2007 to 20.04 2009. At the time of leaving the company he had total flying experience of 5140: 00 hours out of which he had flown 464: 00 hrs as P2 on Mi-172 helicopters. Before that he worked with India International Airways Ltd, Delhi from year 1999. Mi-172 theoretical training of 30 hours and simulator flying of 12 hours was done in January 2007 at St. Petersburg, Russia and thereafter he started flying on Mi-172 helicopter.

Records also indicate that he flew continuously from 11.04.2011 to 19.04.2011 for nine days accumulating 32:40 hours.

1.5.3 Flight Engineer

License Type	Authorisation under Rule 160
Date of Birth	10.07.1961
Date of Issue	30.07.2008
Medical Validity	16.08.2011
Last Route check	22.03.2011
Last refresher	21-22.03.2011
CRM/ DGR last done	17-18.04.2010
Ratings on type	In Indian Air Force: MI-8, MI-17 and AN-32 In PHHL: Mi-172
Total flying hours	4979:00 hrs
Experience on type	869:00 hrs

Flying hours

Last one year	518:40hrs
Last 90 days	99:35 hrs
Last 30 days	64:25 hrs
Last 07 days	05:40 hrs
Last 24 hours	03:30 hrs

The Flight Engineer prior to Joining in PHHL had worked in Indian Air Force since September 1979 and retired from Air Force in 30th September 2005. During his tenure in Air Force he worked as aero engine technician and aero engine fitter for nine years thereafter he worked as flight engineer. He performed the duty of flight engineer on MI-8, MI-17 and AN-32 type of helicopter. He had total of 4105 hours of experience in Indian Air Force.

He joined PHHL on 12th November 2007 as a flight engineer and passed the DGCA written examination after requisite training. Thereafter he started flying duties on Mi-172 helicopter from 14.2.2009.

1.5.4 Cabin Crew

Date of Birth 20.01.1956

He had served in the Air Force for 21 years. He joined PHHL on 30.08.2010 and before this he flew with M/S Mesco Airlines. He was initially approved as cabin crew on 26.03.2007 in Mesco Airlines. He flew with Mesco Airlines for 350: 00 hours on Mi-172 helicopter. After joining the PHHL his proficiency and skill tests were carried out at Itanagar on 02.02.2011.He started flying from 14.02.2011. He had a total of four years of flying experience.

1.5.5 Aircraft Maintenance Engineer

Date of Birth	03.01.1954
License valid	29.06.2012
Last Refresher done	18.05.2010

The engineer joined the PHHL in year 1987 and he had earlier worked in Indian Air Force. After joining PHHL he was sent for manufacturer training at France onAriel IC engine of theDauphin N helicopter in August/Sept 1987

and subsequently undergone airframe training of Dauphin N helicopter at Delhi. He acquired the license on Airframe and Engine in Year 1993 on Dauphin N helicopter. Subsequently he was sent in year 1997 for the Mi-172 helicopter training at Kazak and got endorsement of the Mi-172 on his license in 1998. Thereafter he started working on both Dauphin and Mi-172 type of helicopters.

1.6 Helicopter Information

1.6.1 Helicopter Particulars

Mi-172 Helicopter is a twin-engine helicopter, manufactured by M/S Kazan Helicopters Joint Stock Company, Russia. It is a Medium Lift Helicopter with a passenger seating capacity of 24.

The helicopter fuselage is designed as an all metal semi-monocoque variable section body with three structural joints with four parts namely:

- Nose Section
- Central Section
- Tail Boom
- Pylon

The main framework of the fuselage consists of frames manufactured from pressed aluminum section. The floor and load bearing skin of .08 to 1.2 mm thick bind the fuselage framework as a rigid integral structure. The cockpit glazing is made of CO-95 organic glass commonly referred as the Perspex.

1.6.2 Airframe Particulars

- Mi-172 helicopter VT-PHF bearing aircraft serial No. 356C06 was manufactured in the year 31.10.1996.
- The helicopter was registered in India vide Certificate of Registration No 2801 on 26.12.1996.
- Last weighment was done on 07.07.2006 at Russia and was valid till 06.07.2011.

- Last Certificate of Release to Service was issued at Itanagar on 18.04.2011 and was valid.
- All the mandatory modifications applicable to this helicopter were complied with.
- The helicopter has flown since new = 7360.41 air frame hours as on 17.4.2011. It was last overhauled at JSC Kazan Russia on 18.7.2006.
- The certificate of Airworthiness was valid till 28.08.2011.
- Last C of A was carried out on 29.08.2009.
- Last ARA was done on 14.08.2010.
- The crew formation in helicopter is 3 i.e. Pilot, Co-Pilot and Flt Engineer and the maximum permissible weight is 12000 Kgs.
- Service life of this helicopter was extended from 7000 airframe hours to 7500 hrs by Mil Moscow Helicopter plant on 01.11.2010. It had done 7364.29 hrs before the accident

1.6.3 Engine Particulars

The Mi-172 has two turbo shaft engines TV3-117 VM, fitted at the top of the fuselage. This engine has 12-stage axial compressor with a compression ratio of 9.55:1. It has a 2-stage axial flow compressor turbine and a 2-stage axial flow free turbine. The compressor turbine rotates the engine compressor. The free turbine is independent of the compressor turbine. The engine produces a maximum of 2200 Shaft Horse Power (SHP) at contingency power rating (max power). The maximum temperature allowed at this rating is 990^0C.

The engine has a forced lubrication system with an oil pressure of 3-4 Kgf/cm^2 at normal operation. The recommended oil temperature is 80^0-140^0C. Each engine contains a maximum of 11 litres of oil (OX-38). Thus the total oil is 22 litres in the tank. Inclusive of the oil in the pipelines, the total oil is approximately 25 ltrs.

The drive shafts from both the engines terminate at the Main Gear Box (MGB). They simultaneously provide drive to the gearbox, which in turn

rotates the rotors. In case of a single engine failure, the other engine automatically increases power to the contingency rating. Thus the helicopter is able to sustain single engine flight even if the engine fails at the decision point on the take-off leg.

Port Engine

- Type - TV3- 117 VM
- Sl No. - 7087883302112
- Date of manufacture - 16.12.1993
- Date of overhaul - 28.07.2008
- No. of overhauls done - 02
- Hours flown since new - 4221:21 hrs
- Hours flown since last overhaul - 1230:44 hrs as on 17.04.2011
- Date of installation on helicopter- 09 .08.2009

Star Board Engine

- Type - TV3 – 117 VM
- Sl. No. - 7087883100016
- Date of manufacture - 23.07.1991
- Date of overhaul - 14.09.2009
- No. of overhauls done - 05
- Hours flown since new - 4866:23 hrs
- Hours flown since last overhaul - 1082:18 hrs
- Date of installation on helicopter- 09.11.2009

1.6.4 Fire Fighting System

Fire fighting system of the aircraft is used to suppress the fire at four specified compartments. These are:

- Port Engine Compartment;
- Starboard Engine Compartment;
- Main Gear Box Compartment;
- Cabin Heater (KO 50) and Auxiliary Power Unit (APU) Compartment

A rise of temperature above 150^0C or a rate of rise of 2^0C/second for 60 seconds is detected and is passed to a central unit (SSPKF-Fire Alarm Box). There are 2 fire extinguishers placed in the MGB compartment. The Central Unit automatically fires the bottle and simultaneously opens the valve of the fire system pipelines servicing the fire affected compartment. Thus in the automatic mode the crew have no role to play. At the same time a warning is heard on the headset along with other indications in the cockpit informing the crew that there is a fire in that particular compartment. After re-checking, if the fire is still not extinguished, the flight crew has the option to fire the second bottle manually.

1.6.5 Fuel System

The helicopter uses Aviation Turbine Fuel (ATF) Jet A1. There are 3 fuel tanks carrying a total of 2160 Kgs (2785 litres) of fuel. The main or the service tank is located on top of the helicopter close to the engines and carries 445 litres of fuel. It has one booster pumps to pump fuel into both the engines.

The left and right external fuel tanks are located at the base of the helicopter fuselage adjoining the main wheel oleos. They in turn feed the service fuel tank. Fuel from the external tanks is pumped to the service tank by independent transfer pumps located in each tank. When the tanks dry up, indication is available in the cockpit (transfer pump light goes off) to

indicate to the Pilot that the fuel tank has exhausted fuel. The two tanks are interconnected and can be isolated if found necessary, in flight.

In the event of a total electrical failure, the booster pumps and the transfer pumps will stop functioning. The fuel will be fed by gravity only from the service tank (445 litres).

For start-up and switch off, the fuel flow to the engines can be opened or closed by the HP cocks mounted on the roof of the cockpit, above the Left Hand seat. The HP Cocks can be operated by flight engineer or the captain of the helicopter. In case of engine fire or other emergencies, the Fuel Shut off Valves (LP Cocks) can also cut off fuel supply. They are located in the overhead panel in front of the Flight Engineer.

1.6.6 Hydraulic System

The MGB drives the hydraulic pumps. Hydraulic power is required for the flying controls. The hydraulic system has OM-15 hydraulic oil. Hydraulic System has a main and standby system. Both systems have independent tanks, pumps, accumulators and pipelines. However, both the pipelines feed only a single booster, which in turn moves the control surfaces. There are a total of 4 boosters in the system. One weakness in the system is that if there is a leakage in the booster, there is a possibility of the entire oil from both the main and the standby systems leaking out. The emergency procedure for a total hydraulic failure is to have both pilots flying the aircraft in unison to a landing. Mi 17-1V, which is a military version of the Mi-172, is being flown in the Air Force and the Border Security Force. As per the Flight Manual of this aircraft, the crew is to abandon the aircraft in case of total hydraulic failure. In case they cannot, then they have to resort to flying by both pilots to land immediately. Therefore, the procedure given in Mi-172 Flight Manual for total hydraulic does not inspire confidence in the pilots. All of them feel that this aircraft cannot be flown with a total hydraulic failure.They feel that this aircraft cannot even be taxied on ground with total hydraulic failure. Therefore, this procedure needs to be revalidated by the appropriate authority.

1.6.7 Landing Gear

The helicopter landing gear comprises a castering twin nose wheel unit attached to a single Oleo pneumatic strut and two main landing gear units. The nose gear is attached under the fuselage in the nose section. The main landing gear is of a pyramidical type. Both main landing gear units are located on the fuselage sides. The landing gear main dimensions are:

- Track 4510 mm
- Wheel base 4281 mm

The main landing gear consists of an oleo-pneumatic shock absorber (Oleos/Oleo leg), a radius rod (at the leading edge) and a side strut at the rear end. The Oleo leg is a welded tubular steel structure with a two-chamber shock absorber forming the vertical leg of the pyramid. It is attached at the top with bolts to the side of the fuselage and at the bottom to the axle of the main wheel. The radius rod and the side strut form the base triangle of the pyramid. The eye lug welded to one end of the rod is secured to the bottom of the fuselage. Welded to the other end of the radius rod are a wheel brake attachment flange, side strut attachment eye lug, the eye lug used for attachment of a shock strut universal joint and the eye lug for attachment of a towing gear. Press fitted on to the radius rod is the wheel axle, which is secured in position with two tapered bushings tightened with bolts. The thread cut on one end of the axle serves to receive a wheel attachment nut. The side strut is also a welded tubular structure, which at one end is secured to the bottom of the fuselage.

The other end is fitted to the eye lug on the radius rod. The side strut internal space is used as a compressed air bottle operating at a pressure of 500 Kpa (50kgf/cm^2). The air is used for wheel brakes and can also be used for inflating the wheels through special connections provided at the side strut.

Photo:5 Landing Gear

1.6.8 Emergency Locator Transmitter (ELT)

This helicopter is fitted with ELT C406-2-2. It operates on 406MHz in addition to 121.5 and 243MHz. It transmits the latitude and the longitude of the helicopter on 406 MHz to a satellite system. It claims that the position can be located within 100m of the distress aircraft. The transmitter is identified by Serial Number of the aircraft ID. The transmitter on 406 MHz will operate for 24 hrs continuously and then shuts down. The transmitter on 121.5/243 MHz will continue to operate till the battery power is exhausted. The battery power is likely to be exhausted in about 72 hrs. It gets activated about 2.3G. It is always 'ON' in the aircraft. In this particular accident, the ELT was not activated because the impact forces were less than 2G.

1.6.9 Maintenance Arrangements

Pawan Hans Helicopters Limited has its main base for Mi-172 helicopters located at Itanagar, Arunachal Pradesh. The hangar space is provided by the

State Govt. at Itanagar helipad and with rooms built inside the hangar for operations, crew rest room, engineering, stores etc. The space is sufficient to accommodate the Mi-172 helicopters. At the time of visit by the Committee, an unserviceable Mi 172 of another operator was parked with the main and tail rotors removed, inside the hangar, on the right side. The facilities were good and the hangar was clean. All tools and torque wrenches, publications were available to undertake maintenance activities. The facilities for avionics were at Mumbai where the testing, calibrations and repairs were being carried out.

1.6.10 Maintenance Records

A major maintenance activity was performed to change the MGB on VT PHF from 05.04.2011 to 17.04.2011. This activity involved removal of the following major aggregates:

- Main rotor blades
- Both the engines
- Vibration Damper
- Current Collector
- Unfastening of Main rotor hub retaining nut needing at least six personnel to untorque of 240 Kgf.
- Lowering of main rotor hub
- Lowering of swash plate
- Untorquing of MGB mounts
- Installation of all the components in reverse order to build up

These activities are laborious and time consuming. There were no task cards available. The number of man-hours consumed for such activities were not recorded.

Subsequent actions like filling up of oil, cleaning of filters, detector plugs, anti-corrosion protection of the gearbox external surfaces etc were not recorded.

It was also observed that a re-torque check should have been carried out after the first air test/flight. This re-torque check takes about four hours with adequate personnel. It was observed that such time was not available between the flight check and the next task carried out by the helicopter. The chronology of events on 18.04.2011 is given below:-

Helicopter was offered for flying at 0700 hrs.

Time of take-off	**Time of landing**	**Duration**	**Task**
0705	0725	0:20	Air Test
0750	0830	0:40	Air Test
1035	1100	0:25	Itanagar-Jorhat
1130	1155	0:25	Jorhat-Itanagar
1230	1350	1:20	Itanagar-Guwahati
1450	1555	1:05	Guwahati-Tawang

Yet at Page No 002, Section II of the Flight Log, the following entry has been made, dated 18.04.2011:

"Retorquing done at Itanagar as per Certificate of Release to Service"

There was hardly any time for this check to be done on this helicopter on 18.04.2011. Yet an entry had been made that it was done. This is an important check to be done after a MGB change. Going by the records, the entry in the Flight Log regarding re-torquing being carried out on 18th April is suspect.

A 'duplicate inspection' of Right Hand engine control was done on 17.04.2011. Once done, it was supposed to be counter checked by another AME before being offered to flight. Even though an entry was made in the book, a second AME was not available at Itanagar. Hence, the entry remained unsigned. The next day when the helicopter reached Guwahati, the AME at that location carried out the second duplicate inspection. This was irregular, defeating the very purpose of having the second inspection.

1.6.11 Load and Trim Sheet

In this accident, it was informed that the load and trim sheet for the flight for Tawang-Guwahati of 19.04.2011 was prepared and both the copies were kept on board the helicopter which was destroyed during post crash fire. As per the DGCA regulations CAR Section 2, Series X Part II Para 9.4, every operator, including scheduled, non-scheduled, State Government and private helicopter operator, shall prepare load and trim sheet for helicopter where the manufacturer has provided necessary documentation for the purpose. The load and trim sheet shall indicate the composition and the distribution of the total load carried on board the aircraft as well as the calculated C.G. position for "take-off and landing" configurations before the commencement of the flight. Such load sheets shall be prepared and signed by the Pilot-in-Command or persons duly trained in accordance with CAR Section 2 Series 'F' Part XXII and responsible for supervising the loading of aircraft. In case the load and trim sheet is prepared by a person other than the Pilot-in-Command, the same shall be submitted to the Pilot for his scrutiny and signatures before the commencement of the flight. One copy of the load sheet shall be carried on board the helicopter and one copy shall be retained by the operator for record purposes for a period of at least four months from the date of issue.

However the above requirement was not adhered to by the operator which resulted in not knowing the actual load on the helicopter before/after the flight. The landing loads as calculated approximately for the accident flight are as under:

S No.	Category	Weight
1	Basic + Oil weight	7843.39 kg
2	Weight of 1500 litres fuel (on downwind)	1200.00 kg
3	Weight of 4 crew members @ 85kg/person including baggage	0340.00 kg
4	Weight of 17 adult passengers @75kg/person	1275.00 kg
5	Weight of 2 children @35kg	70.00 kg
6	Weight of baggage @10kg/person for 19 passengers	190.00 kg
7	**Gross total**	**10918 .00Kg**

The helicopter had carried 10,918 Kgs. instead of 10,200 Kgs. However these figures are only estimated from the practice followed by the PHHL. As per this calculation itself, there was a minimum of about 718 Kg of extra

weight. This figure is a very conservative guess. Had the 'Checked In' baggage been weighed, it could have been more. In any case this weight is within OGE configuration but beyond the single engine limitation at that altitude.

Actually many passengers were carrying more baggage as per the statements given by the survivors. Amongst the passengers, there was a family of five going on vacation; there were two couples on a holiday; there was a foreigner and an Indian going to Tawang on a project with an expected stay of a few days. It is to be expected that each of them would have carried more than 10 Kgs of 'Checked In' baggage. There was no system for weighing the actual load going inside the helicopter.

1.6.12 Record of Previous Flights prior to Accident on 19.04.2011

Mi-172 VT-PHF was based in Itanagar. It had been operating on a scheduled programme issued by the Arunachal Pradesh government. The helicopter was given Airworthiness Certificate for CAT 'A' performance, and was being operated by the PHHL, as a NSOP public sector unit of Government of India. On 17.04.2011, the helicopter came out of servicing after the Main Gear Box (MGB) change. On the same day the aircrew carried out a 20 minutes Air test and found No 2 engine under powered. The rectification was done on the same day and the next flight check was done on 18.04.2011 for duration of 40 minutes. During this flight the helicopter was found fit. Thereafter, the helicopter started doing various commitments till it crashed at Tawang civil helipad on 19.04.2011 at 1354 hrs. The data of flying done since the MGB change is as follows:

Sl.No.	Date	From	To	Task	Flight Time
(a)	17.04.2011	Itanagar	Itanagar	Air Test	0:20
(b)	18.04.2011	Itanagar	Itanagar	Air Test	0:40
(c)	18.04.2011	Itanagar	Jorhat	Refuelling	0:25
(d)	18.04.2011	Jorhat	Itanagar	Return	0:25
(e)	18.04.2011	Itanagar	Guwahati	Scheduled Passenger Flight	1:25
(f)	18.04.2011	Guwahati	Tawang	Scheduled Passenger Flight	1:05
(g)	19.04.2011	Tawang	Guwahati	Scheduled Passenger Flight	1:05
(f)	19.04.2011	Guwahati	Tawang	Helicopter crashed	1:05

Total flying done by the Mi-172 VT-PHF after the MGB change was 6 hrs and 30 minutes.

1.6.13 Certification and Performance Category of the Aircraft

Category 'A' Rotor Craft

CAR Series 'O' Part IV Section 8 dated 17.01.2011 defines "Category 'A' Rotor craft means multiengine rotor craft designed with engine and system isolation features specified in FAR- Part 29 and utilizing scheduled take-off and landing operation under a critical engine failure concept which assures adequate designated surface area and adequate performance capability for continued safe flight in the event of engine failure". In other words, a Category 'A' helicopter has duplicate systems for essential services in the helicopter so that a failure of one system does not affect the safety of the helicopter. It is also capable of coping with a single engine failure either on take-off or short finals on approach either by continuing to fly or by an immediate safe landing. The decision to fly away or land depends on a stipulated height on take-off or landing. If the single engine failure occurs below this height, it would be capable of carrying out a safe landing. If it occurs above this height, the helicopter can fly away and land at a suitable helipad. Category 'A' is an aircraft certification criterion. As per the Flight Manual, Mi-172 is certified Category 'A' helicopter.

Performance Class of Helicopter

The performance class determines the outcome after an engine failure, by ensuring that a safe margin exists between what the helicopter is able to achieve and what it is required to achieve. Performance class 1 helicopters can perform as per the Category 'A' norms in Single Engine (Category 'A' includes many issues in addition to the Single engine performance) Performance class 2 aircraft have to force land if an engine fails below a stipulated height either on take-off or landing. Above this height, they perform like a Class 1 aircraft. Performance class 3 aircraft have to force land whenever the engine fails. This is normally attributed to Single engine helicopter. Class 1 and Class 2 have to be twin/multi engine aircraft. The Mi-172 has to be flown under Performance Class 1 as per the manual. It means that the AUW will be restricted by its single engine performance and the helipad size and surrounding should provide a safe landing ground in case of an engine failure below the stipulated height. ICAO Annex 6-Part III

Attachment A – Chapter 2. Para 2.1.1 states that "Helicopter with a passenger seating configuration of more than 19, or helicopters operating to or from a heliport in a congested hostile environment should be operating in performance Class 1. Since the Mi-172 is a 24 seater, it should be operating in Class 1.

1.6.14 Size of Helipad/Level Area Required for Mi-172 as per Flight Manual

The rejected take-off distance varies with elevation of the helipad and temperature. For Tawang, at an elevation of 2500 m, for a temperature of 16^{o}C (as obtaining at the time of accident), the rejected take-off distance for an AUW of 10.2 tons is 270m. This distance is derived from Fig 4.2A given in the Mi-172 Flight Manual. The entire table top area, inclusive of the helipad, would be less than 100m. Therefore, the available distance at Tawang Helipad does not meet the safety requirement of a rejected take-off.

1.6.15 Anomalies Observed in Rejected Take-off Distances

While discussing the subject of rejected take off distances with the test pilots of Hindustan Aeronautics Ltd (HAL) Helicopter Division, an anomaly was noticed. The ALH (Dhruv) helicopter produced by HAL is also certified Category A. Its max AUW is 5300 Kgs compared to 12000 Kgs of Mi-172. Yet, for an AUW of 4900 Kgs (not max AUW), at $+5^{0}$C at Sea Level, it requires a rejected take off distance of 1750 ft or 533m. For the same conditions, a fully loaded Mi-172, at 12000Kgs (max AUW), would need only 260m of distance. The AUW of Mi-172 is more than double in this calculation, and yet it takes less than half the rejected take off distance. This is an anomaly, which requires careful review. The HAL (Research and Design Centre) hassoftware that can calculate the rejected take off distances for helicopters when the required data is fed in. This facility may be of use to DGCA/Mi-172 operators

1.7 Met Information

The helicopter took off from Guwahati Airport and weather at the time of take-off 1230 hrs indicates Winds 310/07 kts, Visibility 8 Kms, Clouds position Scattered at 2000 ft, few 2500 ft and CB to SE, Broken 10000 ft,

Temp 30 °C, DP 21°C, QNH 1007 hPa and trend indicated no significant change.

As per the Met briefing register records of 19.04.2011 no Met briefing was obtained by the Pilot of VT-PHF on the day of accident for Tawang-Guwahati-Tawang sector.

1.7.1 Area Weather Information

As per the Duty Met officer, Regional Meteorological Centre, Guwahati Airport Met forecast issued on 19.04.2011 for Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur & Mizoram the summary of observations made 0830 hrs indicates that light to moderate rain occurred at most places over Arunachal Pradesh at many places over Assam &Meghalaya and at few places over Nagaland, Manipur, Mizoram and Tripura with heavy falls at one or two places during the previous 24 hrs. Day temperature changed a little over the region during last 24 hrs. Those were appreciable above normal over Arunachal Pradesh, Assam, Manipur & Mizoram and normal over rest of the region.

Local forecast for Guwahati and neighbourhood valid for 24 hrs indicates partly cloudy sky. Possibility of rain/thunder shower in some areas. Maximum temperature was expected to be around 32 °C on Wednesday 20.04.2011.

1.7.2 Tawang Weather Information

The weather report of Tawang Army helipad, issued at 1330 hrs, applicable to the accident, had mentioned the surface winds as 230/04 kts, Visibility 6000 meters, Clouds position at 1500 ft, 2000 ft and 8000 ft, cloud amount 5 Octa, Temp 16 °C and QNH 1021 hPa.

The weather report of 1400 hrs i.e. at the time of accident issued by Tawang helipad indicates surface winds 230/04 kts, visibility 6000 mts, Clouds 2SC (Clouds 2 Octa Stratocumulus) at 1500 ft, 2SC (2 Octa Stratocumulus), 1C (1Octa Cumulus) at 2000 ft and 5AC (5 Octa Altocumulus) at 8000 ft with total amount of clouds to 5 Octa, Temp 17 °C, QNH 1021 hPa.

1.7.3 Satellite Imagery

As per the IMD, Delhi Satellite imagery of 19.04.2011 from time 1130 hrs to 1430 hrs, low/medium clouds were observed at Tawang from 1130 Hrs to 1430 Hrs. In Infrared imageries convection was weak throughout, but moderate convection was observed from 1300 hrs to 1400 hrs very near to Tawang.

1.8 Aids to Navigation

The helicopter was fitted with following navigational equipments:

- VOR KN-53
- ADF ARK-15M
- DME RN 62A
- ILS- KN 53
- Localiser Bele IV -KN 53
- Glidepath Receiver-KN 53
- Weather RDR-2000
- ELT-Artex 406-2HM
- GPS Garmin- 150
- ATC Transponder Chmeinizki SO-70
- Radio Altimeter Kamensk VRAL A-037

There was no navigational aid installed at the Tawang helipad and helicopter was making non-instrument approach while coming for landing when the accident occurred.

1.9 Communication

The helicopter was fitted with the following communication equipment:

- VHF Baklan 20- 118 to 135.975 MHz
- HF Yadro –IA1- 2000 to 17999.9 KHz.
- Standby- Balkan-20- 118 to 135.975 KHz

The helicopter VT-PHF took off from Guwahati airport at 1258 hrs and reported entering Bhutan valley at 1323 hrs. Throughout this period it was in communication with Guwahati ATC on different channels. At 1340 hrs it came in contact with the Tawang ATC detachment on VHF and remained in contact till the accident. This detachment also informed the pilot of another helicopter parked on the Western side of the helipad, which was acknowledged by the crew. The Air Field Safety Operator (AFSO) had logged that the PHHL helicopter VT-PHF had met with an accident near the helipad at 1357 hrs.However, after analysis of the FDR, this time is now revised to 1354 hrs.

1.10 Tawang Heliport information

Tawang heliport belongs to Arunachal Pradesh Government and maintained by them. It was constructed by the PWD in the year 2007 and became operational in year 2008. Prior to the construction of the civil helipad the operations of helicopters were being done from the Army helipad. The State Government Civil Aviation Department as well as the PHHL do not have the trial landing report of the civil helipad. The helipad is a table top helipad and is located at an elevation of 8250 feet at Lat- 27°34’23” N and Long- 91° 51’57” E. The take-off and landing directions are 20/02. The size of helipad is 51.80 m X 46.90 m and has two H markings which are 21 m apart. The surface of the helipad is flat and hard. It has an approach in North-South direction. Two wind socks were installed on the helipad on the Eastern and Western corner of helipad. At the time of accident another B3 helicopter of PHHL was parked on the western side of helipad. The heliport has one passenger facilitation building on the eastern side of helipad. It has a building in the Northern edge which is about 10 m below the level of heliport. There is no obstruction on the approach and take off path of helicopter at the helipad in North-South direction. The heliport does not have any refuelling facilities. The fire fighting services are provided by the State Govt. with the help of 16 portable fire extinguisher cylinders positioned at the helipad.

The helipad is manned by two personnel from Govt. of Arunachal Pradesh and five casual workers. One of the Govt. personnel is responsible for ticketing and loading/unloading of passengers. The other person is in charge of the helipad and safety equipment. Both of them are not trained on crash and rescue services. The casual labourers employed are locally trained to

operate the fire extinguishers. There is no crash rescue equipment available at the helipad. There is no one trained on crash rescue of Mi-172 helicopter at the heliport.

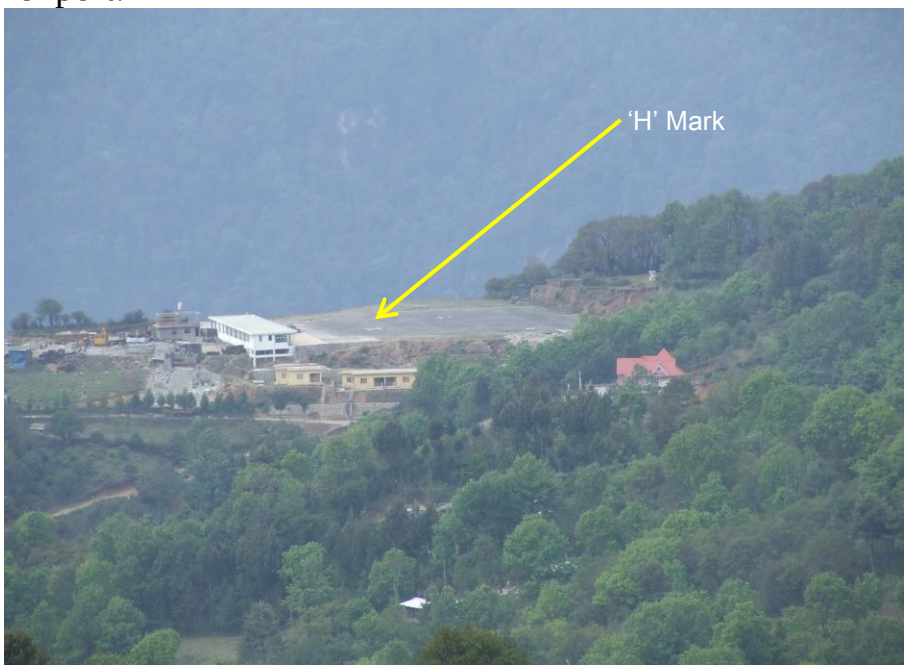


Photo: 6 Tawang Helipad as seen from Army Helipad

The windsock installed on the western side of helipad at times gives conflicting speed and direction of wind compared to the main windsock on the Eastern side. However some pilot contended that while making approach to the H marking on the Western side, that windsock is more relevant.

The heliport was not licensed/inspected by DGCA. It was inaugurated in the beginning of 2008. PHHL had been operating since its inauguration.

There is no fire tender or ambulance available at the helipad during the helicopter movements. Pawan Hans is operating six days a week Mi-172 helicopter flights for the State Government as per a published schedule. On the day of accident also no fire tender/ambulance was available at the helipad.

As per the State Government, the police are responsible for fire services/fire tender at a district. Since a Civil fire tender was not available in that district, no fire tender was available at the civil helipad.

1.10.1 Army Helipad

At Tawang, an Army helipad is located at about 2.1 Kms from the civil heliport. It is about 800 ft higher in elevation. An Air Force ATC detachment from Air Force station Guwahati operates from this helipad. The detachment comprises an overall supervisor, an airfield safety operator (AFSO), a Met assistant, a HF wireless operator and a driver. The detachment personnel are rotated on monthly basis. The detachment has portable VHF set tuned to 129.2 MHz. The call sign of detachment is TANGO control. They remain on watch from 0530 hrs till completions of flying for that day. They have a dry/wet bulb thermometer, an electronic barometer and a wind sock. The wind velocity is assessed by the Met assistant by the position of the wind sock. Being a mountainous region, the wind velocity may differ from this helipad to the civil heliport. From this helipad, the civil heliport is clearly visible without obstructions in between. After the accident, the AFSO had recorded the time of accident as 1357 hrs. However after decoding the FDR, the time of accident is revised to 1354 hrs (13:53:55 hrs).

The PHHL pilots'do not set the QNH as per the Tango Control report. They feel that it is not accurate because it is not co-located. They prefer to fly by the QNH given by Guwahati. Pilots have stated that with the Guwahati QNH, the altimeter reads the correct elevation of the civil helipad after landing. This is questionable. The altitude reading, as recorded by the FDR at the time of accident was 2587m, against the elevation of 2500m.

Even the temperature passed by Tango control is not taken into consideration by some of the pilots. Instead, they prefer to go by the Outside Air Temperature Gauge of helicopter. Being an airborne instrument it has its limitations.

1.10.2 Restrictions

In the PHHL SOP for the Mi-172 helicopter for Itanagar, an advisory is mentioned that sorties to be completed at Tawang helipad before 1400 hrs to avoid variable and gusty winds on approach. However the record of helicopter VT-PHF indicates that on the previous day itself i.e. on 18.4.2011, the helicopter landed at 1555 hrs from Guwahati, thereby ignoring the SOP instructions.

1.11 Flight Recorders

Mi-172 is fitted with a Digital Flight Data Recorder and an analogue Cockpit Voice Recorder. Both are fitted in the tail boom, adjacent to each other. Both were recovered intact but with some burn marks.

1.11.1 Flight Data Recorder

The Mi-172 is fitted with a digital Flight Data Recorder, type BUR-1-2G (FDR). It is fitted at the tail boom at frame No 7. It records 23 analogue and 23 discrete parameters. The sampling rates differ for different parameters.

1.11.2 Decoding of FDR

The FDR was recovered soon after the accident by the Inspector of Accident. The FDR appeared intact externally but had burn marks on one side. The pins were intact. The helicopter being of a Russian origin, the Interstate Aviation Committee (IAC) at Moscow was informed, soon after the accident. The Committee had expressed their inability to send their investigators from Moscow but was willing to extend all help for decoding of recorders and analysis of equipment. Accordingly, the Chairman & the Technical Member visited the Inter State Aviation Committee offices from 27th Jun to 1st Jul 11. After ascertaining the integrity of the original casing and the recording material, it was decided to milk the information from the original casing itself. JSC Kazan Helicopter Plant, the manufacturer of this Mi-172 helicopter had also deputed their Engineer to be present at the IAC, Moscow. The milking and decoding of both the DFDR and the CVR were done under the direct supervision of the Chairman of the Interstate Aviation Committee, Mr. Victor Trusov. In spite of their preoccupation with their own airliner accident involving 45 fatalities, priority was given to the Indian team. The entire process was completed in five days. The total length of recording was 42 hrs. The accident data was located on Track Number 6. The decoding was based on the calibration of BUR-1-2G sensors at 1000 hours servicing by the PHHL at their facility.

1.11.3 Sensor Un-serviceability's and Errors

The Sensors for longitudinal variation of swash plate, longitudinal acceleration, Vertical acceleration and lateral acceleration were faulty.

Therefore, their recording could not be used. 03 secs of data, immediately after the impact had got mixed. It was not easy to extract this data. Parameters before the impact and also after the 3 secs mix-up had been recorded correctly.

1.11.4 Analysis of Data

The engines and the rotors (Main Gear Box) were operating normally till the accident. The accident had occurred at 08:23:55 UTC or 13:53:55 IST. Engine response to variations in the collective pitch has been normal. Tail rotor pitch operating rods and rudder pedals were operating synchronized. Altitude, Indicated Air Speed and Gyro-magnetic headings correspond to expected values till close to the accident. The Engine gas temperatures had been within limits up to the accident. Subsequently, the gas temperatures had gone past 1100^{o} C, against the max permissible temperature of 990^{o} C. The engines had been running for almost two minutes after the accident. Left engine was on fire after 1-½ minutes past the accident. Both the generators on the helicopter failed within a few seconds after the accident. Both had failed more or less simultaneously. Just prior to the accident the collective pitch lever had been raised abruptly from about 9.9^{o} to 13.8^{o}. The bank angle at this point in time was 5^{o} to left. Within a second, the bank angle increased to 85^{o} left. This is the most significant departure from normal seen on the graph of the FDR. The accident time line coincides with this collective pitch/bank angle departure line. This line also coincides with the nose pitch up of 14.6^{o} and sharp variation in rudder input. In fact the nose pitches up from 4.3^{o} to 14.6^{o} in the last ten seconds. The pressure altitude recorded is 2587.3m, Radio Altimeter reading is 7.1 m. The radio altimeter transmitter/receiver is at the tail boom. Therefore, the reading of the altimeter would be that of the depression before the helipad, and not the height above the helipad. This also indicates that the ground cushion could not have been very effective. As per the limitations, IAS readings below 50 kmph are unreliable and hence disregarded. Below this speed, the rotor downwash affects the other pressure instruments also. So, their readings also become inaccurate. The one curious data recorded is the recording of the ‘Shock Strut Compression’ or Oleo leg compression about 40 secs after the accident. The helicopter had in all probability rolled over by this time. A possible explanation is that the damaged Oleo leg sensor had given out a delayed or erratic reading. The sequence of fire in various compartments with sensors is:

Time	Compartment
13:55:30	Left Engine
13:57:00	Right Engine
13:57:10	MGB & APU
13:57:15	K0-50Heater compartment

The time taken from roll out on finals to touch down is less than a minute indicating a shorter approach.

1.11.5 Cockpit Voice Recorder (CVR)

The Mi-172 is fitted with an analogue CVR, type P-507—3B. It is fitted at the tail boom at frame No. 7. It records inputs from the mikes at crew stations and receptions from all stations within range, on the selected frequency. In this helicopter the ambient noise level in flight being high, all inter-crew communication is carried out only through the R/T. There is no open area mike in the cockpit. This Russian CVR is a 4-channel machine that stores the data on to a magnetic tape (metallic base) of ¼ ” width. It has a recording capability for two hrs. It was taken to the Inter-State Aviation committee at Moscow where the spool was removed carefully and put on the ground recorder and channel wise CD copies made.

1.11.6 CVR Data

The CVR data reveals that inter-personal relations amongst the crew were good. There are normal conversations in the cockpit with jokes being shared. All calls were given as expected and ATC calls were acknowledged promptly. They shared a common grouse against the administration for forcing them to stay for an extra night at Tawang. The Flight Engineer was heard carrying out his checks and procedures. There were professional discussions relating to reporting points. As they approach closer to the helipad, the Pilot stated that he was looking forward to sleeping in the afternoon. The Co-Pilot agreed and stated that they all could sleep after lunch. Some concern was expressed about buying/washing of clothes for the extended stay. Close to the helipad Tango control gave them the surface winds as 230/04 and informed them that another helicopter VHT was parked

on the western edge of the helipad. PHF is heard thanking Tango Control for this information. The Flight Engineer is heard carrying out downwind checks and mentions fuel to be 1500 litres. Other parameters are normal. On approach there is a caution by the Co-Pilot stating 'Sir, check your height'. Soon after that Flt Engr calls out that "ground speed is 64 Kts, trim roll to left, auto pilot "neutral". A final indistinct intercom communication was heard almost at the time of accident 'clear up Sir, clear up'. This was soon followed by a series of automated warnings of various systems failure.

The CVR was recording for 3 min 56 sec after the accident. At this point power supply to the CVR was cut off.

1.12 Wreckage and Impact Information

1.12.1 Wreckage Report

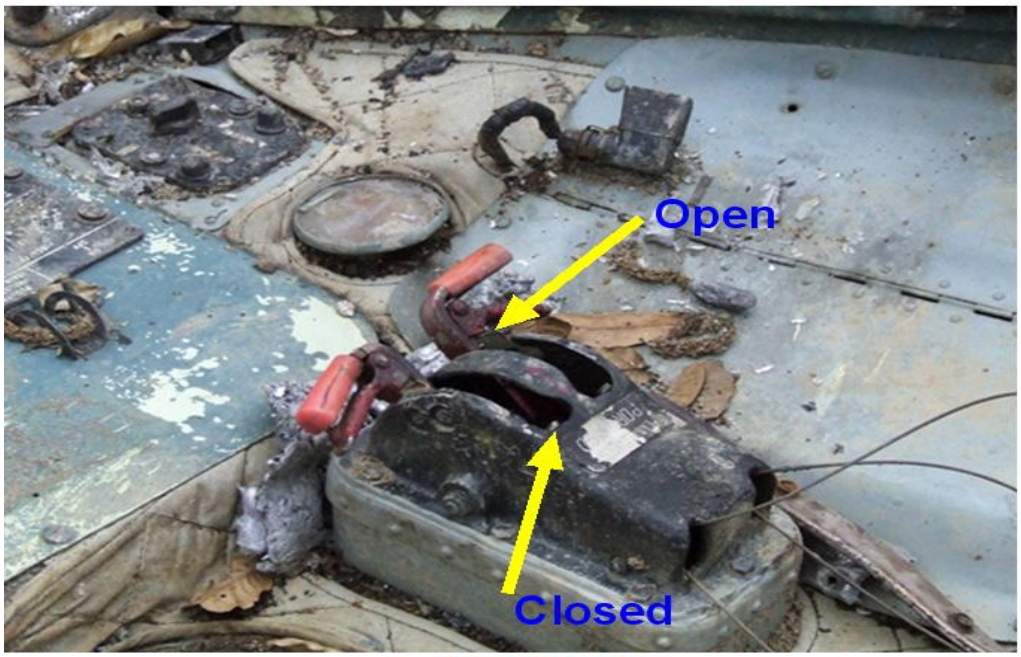


Photo : 7 HP Cocks in Open Position

The wreckage was shifted around on the day of the accident itself to help retrieve the bodies and keep the heliport active. Thus the actual correlation between the impact and the debris could not be established. Most of the helicopter had burnt after the accident within a compact area and very little was left. Only the main rotor blades had broken into pieces and had flown all

around. Rotor pieces were flown as far as 370m from the point of impact. The wreckage distribution table and the diagram are given at Appendix.

All switches and CBs in the cockpit were totally burnt and could not be located. Only the HP cocks were found and they were in fully open position.

1.12.2 Wreckage Relocated

The wreckage was relocated from Tawang helipad to PHHL hangar at Safdarjung, New Delhi.

The main rotor blades were broken into many pieces. The only remains of the transparent bubble of the cockpit were one completely warped Perspex sheet of the sliding door and the shattered pieces of the Pilot's front glass. It was not possible to ascertain whether they were from the Captain's side or Co-Pilot's side. Pitot tubes were not present. All CBs & switches in the cockpit were missing. HP cock was in fully open position. Captain side instrument panel was found in totally burnt condition. Rotor rpm needle was stuck at 107%. Artificial Horizon was showing inverted flight. The needle of VSI was showing 10m/sec descent. Other needles were missing. No Pilot's seats/cushions found. No rudder pedals, collective stick found. Two partially burnt cyclic sticks were found. All controls are presumed melted in the post accident fire. Nose wheel Oleos with attachments found intact. The wheels & tyres were found missing. From the passenger compartment not a single seat was found. All 24 seats had been destroyed by fire. Hand held fire extinguisher found discoloured and discharged. Two batteries found in burnt condition. Portions of the fuselage skin found in burnt condition. Rotor hub found with only four sleeves attached. The fifth sleeve had totally melted. Fire Extinguisher bottles in the Main Gear Box compartment were found discharged. Three Hydraulic accumulator bottles were found intact.

Both the engines were intact with impact damage. The Fuel Control Unit of both the engines was blackened with soot. This soot mark was not seen on other parts of the engine. Portion of the Port engine exhaust was found broken.

Photo : 8

Wreckage Relocated

The free turbine unit was visible and appeared un-burnt and undamaged. It was possible to rotate the left engine free turbine by hand. The outer casing of the port engine appeared undamaged. The starboard engine exhaust cowling appeared darkened and wrinkled. Compared to the extent of heat damage to other portions of the helicopter, the damage sustained by the engines appeared minimal. The free turbine of the starboard engine was not as freely rotating as the port engine.

Port wheel Oleo had sheared off near the top attachment and the bottom attachment. Tyre was burned but the wheel was still intact. The Starboard wheel was missing. The Starboard Oleo had a big chunk of metal missing at the wheel hub end. The forward horizontal support (Radius Rod) for the wheel had cracks on the forward side.

The Gear Box Casing had totally melted. A few components of the Gear Box had detached from the gear train and lying separated. A portion of the tail rotor drive shaft was available.

Photo : 9 Port Engine

The tail boom had cracks at different places when studied at the crash site. However, while shifting, the wreckage had got further damaged and had separated at different places. The forward portion ahead of Doppler Unit, FDR & CVR, was blackened. The Pylon and certain portions forward of the Pylon still had the orange and white paint of PHHL and were not damaged. Two of the tail rotor blades had only slight damage. The third blade, however, was broken into two pieces.

Half a portion of Starboard external tank was recovered. The other portion had been consumed by fire. A burnt oil cooler was recovered. Some burnt portion of the Alternator was also found.

1.12.3 Impact Information

Eyewitnesses had seen the left undercarriage impacting on the edge before the helipad. They were able to pin point the location. Even 20 days after the

accident, the tyre marks on the ledge still remained. There were no reports of the right wheel impacting the ground. The port wheel being closer to the Facilitation Building would have been more clearly visible to the eyewitnesses on ground. Also the helicopter body could have prevented a clear line of sight from the building to the starboard wheel.

Photo : 10 Tyre Marks

1.12.4 Damage to the Landing Gears

The left wheel Oleo-pneumatic shock absorber had completely sheared off from the top and bottom. It was lying detached from the main body of the helicopter. Rest of the port wheel was intact but with the tyre burnt.

Photo : 11 Damage to Left Landing Gear

The starboard oleo leg also had substantial damage at the lower side. The starboard radius rod was cracked and dented at the leading edge (forward portion).

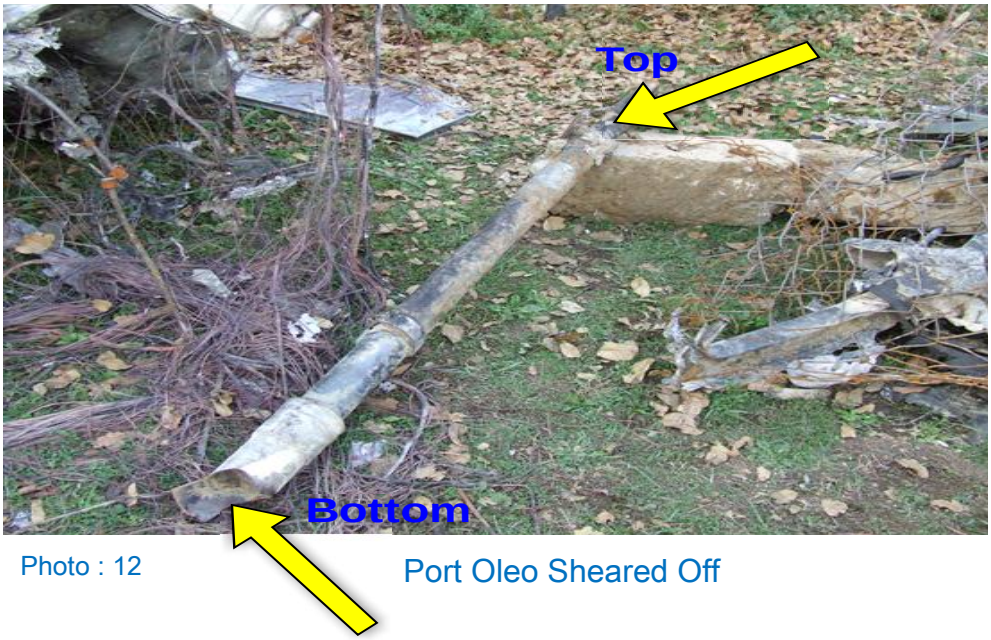


Photo : 12 Port Oleo Sheared Off

Photo : 13 Damage to Starboard Oleo

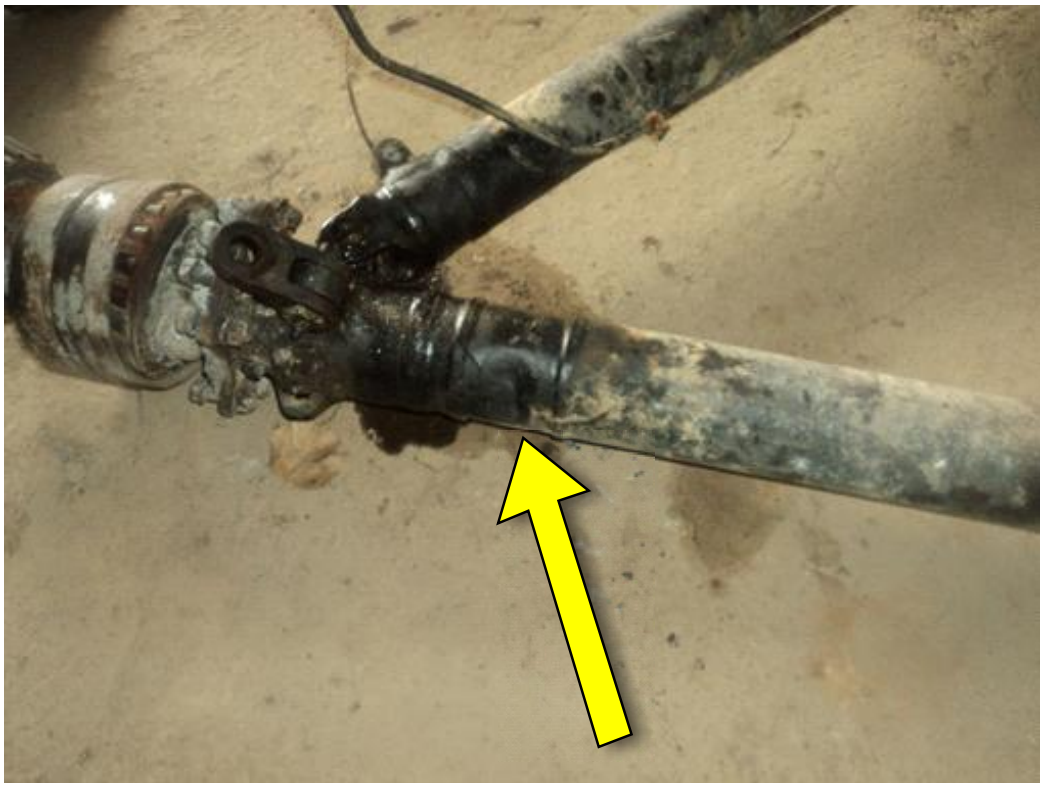


Photo : 14 Damage to Starboard Radius Rod

1.13 Medical and Pathological Information

Of the 23 occupants, six managed to escape (four passengers and two crewmembers) immediately after the crash. The rest of the occupants could not escape due to incapacitation and were burnt with the crashed heptr. The occupants who managed to escape had sustained burn injuries and were evacuated to Tawang Civil Hospital for first aid and further management. Post-Mortem of the 17 occupants recovered from the crash debris was conducted at Tawang Hospital. One passenger who had escaped initially and sustained major burns (45%) was evacuated to AIIMS New Delhi for further management. He too succumbed to injuries on 08th May 2011.

1.13.1 Shortcoming in conduct of Post-mortem

The post-mortem was conducted at Tawang Civil Hospital on 20th April 2011 on all the 17 occupants that were extricated from the crash debris after the crash fire was put off. The procedure of conduct of post-mortem in casualties of helicopter accident is carried out as per Air Safety Circular No. 6 of 2010. The post-mortem was carried out by Tawang Civil Hospital in the format as available for normal post-mortem. The following were not observed/preserved:

- X Rays of the bodies not carried out especially when evidence of fracture/dislocation/amputation was visible on gross examination.
- Specimen for biochemical/histological/toxicological evaluation (brain, blood, muscle, urine and gastric contents) were not preserved and sent for evaluation.
- Opinion/remarks/findings endorsed in post-mortem report are not as per Appendix A to Air Safety Circular No. 6 of 2010.

1.13.2 Analysis of Injuries

A brief description of the PM findings and cause of death is as follows:-

- **External Examination -** All 17 occupants recovered from the crash debris were severely burnt and charred. Heat stiffening of the bodies (Pugilistic Attitude) was seen. Two had their abdomen burst open.

- **Internal Examination**

  - **Head & Face-**Seven occupants had sustained severe head injuries indicated by amputation and fracture of the skull. It was not clear whether the amputation was ante-mortem or post-mortem as the skull contents were severely burnt and charred.

  - **Neck & Thorax-** Severe burn injuries seen in all. The larynx/trachea and both lungs was congested, inflamed and with soot particle deposits. Heart cavity had clotted blood and no tears were seen.

  - **Abdomen -**Wall was charred in all. Esophagus and mouth was congested and with soot deposits. Intestines were charred and burst. Liver/spleen wascharred/congested.

  - **Extremities** - Of the 17 occupants, 10 had sustained fractures/dislocation of various parts of the limbs. Some had their limbs amputated. In absence of X-Rays it is difficult to establish the nature of fractures/dislocation. Possibility of thermal fractures also cannot be ruled out.

- **Cause of Death-** The PM report cites the cause of death due to severe burns in all the 17 occupants.

The exact cause of death in presence of the shortcoming in post-mortem procedure can only be approximately surmised. Presence of soot in the oropharynx, airways and lungs suggests that all occupants had inhaled the thick smoke prior to death. As per eyewitness, thick smoke preceded fire after the accident. The thick smoke in the cockpit and cabin was subsequent to combustion of oil/lubricant from the engine compartment of the helicopter. The burning of internal structures of the cabin/cockpit would have also contributed to the smoke post accident.

Smoke resulting from burning of oil/lubricant/rubber/plastic/ wool/silk etc. contains high levels of carbon monoxide (CO) and cyanide (CN). Fires can raise CO levels in the blood of unprotected persons to 150 times normal in one minute; CO poisoning is the most frequent cause of immediate death associated with fire. High concentrations quickly cause death within a few

minutes. Cyanide is 20 times more toxic than CO and can cause immediate respiratory arrest. A combination of both in high concentrations is inexorably toxic.

The thick smoke in cabin and cockpit immediately post accident would have resulted in loss of consciousness and even death in occupants who could not escape due to severe asphyxia. The blinding effect of thick smoke engulfing the cabin would have added to the woes of the passengers striving to escape. The helicopter was loaded with max number of occupants, majority of them were passengers, and presumed that with their accompanying luggage would have added to cramping of available space in the cabin thereby restraining their escape. Turning turtle of the helicopter post impact would have resulted in physical injuries to the occupants, especially those unrestrained and due to hurled loose objects.

The exact cause of death therefore could be due to any or a combination of the above causes. The fact that some of the occupants who managed to escape had sustained burn injuries is proof that fire had engulfed the cockpit/cabin immediately post-crash. However, with the available evidence, it can be concluded that immediate cause of death in all could have been asphyxia due to inhalation of toxic smoke leading to cardio-respiratory arrest and subsequently the bodies continued to burn till charred.

A survivor admitted to a specialist Burn Hospital in Mumbai, with 42% burns also succumbed on 09.06.2011. Since the death had occurred after almost 50 days of the accident, this death is classified as 'Serious' and not as 'Fatal'. The cause of death as per Post Mortem report is "Septiceamic shock due to burns"

1.13.3 Injury Report of Pilot in Command

The PIC had minor injuries. He had suffered "Haematoma with associated pain and aches which can dissolve over after few days of treatment"

1.13.4 Injury Report of Flight Engineer

The Flight Engineer had suffered serious injuries requiring hospitalization for about 10 days. He had a fracture of nasal bone with the nasal sepleen deviated to left. He also had multiple lacerated wounds on face.

1.14 Fire

The helicopter caught fire after the accident. The port engine was on fire after 1½ minutes after the accident as recorded on the FDR. The other compartments in the helicopter caught fire later as already discussed. However, the time when the fuel tanks and other airframe structures caught fire is not clear. The first survivor could have escaped in less than two minutes, from the starboard window. He had burns. He stated that it was due to fire. So the earliest estimate is that some portions of the helicopter might have caught fire in about two minutes. Major fire could have started after about 5-6 minutes, based on video evidence. It continued burning till the arrival of Army Fire Tender, which was after atleast 30 minutes.

1.14.1 Fire Fighting Equipment Available at Helipad

The heliport had the following portable fire extinguisher bottles:

- DCP 10Kgs - Quantity 10
- M/foam type 9ltrs cap - Quantity 5
- CO_2 6.8Kgs cap - Quantity 1

They were located at about 50m from the accident site. They were manually carried by the personnel at the heliport. Many uniformed personnel who had come to receive the passengers also helped. The two State Government personnel and the five casual employees at the heliport were not trained on fire fighting. There was no crash rescue equipment available at the site.

1.14.2 Fire Fighting Equipment Needed as per CAR

The total length of Mi-172 is 26 m. This places it in Category H3 for fire fighting.(CAR Section 4, Series B, Part III, dated 28.08.2006, on Heliports, Para 6).For meeting performance Level B, as mandated, the requirements are as follows:

				Complimentary Agents	
Category	Water (Ltr)	Discharge rate foam (L/min)	Dry Chemical Powder (Kg) OR	Halons (Kg) OR	CO_2
H3	1600	800	90	90	180

1.15 Survival Aspects

The thick smoke that enveloped the helicopter soon after the crash inflicted fatalities to most of the passengers. One of the survivors had described it as acrid and suffocating. It is this suffocating nature of the smoke that had prompted the survivor to seek out fresh air. The Flight Engineer and the PIC had managed to escape through a break in the nose Perspex bubble. A passenger who had sat closest to the cockpit but facing the rear, had managed to break one of the emergency exit windows of the starboard side with the metal 'choke' used for placing under the wheel. He stated that he was not wearing seat belts. He was the first passenger to escape. In spite of that he was seriously injured and even after a month had complaints about burning sensation in the oesophagus. The second survivor managed to get out from the rear door. He was rescued much later, at least five minutes after the accident. The rear exit door was jammed and had to be broken open by untrained people with inadequate equipments-like fire extinguisher cylinders and so on. He also complained of burning sensation in his chest. Most notably, he stated that there was no cry for help or shouting from others in the cabin at the time of his escape. It is presumed that they were all incapacitated by the smoke and were not conscious. The fire started later.

The second survivor had stated that he had fainted for some time after the accident. When he awoke he saw someone calling out from the rear door, which was now open. This door was to his left and to his right, he saw fire. He had fallen close to this exit door and so he managed to step out. A total of three persons had escaped through this door. Unfortunately two of them died because of burns and other complications without being discharged from the Hospital. This Committee could not interview them.

The Co-Pilot had fallen across the cyclic and was probably unconscious immediately after the accident. The PIC called out to him and he did not respond. He was not wearing the shoulder harness. It is felt that this simple precaution of wearing shoulder harness could have saved his life. After the accident, his seat was higher (away from the ground) and his weight was borne by his lap straps and the buckle. Attempts by the PIC to unbuckle him from his seat in this position failed. Since the PIC felt his strength draining due to suffocation, he gave up his attempts to rescue and exited through the nose section. Rescue attempts were given up once the helicopter fuel started exploding. The explosions could be seen in the video that is available on

'YouTube' www.youtube.com/watch? V=WO wh f69BLY "19 April Tawang Pawan Hans Crash Video". This, same video was available on cell phone with many at Tawang. A witness also handed over another video taken from a different direction to the Committee. These videos were a great help in understanding what happened in the accident. It also shows the PIC being a part of the rescuers from outside the helicopter.

This was a survivable accident but 19 persons were killed due to inadequate fire-fighting equipment and non-availability of crash rescue facilities and personnel trained in their use.

1.15.1 Origin of Black Smoke

All survivors repeatedly talked about the smoke and not so much of the fire. The smoke was reported to be coming from the passenger cabin. It had spread very quickly. It was caused by the Gear Box/Engine Oil (OX 38) and hydraulic oil (OM 15) falling on to the hot engine & exhaust. The max gas temperature permitted at full power is 990^{o}C. Immediately after the accident, the gas temperature of the engine had gone above 1100^{o}C.

1.15.2 Factors that could have reduced Smoke & Fire

As per the FDR, the engine was running for at least two minutes after the accident. The FDR was able to record this because electrical supply was available till about five minutes after the accident. Possibly fire or a short circuit prevented further recording of the FDR. From the wreckage, 'fully open' HP Cocks were recovered. If the HP Cocks/ fuel shut off valves and Battery had been switched off immediately after the accident, the severity of the disaster might have been mitigated.

1.15.3 Emergency Exits

Photo : 15 Passenger Entry Door/Emergency Exit

The helicopter has four emergency exits. One is the passenger entry door itself on the port side.

Photo : 16 Emergency Escape Starboard

Two windows on the starboard side are also emergency exits. In addition an area marked for cutting open from the outside also exists.

Photo : 17 Emergency Starboard Escape(Forward) and Cut Away

The baggage-handling door at the rear is also an emergency exit.

Photo : 18 Rear Emergency Exit

In this accident the port side exit was up against the mound and could not be operated. The exit windows on starboard were high above the ground and could not be reached by rescuers from the outside. The lone survivor who exited through one of these windows described his fall to the ground as traumatic. The rear exit door was either jammed or could not be opened by the untrained hands. It was broken open subsequently with fire extinguishing cylindersand other unconventional items. Three persons were rescued through this door. In the Mi- 172, there is a hatch on the floor of the Cabin, meant for monitoring the behaviour of under slug load when carried. It is narrow, but can be opened as an additional exit. However, in order to open this, the side handle of the nearest seat will have to be removed. If this handle is not removed, it will not be possible to open the hatch.

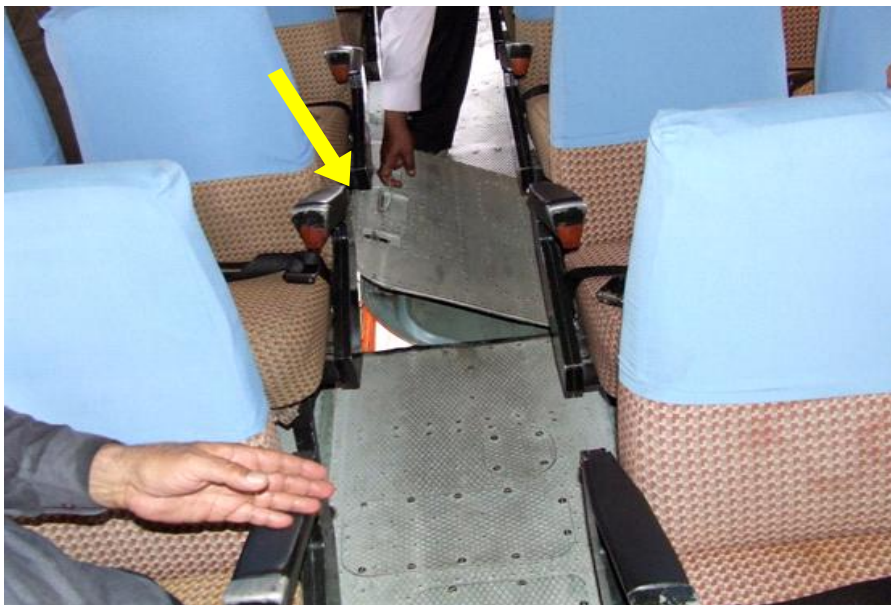


Photo : 19 Cargo Sling Hatch-Possible Additional Emergency Exit (Can be opened only when the seat hand rest is removed)

In this particular accident, this hatch would not have helped much. However, this could be of use in an emergency. Technicians in the IAF/BSF, routinely use it for servicing Mi 17-1V (the military version of Mi-172) under the belly.

1.15.4 Seating of Passengers

The helicopter had free seating and hence no seating plan was made at departure. Refer Appendix; Passenger seating plan for this flight was drawn up on the basis of the recollection of survivors. It is neither accurate nor complete. But it is the best there is. The only pattern seen is that three of the survivors, were sitting on the starboard half of the helicopter. The fourth survivor's seating could not be confirmed.

1.15.5 Assistance to the Injured

The local district authorities had rendered the initial assistance to the injured. Army & Arunachal Pradesh Government medical facilities were utilized for the purpose. When the patients had stabilized, they were air-evacuated to

facilities at Guwahati by PHHL. From Guwahati, the injured had opted to obtain medical treatment at hospitals in Delhi.

Subsequently the first of the survivors succumbed to injuries at Delhi on 08.05.2011. Another survivor was transferred to a specialist Burn Hospital in Mumbai. This person survived for about 50 days before succumbing on 09.06.2011. The father of this survivor had informed that he had spent Rs. 20, 00,000/- on the treatment, but without success. PHHL has stated that the Insurance is adequate to meet all the bills. Though only part payment has been made till now, the reminder is likely to be paid through the insurance company.

1.15.6 Wearing of Shoulder Harness

As per CARSection 8, Series 'O', Part IV Para 2.4.4.4,the PHHL Operations Manual, Section 8 Para 8.2.7and ASC 3 of 2006 Shoulder Harness is to be worn by the Pilots in flight. However, the Mi-172 Pilots that the Committee interacted with have stated that they routinely avoided wearing the shoulder harness. The Committee strongly feels that the Co-Pilot, might have had a chance to survive, if he had worn the shoulder harness.

1.16 Tests and Research

Tests were carried out on the fuel and the under carriage struts of the helicopter. Investigation was carried on the wreckage to find out any evidence of sabotage/explosives. The weather pattern was studied to ascertain the feasibility of Updrafts/downdrafts and wind shear at the time of the accident. Ab-initio research was carried out to ascertain the cause and the contents of the black smoke. Finally, an animation of the flight path was created to visualize the final flight path of the helicopter in the last 30 seconds.

1.16.1 Fuel Examination

After the accident, the fuel sample from Guwahati airport IOC equipment from where the refuelling was carried out for the VT-PHF on 19.4.2011 was tested in the Lab and the sample met the test requirements.

1.16.2 Updraft/Downdrafts

As per the specialist report obtained from the India Met Department, which is based on the prevailing weather information at the time of accident and topographic information of the accident site, it is inferred that updraft/downdraft is very much unlikely to occur at the place and time of accident.

1.16.3 Explosives Investigation

The wreckage was examined by the Bureau of Civil Aviation Security from an explosives angle. The explosives experts visited the accident site on 14.5.2011. As per their report none of the parts of the wreckage showed any indication of explosion. Effects of an explosion like blast, pressure, thermal and fragmentation were not seen in any part of the wreckage or surrounding area. The complete wreckage was confined to a limited area next to the helipad. Most of the broken metal parts indicated damage due to shearing off on impact. No sharp edged fragments or molten metal, which are typical in case of explosion, were to be found in wreckage.

In the absence of the any physical evidence of an explosion or traces of explosive substances in the wreckage of Mi-172, the possibility of sabotage with use of explosives is ruled out.

1.16.4 Oleo legs Examination

The oleo legs were sent to the National Aerospace Laboratories at Bangalore.Their examination revealed that the failure of the oleo legs took place under bending load acting in a direction forward to rearward at a shallow angle with the horizontal. The failure patterns observed on the oleo legs suggest that the helicopter probably was approaching the helipad with a minimum possible speed when the edge of the helipad obstructed the undercarriage. Hence, the impact force acted on the undercarriage was not high. Instead, it appears that the failure of various components was due to bending force on the undercarriage resulting from engine thrust that was necessary for the forward movement of the helicopter. Study also revealed that at the time of accident, the vertical axis of the helicopter was tilted towards port side such that the LH wheel of the undercarriage was completely obstructed while the RH wheel was on the surface. This would

have resulted in not only more load on the LH oleo leg but also in-plane rotation of the helicopter in anticlockwise direction. This, in conjunction with the reaction force because of the engine thrust resulted in toppling of the helicopter in a direction right to left. During this process, all attachment points of the undercarriage got detached from the helicopter body by shearing.

In summary, it is concluded that the oleo legs did not suffer impact of high magnitude. Instead, it had failed and got separated from the helicopter body under load acting in a direction forward to rearward at a shallow angle with the horizontal. It is, therefore, logical to state that the helicopter was approaching the helipad at a shallow angle and probably, with a minimum possible speed. It is most probable that the helicopter lost height earlier than it should have had, and this appears to be the reason for the undercarriage getting obstructed by the edge of the helipad.

1.16.5 Wind Shear

India Met Department was approached for the second time to find out the possibility of wind shear occurring in Tawang helipad region at the time of the accident. After a study their report conclusively stated that wind shear was not possible at that time.

1.16.6 Experiments on Engine/MGB Oil and Hydraulic System Fluid

The National Centre for Catalysis Research located at Indian Institute of Technology Madras, Chennai was requested to study the behaviour of the engine and gearbox oil-OX 38 (Mobil Jet Oil-II in the following table) and the Hydraulic Oil-OM 15 (Aero Shell Fluid-II) under high temperature conditions. After conducting experiments their report is:-

“Few deductions are as follows:

- When these liquids fall on a hot surface there appear to be incomplete combustion and hence CO level is higher than normally seen.

- The carbon particles are higher when it catches fire and the particles are very smaller and hence it could have been present in the air and could have been inhaled.

- We did not look for any carbon nitrogen compounds and hence we do not wish to comment on the possibility of these being present as cyanide. Our examination showed that the cyanide content may be small or negligible but we have no proof to give for this, these are only deductions that we have made."

Test	(OX 38) Mobil Jet Oil –II	(OM 15) Aero shell Fluid-II
0.5 ml on Hot plate	Evolving white fumes slowly	evolving white fumes speedily
0.5 ml in flame	Yellow colour flame evolving carbon	Yellow colour flame evolving carbon higher than mobile jet oil- II
Speed of catching of fire	Slow	Fast

1.16.7 Animation of Flight Path

HAL, Flight Operations Division (Rotary Wing), Bangalore, has developed software for animation of flight path of ALH helicopters, utilizing the FDR and CVR data. This becomes a good investigation tool for visualizing the last few minutes of an ALH accident/incident. They were requested to animate the Mi-172 flight, 30 seconds before the accident.

The data recorded by the FDRs of ALH and the Mi-172 are slightly different. Therefore, there were information gaps in animation of Mi-172. Guesstimates were made to fill in the gaps. Therefore, this animation cannot be used as evidence, as they are not fully based on available information. Inspite of this limitation, what could be achieved was very useful. The actual effect of some of the values seen in the FDR graph was striking and had given the committee a better understanding. The significance of the helicopter pitching movements towards the last 10 seconds was learnt from this animation.

1.17 Organisation and management information

1.17.1 Government of Arunachal Pradesh

The Secretary DST is the ex-officio Commissioner of Aviation of Arunachal Pradesh. Under him, there is a Director for Aviation assisted by two Assistant Directors. All personnel are from non-aviation background. The Dept. of Supply and Transport was earlier coordinating the supply of rations to remote areas through IAF fixed wing and rotary wing aircraft. With the improvement in roads, the need for aircraft for supplies has reduced. This Dept. now coordinates helicopter operations with operators.

In 2008, the new Tawang Helipad was opened. Till then, the civil helicopters were using the Army Helipad. A contract was concluded with PHHL for Mi-172 helicopters to ferry passengers from Guwahati-Tawang-Guwahati. They make a helicopter schedule for six days in a week, and are published on their website and in local newspapers. As per the contract between both these parties the PHHL is responsible to follow all rules and regulations as per ICAO & DGCA. The State Govt. was responsible for ticketing of passengers, security checks and loading of the luggage. In case of night halts outside of their designated base, the Govt. would also provide accommodation and other admin facilities. The PHHL was to adhere to the schedule given by the Govt. In order to achieve this, the stipulated terms were that the PHHL would position helicopters which were not more than five years old and also position a standby helicopter at base to cater to sudden unserviceabilities, i.e. two helicopters would always be present to service the contract. Subsequently, a similar contract was drawn up for flying in the eastern regions of AP. Thus, as per the Govt. of AP, four Mi-172 helicopters should have been positioned at Itanagar to service their contracts.

While interacting with their Civil Aviation Department, they had expressed their dissatisfaction with the Services provided by PHHL. They mentioned frequent unserviceabilities due to which their schedules were not met. They blamed it on poor maintenance and old helicopter. They gave the Committee copies of correspondence with PHHL where they had listed their dissatisfaction. They informed that PHHL never replied to their correspondence, adding further to their dissatisfaction.

It was also learnt that there was hardly any communication between them and the DGCA on matters concerning aviation. They were not aware of the various safety services to be provided at heliports. In spite of having about 120 helipads in their State, not one helipad was licensed.

1.17.2 Pawan Hans Helicopter Limited (PHHL)

PHHL was incorporated in October, 1985. It is a non-scheduled air transport operator with NSOP No 2/1998 valid till 15.3.2013and also engaged in Helicopter charter operations. It gives support to petroleum sector mainly ONGC, connecting inaccessible areas in the North and North-East, travel tourism and intra city transportation. The area of operations is limited to the geographical boundaries of India. The company owns 42 helicopters and carries out operations and maintenance contract of helicopters across the country. This makes the PHHL the largest helicopter operator in the Asian continent. The Board of Directors is the apex body for PHHL. Its normal operations are overseen by the CMD. It has General Managers (GMs) as Head of Operations, Engineering, HRD and Finance at Headquarters level. For ease of operations, it is divided into two areas namely Western Region and Northern Region. These regions are also overseen by GMs.

It has a total of 158 pilots with 50 of them operating under Rule 160. Total number of Mi-172 qualified pilots-9, Flight Engineers-05 and Cabin Crew-6; total number of AMEs working in Pawan Hans is 100. Of these those qualified on Mi-172 are 16. The total number of technicians is 248 which include 12 qualified on Mi-172.

Pawan Hans initially acquired three Mi-172 helicopters (two in 1996 and one in1998). Of these one was destroyed by fire while parked at Bombay High in 2005. Another met with an accident at Tawang on 19th April, 2011 (the subject of this investigation). Therefore, PHHL is left with only one Mi-172helicopter now. Ithas placed order for two new Mi-172s on 20th July 2010, which is expected to be delivered in the first quarter of 2012.

Pawan Hans has set up an institute viz National Institute for Aviation Safety and Services (NIASS) to conduct training on CRM, Dangerous Goods Safety and Special VFR. It also conducts special courses on accident investigation &prevention and other flight related issues.

It operates 6 types of helicopters namely 30xDauphin helicopters; 3xBell 206 helicopters; 04xBell 407; 09xALH; one Mi-172; 2xAS-350B3. Each fleet has a Fleet Manager who handles all flight related operational issues including the pilot roaster. A list of pilot training records is maintained centrally. All Bell and Dauphin pilots are sent for simulator training periodically. Simulator training of ALH pilots is yet to start at HATSOFF at Bangalore. However, simulator training for Mi 172 pilots had not been conducted as specified, for a long time.

During the discussions, it was learnt that the DGM (Ops) Northern Region is also officiating as GM (Ops). The post of GM (Ops) has been lying vacant for some time. When queried, it was informed that there was no pilot senior enough to be appointed as GM. The GM (F&A) was unable to explain as to why they did not appoint a GM through open advertisement if their personnel were not considered senior enough. It is not clear as to how a single person can take on the tasks of operations at two different levels and still do justice to those jobs.

It was also noticed that for air safety, a post of DGM exists but no one is appointed. A Senior Manager is doing this job. Again it could not be explained as to why a regular DGM could not be appointed. It was also noticed that the DGM (Air Safety) is reporting to the GM (Ops) as per the organisational chart. This means that the DGM (Air Safety) was reporting to the very man whose operations he was supposed to check. Organisationally, this was a weak arrangement for enabling flight safety. After a spate of recent accidents, it was informed that a GM (Air Safety) has been appointed who now reports directly to the CMD.

During the earlier years of Pawan Hans, there was an Executive Director (ED) under the CMD to oversee the functions of Pawan Hans. The ED was a pilot, but for many years now this post has been lying vacant. During discussions, it was informed that the GM (Engg.) is officiating as the ED. This again seems to have been incorporated after accidents.

As can be seen, the supervisory posts tenable by pilots have been lying vacant for some time. Adequate efforts have not been made to fill up these posts. Due to the absence of such supervisory posts there has been a lack of oversight on pilots and their activities. In a commercial flying organization, giving low status/appointment for flying operations is not conducive in flight safety. The importance of commercial aspects cannot be denied. However,

such commercial operations will not be possible if air safety takes a back seat. This aspect therefore needs to be addressed by the organization.

1.17.2.1 Observations on Mi-172 operations in PHHL

- Pilots are routinely not wearing shoulder harness;
- In the load manifest, the weight of 'Checked In' luggage carried by each person is routinely left out. At all Helipads, the 'Checked In' luggage that is loaded is never weighed.
- On 19th April 2011, all the documents including the load and trim sheet carried in the helicopter was destroyed in the accident at Twang. During the inquiry, it was revealed that the operator does not leave the duplicate copy of load and trim sheet at Guwahati. The duplicate trim sheets are taken to Itanagar by the same helicopter. The scrutiny of old load and trim sheets revealed that the 'Checked In' baggage carried by each passenger was shown as 10 Kg. In practice most of the passengers carry 20-25 kg baggage similar to what is carried in Boeing or Airbus. There is no system of keeping weighing machines at any of the helipads / launching bases

1.17.3 Directorate General of Civil Aviation (DGCA)

Amongst the many functions that the DGCA is entrusted a few are listed below:

- Registration of civil aircraft;
- Formulation of standards of airworthiness for civil aircraft registered in India and grant of certificates of airworthiness to such aircraft;
- Licensing of pilots, aircraft maintenance engineers and flight engineers, and conducting examinations and checks for that purpose;
- Licensing of air traffic controllers;
- Certification of aerodromes and CNS/ATM facilities;

- Maintaining a check on the proficiency of flight crew, and also of other operational personnel such as flight dispatchers and cabin crew;

- Coordination of ICAO matters with all agencies and sending replies to State Letters, and taking all necessary action arising out of the Universal Safety Oversight Audit Programme (USOAP) of ICAO;

- Supervision of the institutes/clubs/schools engaged in flying training including simulator training, AME training or any other training related with aviation, with a view to ensuring a high quality of training;

- Rendering advice to the Government on matters relating to air transport including bilateral air services agreements, on ICAO matters and generally on all technical matters relating to civil aviation, and to act as an overall regulatory and developmental body for civil aviation in the country;

- Promoting indigenous design and manufacture of aircraft and aircraft components by acting as a catalytic agent;

The DGCA is the single regulating body for Civil Aviation in India. It is severely understaffed. There are about 80 aerodromes in India but only about 25 or so have been licensed. The primary task at present is to ensure that all air fields are licensed to which commercial airlines are undertaking flights. In the aerodrome standard division there is an authorisation of 44 officers. Against this, only one is available and is employed as the Director. They have been employing people from other departments to help them out in the task. It is seen that on an average the DGCA is running only on 20-25% manning. At this level of manning it is not in a position to even fulfil its basic statutory requirement.

1.17.3.1 Flight Inspection Directorate of DGCA

Flight Inspectors are responsible for carrying out checks on the proficiency of the flight crew. The profession of flying, in any capacity, is a highly paying job. Hence, it is very difficult to get such professionals at the scales that the Government is willing to pay. The problem is especially acute in pilots. The DGCA has tried to solve this problem by getting pilots on

deputation from Air India and PHHL. These people are paid by their parent organisations and not by the DGCA. Hence, their involvement in trying to point out transgressions in their parent organization would be limited. This dilutes their job as a Flight Inspector. This in turn affects the flying discipline of the aircrew and has serious flight safety implications. In addition, the DGCA needs some test pilots also, for certification of Indian Aircraft being produced by the HAL. The ALH has recently been certified. Thus, the need for pilots and test pilots is likely to grow as our aviation industry expands.

1.17.3.2 Licensing and Inspection of Helipads

As informed by the Department of Aviation of Arunachal Pradesh, there are at least 120 helipads in that State alone. Arunachal Pradesh is one of the smaller states amongst the 28 states in India. Rail network is non-existent and the road network is not extensive and poorly maintained. Therefore, heli-lift is one of the important means of communication within the state. Not even one helipad is licensed in the state. On a query to DGCA, it was learnt that there are only 9 helipads licensed in the entire country. All the 9 helipads are in the private sector. Their list is not available on DGCA website.

The Central Govt. Rules for the licensing of aerodromes are contained in Part XI of the Aircraft Rules 1937. Rule 78 requires that no aerodrome shall be used as a regular place for landing and departure by a scheduled air transport service or for a series of landing and departures by any aircraft carrying passengers or cargo for hire or reward unless it has been licensed. This pertains not only to the licensing of the aerodrome but also include heliports for Public use. (CAR Section 4 Series F Part I)

As per Regulations, it is the responsibility of the operator to ensure that he lands at a licensed aerodrome. At the same time, we have a situation where not even one helipad is licensed or authorized in Arunachal Pradesh. Therefore if the operator refuses to operate, quoting the Regulations, communication within Arunachal Pradesh will be greatly affected. This is not in the national interest. If he operates to these helipads he would be doing so in violation of the laid down Rules and Regulations. The DGCA does not have the kind of manpower required to inspect all the helipads in India or even just Arunachal Pradesh alone. The inspection of aerodromes and helipads requires special knowledge and experience, whichis not generally available in the market. This is not a subject taught in any

University. Therefore, there is a serious problem of recruiting people for this task and make them specialized in this field. The organizations other than the DGCA, which have a sizeable number of specialists in this field, are the Armed Forces& Airports Authority of India (AAI). The Armed Forces themselves are understaffed. Therefore, they may not be in a position to spare their personnel for extended deputations. However, calling them on task based deputation for very short periods (just 2 to 3 months) for inspection/licensing of helipads in specific regions/states could be a viable option. The same arrangements could be made with the AAI also.

1.18 Additional Information

1.18.1 Wet Lease Agreement

The Government of Arunachal Pradesh and PHHL had signed a contract for wet lease of Mi-172 for operation from Guwahati to Tawang. Initially the contract was for a period of one year from 28.06.2008 to 27.06.2009. Subsequently, the wet lease was extended for another year upto 27.06.2010. Subsequent to this period, no formal contract was signed, but the period of lease was extended piece meal at the old rates upto end Jun 2011, when the contract was terminated. During the period of operation of this contract, another identical contract was drawn up for another Mi-172 for operation to the helipads of Eastern region of Arunachal Pradesh from Itanagar. The original operating base for Tawang helicopter was Guwahati which was also changed to Itanagar. Thus both agreements had the helicopters operating out of Itanagar. The other aspects covered in the agreement are:

- PHHL will indemnify the Govt. Of Arunachal Pradesh against all claims arising out of their operations.
- PHHL will pay all fees, expenses and other dues to all agencies, which support these operations.
- The Government of Arunachal Pradesh agreed to pay PHHL an amount for each hour of flying.
- The down time permissible for the helicopters was stipulated.
- Pawan Hans was supposed to provide Mi-172 helicopters that were not more than 5 years of age. They were to provide these helicopters

within six months of signing the initial contract. Otherwise, the State Government had the right to terminate the contract.

- A Mi-172 helicopter is to be kept as back up for the main helicopter to cater to unserviceabilities which increase the down time beyond acceptable limits. This means that for the two helicopters flying under different contracts, there should have been two Mi-172s as backups at all times i.e. a total of four Mi-172s.

- The PHHL is to follow all rules and regulations applicable to flying operations.

The anomalies noticed in these leases were:

- At the time of signing the contract, PHHL did not have any Mi-172 helicopter that was less than 10 years of age.

- PHHL had only two Mi-172s on its fleet when it signed the agreements requiring it to maintain four helicopters at Itanagar

1.18.2 Issues Pertaining to CARs

While discussing with aviation authorities in Arunachal Pradesh, it was learnt that they use the DGCA website to download CARs. Similarly, many pilots were also happy with this facility of being able to access the CARs easily. However, the general difficulty was that in order to understand a single subject, one had to refer extensively to ICAO publications which are not freely available on the net and need to be paid for. The Main Offices of commercial aviation companies do hold these ICAO publications. They are practically inaccessible to the other people in the field. Therefore, if the relevant publications of the ICAO or any other publications were to be included in the CARs ab-initio, it would lead to better compliance and better safety. Just a single illustration of the difficulty faced by the operator is given here. In the Heliport CAR stated above, there is no mention of crash rescue implements needed at the heliports; there is a mention that complimentary agents can be substituted for the primary agents either partially or fully. However, it does not explain the quantity of complimentary agents needed to replace 1 litre of water. These are given in CAR Section 4, Series B, Part I dealing with Aerodrome Design &

Operation. A reference to the relevant Paras of this CAR leads the reader to ICAO Services Manual, ICAO Annex 13, ICAO Manual on Surface Movements Guidance and Control System, ICAO Air Traffic Services Planning Manual etc. Such extensive references make understanding of the requirement itself difficult and dilute compliance.

Another issue noticed was that CAR Section 4, Series B , Part II, dealing with temporary helipads, lists the requirements of first aid at Para 3.8. This issue of first aid is not addressed in the CAR dealing with heliports.

1.18.3 Indian Aircraft Rule 160

One of the provisions of Rule 160 is that the Central Government may permit Aircrew to do commercial flying without license. Under this Rule, ex Armed Forces aircrews have been permitted to fly in the Pawan Hans Helicopter Ltd helicopters without license. Applicability of this Rule is beneficial to both the aircrews that are being released from the Armed Forces, but without a license and, also those commercial helicopter operators from PSUs looking for air crew. A person can continue to fly indefinitely under this Rule without obtaining license. In the present accident, the Pilot in Command had not flown in the Air Force for about 10 ½ years prior to retirement in December, 2002. Subsequently, he joined Pawan Hans in January, 2007 where he started flying under Rule 160. As a result he had been out of touch with flying environment for approx. 15 years. Even though he underwent flying training and testing prior to commencement of commercial flying, his aviation knowledge was never tested. This is a serious lacuna in the system. A person flying under Rule 160 can avoid all aviation knowledge testing for the entire duration of his commercial career. This is not good either for the system or for the individual. Therefore, limiting applicability of Rule 160 to a maximum period of 2 years per individual would allow the benefit to continue to the individuals and the operators without the current lacuna.

The total number of licensed commercial helicopter pilots is 1093. The number of pilots who are flying under Rule 160 in PHHL and Rotary Wing Academy is 54. Thus, the exemption under Rule 160 is applied to about 5% of commercial helicopter pilots in India.

1.18.4 Acceptance of Lowered Threshold of Safety

As per ICAO Annex 6, Part 3, 6th Edition 2007, Attachment A- which is supplementary to Section II Chapter 3 and Section III Chapter 3 Note 1, "it is recognized that there may be instances in which a safe forced landing may not be possible due to environmental or other factors. Many states have already applied risk management and permitted variations to specific operations such as operations to helidecks where exposure to an engine failure is present without a safe forced landing. Permitting variations based on risk assessment is a normal part of the process of a state developing a code of performance. When operations without suitable areas for safe forced landing are being considered, all relevant factors should be evaluated. These may include the likelihood of the event, the possible consequences, any mitigating measures as well as potential benefits and costs of the operations. The specific process for conducting evaluation is to be decided by the State. In any case, appropriate considerations of a safe forced landing should be either implicit or explicit to a performance code's construction. Accident history and other relevant safety data and analysis are crucial to the development of operational regulations in this area. The resulting requirements may take many forms, such as designation of approved operational areas, routes of flight and obstacle clearance requirements."

In the hilly terrains of India, it is not easy to find areas large enough for a helipad meeting the requirements of rejected take-off distance of a Category 'A' helicopter. In the case of Mi-172, the rejected take-off distance for Tawang is approx. 270 m. Even when lightly loaded at an AUW of 10000 Kgs at +5^{o}C at sea level, the rejected take-off distance is around 165 m. The entire area of the table top helipad at Tawang including the under-shoot and over-run areas is not more than 70 m. Applying Category 'A'/ performance class 1 category criteria for all Mi-172 helipads could make flying in hilly regions of India very difficult

1.18.5 Certain Relevant Features of Helicopter Aerodynamics

There are certain peculiarities of helicopter aerodynamics which had played a part in this accident. They need to be understood to be able to appreciate what had happened to the helicopter. So, only the rudimentary issues are tackled in the subsequent Paras.

1.18.5.1 Helicopter Lift & Thrust

In a fixed wing, the jet engines or propellers provide the thrust needed for forward movement and the wings provide the lift needed to be airborne. In the helicopters, the rotors provide both the thrust needed for movement and the lift needed to be airborne. The engines are needed to keep the rotors rotating. While at hover, the total lifting force or rotor thrust is equal to the weight. Rotor thrust acts vertically upwards balancing the weight, which is pulling the helicopter vertically downwards. If this thrust is tilted in any direction away from the vertical, it will be resolved into two forces, one still acting vertically up and another horizontally in the direction of the tilt. This horizontal force will provide movement of the helicopter in that direction. More the tilt, more is the horizontal force and faster is the movement in that direction. In order to balance the weight, the vertical component or lift is to be maintained at the same level even with the increased horizontal force. This is maintained by increasing the overall rotor thrust.

1.18.5.2 Anti-torque Force

In the Mi-172, the rotors revolve in a clockwise direction as seen from the cockpit (i.e., the blades appear to move from left to right). Since this is a rotating force, as per Newton's Third Law, a reaction would make the fuselage rotate in the opposite direction or the nose will rotate anti clock wise (i.e. the nose will rotate to the left). To counter this rotation, a vertical tail rotor is placed at the rear, which provides a horizontal sideways force. The moment of this sideways force about the centre of gravity of the helicopter counters the reaction of the fuselage. In the Mi-172, this tail rotor force acts to the Port, as seen from the rear of the helicopter.

1.18.5.3 Helicopter Flying Controls

The helicopter controls are called the collective, cyclic and rudder. The rudder is the only common term for both the fixed wing and the rotary wing aircraft. Rudders are meant to change direction. In the helicopters, they achieve this by increasing the horizontal force at the tail rotor. The collective is a lever placed on the left hand side of the Pilot. It is hinged at the rear and can be raised or lowered by the Pilot. It controls the total rotor thrust produced by the rotors. It has automatic linkages with the engine, which

ensures that as the rotor thrust is increased the engine power is also increased, and vice versa.

The third control, the cyclic, is located in front of the Pilot, between his seat and the rudder pedals. This is similar to the Control Column or stick in the fixed wing. The cyclic tilts the rotor in any desired direction thereby making the helicopter move in that direction. The speed of movement will be decided by the amount of tilt. Therefore, in summary, the collective is used to go up or down, the cyclic is used to move forward (or in any other direction) and the rudders are for turning the nose to the left or right.

1.18.5.4 Helicopter Approach and Landing

A helicopter glide slope is generally steeper than a fixed wing approach. In a helicopter approach, the glideslope is maintainedvisually (perspective), while the pilot slowly reduces the speed to zero. As the speed reduces, the helicopter tends to sink which needs to be counteracted by raising the collective. The aim on approach is to get the speed to zero over the 'H' marked on the helipad, at a height of 2-3 m. To obtain this, the helicopter should be around 6-7 m of height at a distance of about 25-30 m from the 'H'. His speed at this distance would be the taxiing speed. His power or collective position is almost the same as that of the helicopter at take-off. Thus, the power requirement for take-off and landing is almost the same i.e. close to maximum power. Accordingly, the tail rotor force will also be close to the maximum, at this point.

1.18.5.5 Ground Cushion

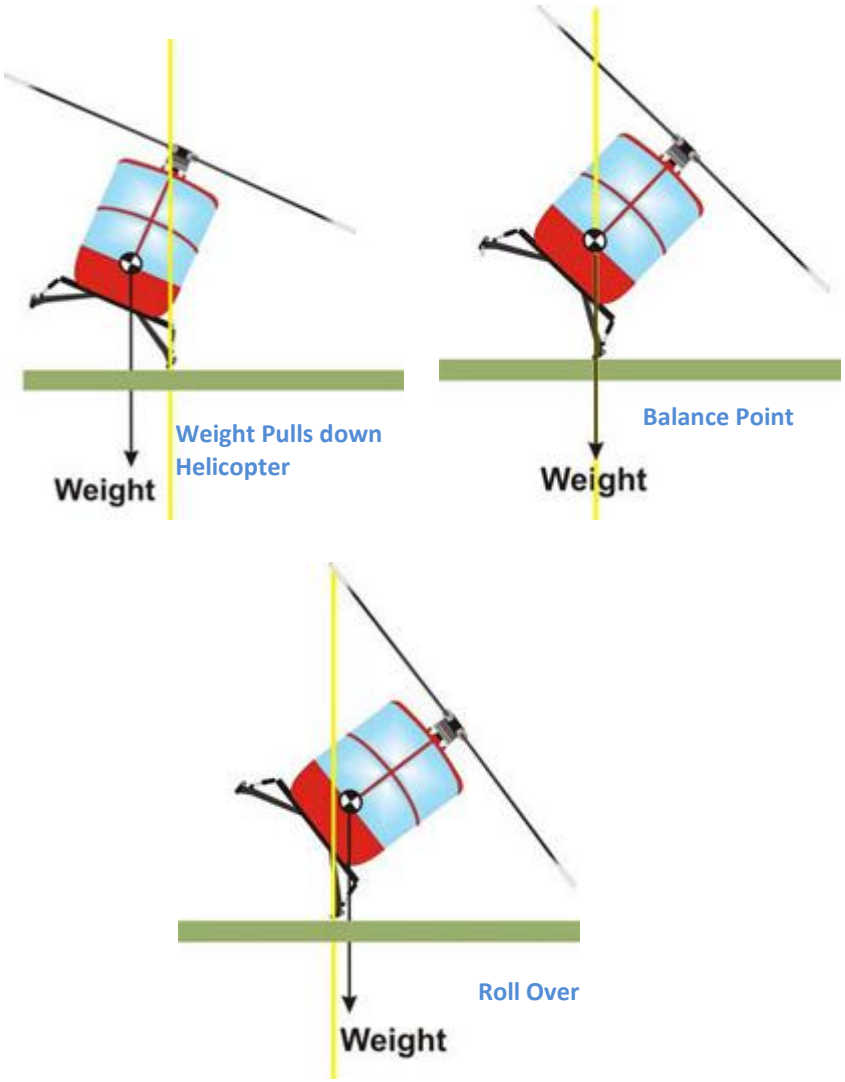
Ground cushion, as the name implies, is a phenomenon that occurs when the helicopter is hovering close to the ground. When the helicopter is hovering at a height of say 1000 ft or 300 m, the downwash below the rotor encounters no resistance from the surrounding air and quickly dissipates. When the helicopter is hovering at say 5 ft on a runway, the downwash first hits the runway and then has to dissipate sideways along the runway. This slows down the rate of dissipation of the downwash leading to a high-pressure area below the rotor. This high-pressure area brings about certain aerodynamic changes, which result in increasing the angle of attack of the blades leading to increased total rotor thrust. This is called ground cushion. Thus, to balance the same weight of the helicopter, the power required is less

at 2 ft off the ground compared to 20 ft off the ground. The effect of ground cushion wears off rapidly with height. There are different estimates as to when this effect becomes zero. Some books peg it at 1 rotor diameter and others at 0.75-rotor diameter. Therefore, at the same helipad, the max AUW for take-off 'In Ground Effect' (IGE) will be more than thatof 'Out of Ground Effect' (OGE). In some medium lift helicopter, the difference in AUW can be around 1000 Kgs. In the case of Mi-172, the OGE graph is drawn for hover above 10 m height. This height is slightly less than 0.5 rotor diameter. One inference for this lower height is that the rate of drop in ground cushion may be rapid up to 10 m. The max AUW, IGE, for Tawang for the reported 16^0C temperature is 12,000 Kg. Therefore, even though the helicopter was above the stipulated limit for Tawang, as per their Operations Manual, it was within the IGE limits.

1.18.5.6 Dynamic Roll Over.

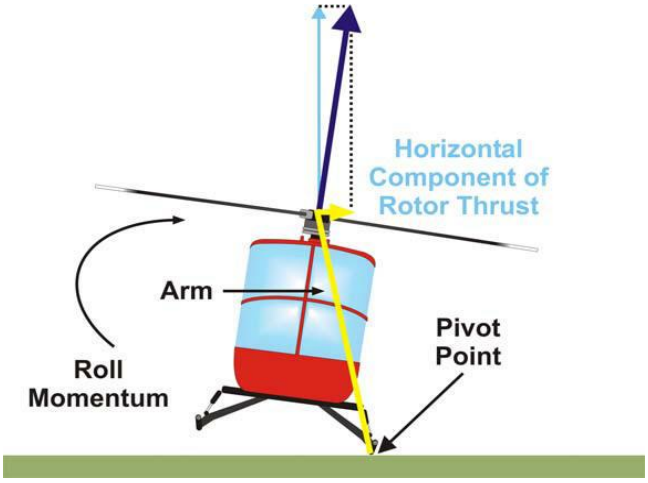
To understand dynamic roll over, it helps to havean understanding of static roll over. We could first consider a switched off stationary helicopter. If we lift one side, it would pivot on the other wheel or skid(See diagrams on page-69). As long as the line passing through the CG is between the pivot position and the original position shown above, the helicopter would roll back to the level position. When the line passing through the CG passes through the pivot point, the helicopter would neither roll back nor roll over. It would balance on one skid. If some disturbance causes the vertical line from the CG to move outside of the pivot point, the helicopter would roll over. This is static roll over.

Dynamic roll occurs when the rotor lift is almost equal to the weight. The helicopter is light on wheels. At this stage of flight, when the helicopter is about to be airborne, if one of the wheels is stuck to the ground, for whatever reason, the helicopter starts to pivot about this wheel. If the Pilot holds the cyclic wherever it was, the helicopter would show a tendency to roll or bank to the side where the wheelis stuck. This is because of the tilt of the total rotor thrust. One component balances the weight acting vertically downwards and the other component provides the horizontal force.

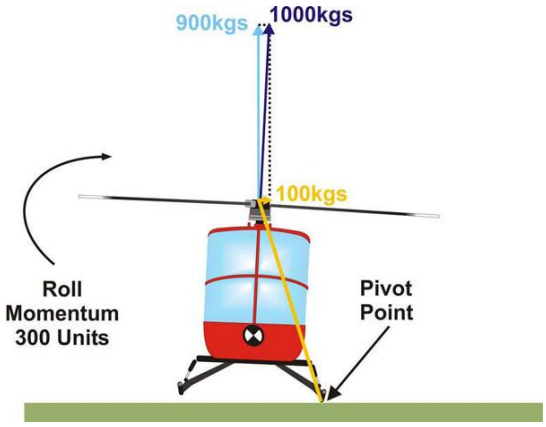


The moment of this horizontal component (= force x distance) is the force x the entire length from the rotor head to the pivot point (unlike force x the distance from rotor head to the CG, which happens at normal circumstances). Thus, a moment has been created, which effectively tends to roll the helicopter over.

The helicopter, as it starts to roll, experiences an increase in momentum and will want to continue to roll unless another force is applied to stop it. In a normal hover, the cyclic can be used to counter any roll. The cyclic produces a couple between the horizontal component of rotor thrust and the CG of the helicopter, asmentioned earlier. The cyclic is thus able to handle only a certain amount of roll rate. If the design limit of roll rate is exceeded, then applying opposite cyclic will not be able to counter it.

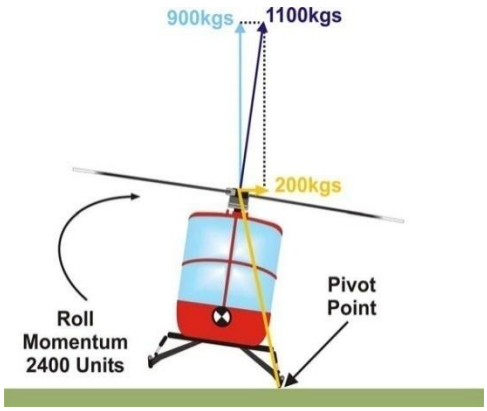


In other words, it will have no effect. Mathematically, the roll momentum = Horizontal force (of the Rotor thrust) x the arm of the Pivot Point x Square of the roll rate. Though the actual values that the cyclic is designed to handle in a helicopter is not known, let us assume that it is designed to handle a roll rate of 10^0 per second or 10,000 units of roll momentum, whichever occurs earlier. For the sake of simplicity, let us take the distance from the rotor head to the wheel (or the pivot point) to be 3m. If the Pilot generates a roll rate of 1^o per second, with the horizontal component of total rotor thrust = 100 Kgs, then the roll momentum is 100 Kgs x 3m x $(1^0)^2$ = 300 units of roll momentum. This being within limits is easily controllable.

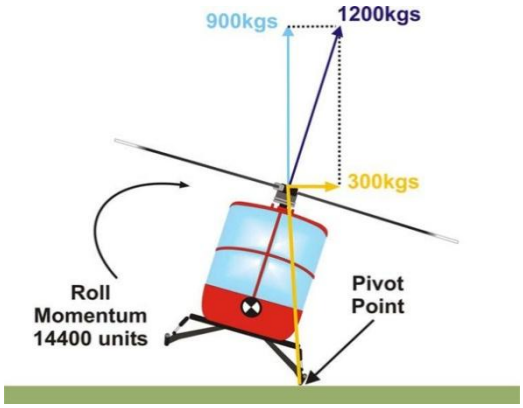


If the collective is raised further without arresting the roll, the helicopter would roll further and the roll rate would increase. It may become something like 200 Kg x 3m x $(2^0)^2$ = 2400 units of roll momentum. The roll

momentum thus has increased from 300 units to 2400 units or by 8 times. Thus by doubling the roll rate, the roll momentum has increased by 8 times.



If we double it further, it could by 300 kg x 3m x $(4^0)^2$ = 14400 units or a 6 times increase in roll momentum and is already well beyond limits.



Thus, by permitting the roll rate to increase from 1^o per second to 4^o per second, the roll momentum has increased from 300 units to 14400 units or by 48 times. Thus, the helicopter will roll over due to excessive roll momentum even if it had rolled (or banked) only 5^o from level attitude. The only way this can be counteracted is, if the Pilot recognizes the symptoms early and lowers the collective early to reduce the total rotor thrust and counteracts with the cyclic.

2. ANALYSIS

2.1 General

This section will analyse as to what happened, how it happened and why it happened. The immediate cause of the accident may be limited to the people operating the helicopter namely the air crew and the ground crew. However, those organizational and other factors which have a bearing on this accident would also be discussed.

2.2 Sequence of Event

2.2.1 Pre-departure schedule at Guwahati

On 19th April 2011, the helicopter took from Tawang at 1100 Hrs and landed at Guwahati at 1205 Hrs. After a check by the Flight Engineer, the helicopter was ready to fly. There were no snags in the helicopter and pre-flight check was carried out by the Pilot also prior to start up.

2.2.2 Initial Portion of Sortie

At take-off the AUW of the helicopter was within limits for Guwahati. The take-off and climb were normal. There were regular contacts with ATC. The CVR indicates a harmonised crew. Even though the local company and personal matters were discussed, the main issue of flying was not lost sight of. Position reports and engine parameters checks were being carried out at the appropriate times. The entire leg, right up to Tawang, had been uneventful.

Contact with Tawang was made from the appropriate position. At Tawang, the winds were 230/04 kts. The pilots were talking about having nap in the afternoon. This is not considered unusual. The time was around 2.00 PM. Therefore, they were looking forward to some rest. It was also seen that there was certain amount of irritation for the situation that they were in. They had not planned for even a single night halt when they left their hotels on the previous morning. Yet they had landed up in a situation where they had to do two night halts continuously.

2.2.3 Circuit

Proper downwind checks were carried out on circuit. Going by the FDR, the indicated altitude on downwind was around 2722m. On the same QNH setting, the indicated altitude just after the accident was 2587m. Thus the

height above the helipad while on downwind was about 135m, against an expected height of 200m. However, the pilot would not have known this till landing. As per his estimate, the altimeter should show 2500m on landing.

In this case, the QNH had given an erroneous height reading on circuit. The turn on to finals had been executed slightly early. Soon after rolling out, the co-pilot had cautioned the pilot to check the height. This issue was discussed with the pilot. He said that it was a normal caution given as a CRM measure between the pilots.

The (roll out on to) finals was for about 50 seconds. This is decidedly a shorter duration than is expected. The engine and the control responses throughout the approach had been normal. Flight Engineer had carried out his checks on approach and trimmed the autopilot. This is again a regular crew action. There is no warning or caution from any of the crew in the cockpit. The possibility of up-drafts and down-drafts had been ruled out. The wind direction as observed by the Air Force elements at Tawang about 2Km away, was 230/04 Kts and the approach direction decided by the Pilot based on the winds was 200^{o}. Therefore, starting from the helipad to a distance of at least about 2 Km, there had been hardly any change in wind direction. Therefore any horizontal wind shear under the circumstances is ruled out. Vertical wind shear had also been ruled out earlier by ruling out up drafts or down drafts. It being around 2:00 PM, it was to be expected that some amount of thermal turbulence would be present. It was also to be expected that the Pilot would be able to cope with such turbulences on this approach.

2.2.4 Accident

When the wheels touched the helipad, the helicopter would have come to a stop momentarily. However, the shear force on the undercarriage was enough to cause serious damage to the right oleo leg even though it had rolled on the ground. At least the same amount of force would have been felt on the left main wheel. Since the left wheel touched the cemented portion, it could not move and hence the force felt on it would be more. This had resulted in the shearing of the complete left oleo leg both from the top and the bottom. As analysed by NAL, the main oleo leg is meant only to take a vertical load. Even a small amount of transverse load would cause it to shear. Thus, the slow forward speed combined with low rate of descent and impacting on a cement surface had produced the shearing of the left oleo.

2.2.5 Control of Height on Approach

Closer to the helipad, it is expected that the collective would be rising continuously. In the instant case, it was noticed that collective was not only raised but also had been lowered very close to the helipad. This may be because of incorrect appreciation of the perspective by the pilot. Probably at the point of impact, pilot realizing that the helicopter was not moving forward had raised the collective from about 9^{o} to 13.8^{o}. This is a massive increase in collective at this point in time. This is not a controlled movement but a jerk. Perhaps it is at this time that the left oleo also sheared off creating a force to roll the helicopter to the left. About the same time, the rotor thrust was also increased. Both these forces together created such a high angular momentum that from 5^{o} bank to the left, the helicopter had rolled almost 85^{o} in one second. With the rotors striking the ground, they broke into pieces and flew in all directions. The helicopter rolled over to the left and slid down the slope and came to rest almost on its back. Since the helicopter was in full power, the gas temperature was around 900^{o}C. The Gear Box, engine and hydraulic oils had leaked out in the near inverted position and fallen on the hot engine cowling. The oil immediately vaporized and very quickly enveloped the helicopter. It was acrid, hot and suffocating. The people who inhaled the least amount of smoke were the cockpit crew. As seen by the injuries, the Captain is the only person who had minor injury. All the others were either major injuries or fatal. The surviving passengers were complaining of burning sensation in the chest long after the accident. The cockpit crew comparatively suffered less. The Flight Engineer had suffered serious injuries but no serious damage to his chest cavity.

2.2.6 Effect of Engine not being switched off

The production of smoke could have been reduced if the engine had been switched off. There is about 90 litres of oil at the top inengine and MGB compartments. The leakage of oil on to the engine had been producing the smoke. If the engine had been switched off, it would have cooled rapidly and production of smoke reduced drastically. In this accident, the engine was not switched off, either by the Captain or by the Flight Engineer. There is a Master Battery Switch located close to Flight Engineer and within reach of the Captain which could have been put off. If this had been put off, it would have immediately switched off all power supply in the helicopter. The booster pump located in the main fuel tank would have been switched off. This would have resulted in fuel starvation to the engines, especially in

the inverted position. Also a switched off battery would have prevented sparking at different places and the consequent fire.

2.2.7 Causes of Fire

From start up to final approach at Tawang the Flight Engineer had been continuously monitoring all the systems and reporting over the intercom to the Pilot in Command (PIC). At all times, the temperatures and pressures were normal and warning lights were off. If there had been fire in the air, it would have been indicated by flashing lights in the cockpit along with a voice warning over the RT. Such a thing was never reported by the crew or recorded in the CVR. The FDR recorded a fire only after the accident.

2.2.8 Other Likely Causes

Tawang is a heliport with no navigational or approach facilities. Hence, navigational or approach aid malfunction cannot be the cause of the accident. Helicopter VT-PHF crew always remained in communication with the ATC Guwahati and Tawang on VHF till the time of accident and is not considered a factor to the accident.

2.2.9 Use of Escape Hatches

The passengers were briefed on use of escape hatches by the flight attendant prior to start up. No one was in a position to use the escape hatches as the main entrance door was wedged against land making it difficult to open. The two emergency escape hatches on the starboard side could not be reached by the passengers easily as they were up in the air. The rescue workers did not have a ladder to reach these emergency exits. The rear door was probably jammed and the passengers could not open it. The flight crew could have escaped through the two side windows which could easily be opened. Yet in this accident, there was no escape route from the Captain's window and the Co-Pilot's window was high up in the air, an escape through which would have resulted in a fall of 3 to 4 meters. Fortunately for them a portion of the nose Perspex was broken and they used it. By all indications, the Co-Pilot was incapacitated after the 'roll over' and was not responding to voice instructions by the PIC. Therefore, all the escape hatches provided for in the helicopter had become unusable after the accident.

2.2.10 Passenger Inaction to Escape

Only one passenger who was alert managed to escape unassisted from the accident. All his actions were unorthodox. To begin with he did not wear seat belts. Secondly, he did not open the exit hatch; instead he broke the exit hatch window with a metal choke. He further climbed out through the starboard side and jumped 3-4 meters to save his life. The three other passengers who were evacuated after breaking open the cargo door at the back had several serious injuries. Two of them had more than 40% burns and did not survive. The third person is the only person who survived. All reports indicate that the smoke was overpowering and suffocating. The last survivor through the cargo door stated that he did not hear anybody moaning or crying for help at the time of his escape. Considering he himself had fainted after the accident for a short time, it can be presumed that others had similarly fainted or sustained other injuries due to the accident. The Carbon Monoxide in the smoke could have been the cause of incapacitating the rest of the passengers making it impossible for them to escape. The fire could have incinerated the people who were already dead. Therefore, the people had died of asphyxiation and not due to the fire.

2.3 Flight Crew Performance

2.3.1 Crew Resource Management

As per the CVR, crews were in constant communication with each other and happened to have good inter-personal relations. Even the cabin crew i.e. the flight attendant at times had partaken in the conversation in the cockpit. The Flight Engineer had been carrying out his checks and procedures periodically. The Co-Pilot had been giving RT calls as required. He even reminded the Captain of his approach height on the finals. The last cockpit transmission could have been by him stating “clear up” “clear up”. Unfortunately, it was late.

2.3.2 Effect of Exceedence of All Up Weight (AUW) for Tawang

AUW of the helicopter as calculated at take off at Guwahati was 11478 Kgs. This does not take into consideration certain excess weight that could have been there because of non-availability of weighing facilities at Guwahati. There was a family of 5 on a holiday. There were two couples who were also on holiday. There were two passengers, including a foreigner, who

were going to Tawang for a project lasting a few days. It is, therefore, to be expected that these people would have carried more than 10 Kgs per head. Since exact value cannot be placed on the additional weight that might have been carried, arbitrarily we could add about 5 Kgs extra for each passenger making it 90 Kgs and further rounded off to 100 Kgs. Thus the AUW of the helicopter could have been around 11478 + 100 = 11578 Kgs. The fuel on down wind at Tawang was 1500 litres. The AUW as earlier calculated was 10918 Kgs, without adding these additional 100 Kgs. If we add this, the AUW becomes 11018 Kgs. We could expect further consumption of fuel before the helicopter met with the accident about 2 minutes later. Erring on the positive side we could assume the consumption of fuel to be 100 litres from downwind to touchdown/accident. In all this, instrument errors, parallax errors etc are ignored. 100 litres = 80 Kgs. Thus the AUW at the point of accident could have been 11018-80=10938 Kgs. The temperature as recorded at 1400 hrs was 17^{o}C at the military helipad. The temperature as taken for calculation by the PIC was 5 – 10^{o}C as read out from Outside Air Temperature (OAT) gauge of the helicopter. For a temperature 10^{o}C, the AUW permitted is 10600 Kgs. Thus, even for a temperature of 10^{o}C, the actual AUW was more than permitted. However, we need to consider that the civil helipad is about 800 ft lower than the military helipad. Therefore, when the reading at military helipad is 17^{0}C, the actual temperature at civil helipad could have been around 18.5^{o}C (allowing for a lapse rate of 1.98^{o}C per 1000 ft). At this temperature, the AUW permissible is around 10020 Kgs. Therefore, the helicopter was overloaded for that altitude and temperature for 'Category A' performance. However, it was close to the limit of out of ground effect (OGE) performance, which was 11600 Kgs. As per the Flight Manual, the OGE performance is calculated at full power where the rotor RPM is 93%. Anything less than the full power would cause the helicopter to sink. Therefore, even though the AUW was higher than that permitted by the SOP, it was still within limits for a 'Category B' performance.

At Tawang, there is a depression of about 7 meters sloping away from the beginning of the helipad. This is followed by buildings which have a base that is another 3 meters below. Therefore, in effect, from the base of the building to the elevation of the helipad, the total height could be around 10 meters. Also a sloping ground tends to displace ground cushion making it weak. Coming to a hover before the helipad and over the depression, would amount to hovering out of ground effect. A slow forward movement would also tend to dissipate anyremaining ground cushion. In this case, in addition

to being in OGE configuration, the helicopter also had a slight forward movement at hover before the helipad. Thus it would have a tendency to sink slightly which was experienced by the pilot. Since he had not landed earlier at this particular 'H' mark, which is very close to this depression, he might not have anticipated it. The engine has a lag, and responds to collective movement only after about two seconds. When the accident occurred the Pilot did not have these two seconds. The helicopter moved forward and hit the beginning of the helipad. This was the time perhaps the Co-Pilot was heard calling out "clear up". The Pilot reacted by raising the collective further, at about the time when the left oleo sheared off, giving an impetus to a left roll. The increase in collective pitch, which increased the total rotor thrust, and the roll caused by the oleos led to the dynamic roll.

2.3.3 Incorrect approach and Landing Technique

During the approach, the Pilot slowly reduces the speed and height so as to arrive at 2-3m hover above the 'H' marked on the helipad. Top of approach is 100m at 100 kmph IAS. In this case, the helicopter had 100m on finals, but it descended in stages and had become shallow towards the middle of the approach.In case the approach becomes shallow, for whatever reason, the speed reduction would be delayed so that the helicopter can make it to the helipad (and not come to hover before the helipad). The disadvantage of having a faster closure rate on to the helipad especially at a greater AUW and higher altitudes is that the speed does not wash off easily. Therefore, the Pilot would have to pitch the nose up well in advance of the helipad, to wash off the speed. With such an approach, it will not be easy to predict where the helicopter wouldfinally come to a stop. Therefore, control of speed on approach especially at higher altitudes is very important. Also control of height in a shallow approach is a little more difficult than in a normal approach. As seen by the FDR chart, there had been three distinct pitch up inputs close to the helipad in an attempt to reduce the speed. The third pitch up was sharp and given close to the impact time. That is the reason that the nose cleared the helipad whereas the main wheels didn't, leading to the accident. In the final 10 seconds, the nose had pitched up in stages from 4.2^{o} to 18.5^{o}. This is excessive.

2.3.4 Presence of other Helicopter

Tango control had informed the crew that there was another helicopter VHT on the western side of the helipad. As glimpsed at in one of the videos seen

after the accident, this helicopter was positioned in an area leaving the entire helipad clear for approach and landing. Therefore the presence of the other helicopter did not reduce the area for landing for this helicopter. Therefore, the presence of the other helicopter did not cause the accident.

2.3.5 Flight Engineer's Action after the Crash

The Flight Engineer had stated that he had lost consciousness immediately after the accident. When he came to his senses he found that the cockpit was filled with smoke and he was injured. He found an opening in the Perspex and he rushed out. Apparently, the Flight Engineer had left the cockpit earlier than the Captain. Therefore, even if he had lost consciousness, it did not last for a long time; it might have been a momentary black out. In this situation, if the Master Battery Switch had been put off, the booster pump of the fuel tank would have switched off. In the inverted position of the helicopter, if the booster pump had been switched off, there would not have been any gravity feed to the engine. The engine, as a result, would have flamed out. Or the HP Cocks could have been shut off thereby switching off the engine. These actions could have prevented further fire and production of smoke.

2.3.6 Pilot in Command (PIC)'s action after Crash

The PIC has stated that he shouted for the engine to be switched off. The cockpit was filled with black smoke and he was having breathing difficulty. He had seen through his side window that there was no escape route that side. Escape through the co-pilot side would have resulted in a sheer fall. He also saw that the Co-Pilot was immobile and leaning towards him. He tried to make him respond by trying to wake him up and subsequently trying to unbuckle him. He found his strength was waning and so he also got out in the same way as the Flight Engineer. He gulped some air and came back again to un-strap the co-pilot. He gave up when he found out it was not possible. The HP Cocks and Master Battery Switch were accessible to the pilot also.

2.3.7 Efficacy of Ground Staff to suppress Fire and Evacuate Passengers

None of the ground staff manning the Arunachal Pradesh helipad were appropriately trained in fire fighting. They were not trained in crash fire rescue. The fire fighting equipment available was inadequate for the

Category of Mi-172 helicopter. Due to non-availability of proper fire fighting equipment, the helicopter continued to burn. Due to non-availability of crash fire equipment, the passengers could not be evacuated in time. The actual fire fighting started only after the arrival of military/paramilitary fire fighting equipment. Eye witness accounts vary regarding the time of arrival of these resources. They vary from 30 minutes to 50 minutes after the accident. In any case, they arrived too late to save the passengers of the helicopter.

2.3.8 Duration of Fire

It is difficult to establish the exact time at which the fire started. The first passenger to escape from the starboard emergency hatch window stated that he had suffered fire burns while escaping. He could have escaped within the first minute of this accident. At this point it is very difficult to establish whether it is actually the fire which burnt him or the hot gases generated by the oil. The PIC had also taken up to two minutes to completely clear the helicopter and come around to supervise fire fighting. The rear door could have been broken open in may be 5 – 6 minutes. This is only an estimate. Some of the videos received by the Committee of Enquiry indicate that actual blasts of the helicopter due to fire occurred only after the rear exit door was opened. This would have been the most active phase of the fire which ultimately consumed the helicopter. So, one could say that the helicopter was consumed by uncontrollable fire only after about six minutes of impact. It could have continued burning for another 30 – 40 minutes till the army fire tender reached the spot.

2.4 Engine Response prior to Crash

The engine was operating normally right till the end. Engine parameters were frequently checked by the Flight Engineer throughout the flight. There has been no abnormality recorded or stated by the Flight Engineer. The FDR record for the last few minutes before the accident, indicate proper response from the Engine right up to the point of accident. Engine caught fire only after 2 minutes after the crash. Therefore, the engine response is not the cause of the accident.

2.5 Flight Control Response in Flight

The Pilot would be the first one to notice any abnormality in the flight control response. Neither in CVR reading nor in the statement of the Pilot was there any mention of abnormality of the flight control response. The FDR recordings also show a proper correlation between the flight control inputs and the control surfaces response. Therefore, flight control response in flight is not the cause of the accident.

2.6. Main Gear Box (MGB)/Rotor Response

The helicopter had come out of a major maintenance work involving the MGB change. After the maintenance work, flight checks were carried out to check the performance of the MGB and the Rotor. There are doubts about the maintenance procedure followed in the MGB change. Notwithstanding the doubts, the MGB had performed properly during the flight checks and also in subsequent sorties. In fact after the flight check, this was the sixth sortie flown on this helicopter. FDR report had also established proper correlation between the controls and the Rotor response. If there had been a MGB fire it would have shown up on the recordings of the FDR and the CVR. The crew also would have reported accordingly. Taking all these into consideration, the possibility of MGB/Rotor response being the cause of the accident is ruled out.

2.7 Effect of Size of Helipad

As mentioned earlier, the helipad is approximately 52 m x 47 m. The helipad is constructed at an elevation of 8250 ft or 2525 mts.Mi-172 helicopter is certified ‘Category A’ helicopter and was expected to operate in performance class 1 at all times. Because of this, the stipulated size of the helipad to allow for rejected take off distance is much higher. As per the Flight Manual, the distance required is 270 mts, which is not available at this location. But the helicopter is capable of landing in ‘Category B’ Configuration, with both engines operating, at this helipad. It requires proper training for landing on this table top helipad. Helicopters had been operating to this helipad and had carried out hundreds of take offs and landings without problems. Hence, it was possible to operate from this helipad safely. Therefore, size of the helipad is not the cause of the accident (irrespective of the fact that it did not meet the ‘Category A’ safety conditions).

2.8 Weather Conditions

The weather was VFR as reported by Tawang at the time of the accident. The possibility of mountain wave phenomenon or severe up drafts or down drafts were also considered. It had been ruled as not possible by the specialists at Indian Meteorological Department. The issue of wind shear was also discussed. The winds at the civil helipad and the military helipad at about (2.1 km away) indicated approximately the same wind velocity. Therefore, horizontal wind shearwas ruled out. In the absence of severe up drafts and down drafts the possibility of vertical wind shearwas also ruled out. Since the cloud amount, visibility, wind velocity, up drafts/down drafts and wind shear are not the factors, the possibility of weather being the cause of the accident is ruled out.

2.9 Sabotage Aspects

The Bureau of Civil Aviation Security personnel had visited the site after the accident. After an extensive survey, they had come to the conclusion that sabotage was not involved. Therefore, this also is ruled out as of the cause of the accident.

2.10 Aero-Medical Aspects

2.10.1 Medical History of the flight crew

The flight crew had undergone medical review periodically and had been found fit for flying. The PIC was taking medication which was in the knowledge of the Medical Board before it cleared him. Therefore, aero-medical aspects were not a cause for the accident.

2.10.2 Pre-Flight Medical Examination

The crew had not undergone pre flight medical exam on the day of the accident at Tawang on 19.04.2011. This was not their operating base. Hence there was no prescribed medical practitioner who could have carried out these checks. They could have carried out medical examination at Guwahati, provided there was adequate time between the two sorties. Since that was not available, they could not get checked at Guwahati also.

However, they had undergone medical check on the previous day at Itanagar. There is nothing to show that their medical condition on that day could have led to the accident. Therefore, this is also ruled out.

2.10.3 Fatigue/Alcohol Consumption

The crew had adequate rest prior to the flight. Their having consumed a few drinks, at the Chief Minister's Social Evening is not considered a factor. There was more than 12 hours gap between that event and their eventual take off.The alcohol would have metabolized by then. Therefore, aircrew fatigue/alcohol causing the accident is also ruled out.

2.10.4 Survivors

Amongst the passengers, initially there were four survivors. Of these, one had more than 45% burns. The other had 40% burns and the remaining two had less than 10 % burns. The passenger with 45% burns succumbed to his injuries within the first 30 days. Therefore as per the rules, he has been shown as a fatality in the accident. The other passenger had survived for about 50 days in a specialized care hospital and yet finally succumbed. This passenger was never discharged from hospital after the accident even though there had been transfers from one hospital to another without a break in-between. Since the time elapsed between the accident and the person's death was more than 30 days, this case has been included in the serious casualty category. The other two survivors had undergone hospitalization for more than 48 hours. So they are also classified as serious casualties.

2.10.5 Adequacy of Post-mortem

Tawang is a border town of India. It has a District hospital but without many facilities. The post-mortem was carried out as per schedule for a normal accident. It was not carried out as per provisions of Air Safety Circular 6/2010. Therefore, many aspects were left out including X-Rays, viscera examination etc, which should have been taken. Therefore, the post-mortem report was of limited use due to these deficiencies.

2.11 Recorder Analysis

2.11.1 FDR Analysis

The FDR had established that all systems were functional right up to the point of the accident. The approach was somewhat shallow closer to the helipad. There were attempts close to the helipad to pitch the nose up probably with an intention to reduce the speed. When the nose is pitched up at a higher speed, the helicopter tends to 'balloon' or the rate of descent reduces considerably. In order to maintain the same perspective it then become necessary to lower the collective slightly which is seen in the FDR graph. The FDR also indicates the nose pitch up just prior to impact and the collective pitch going up to 13.8^{o} which is not normal. It also indicates the onset of a 5^{o} bank to left which increases to 85^{o} bank in about a second. This is followed by a sharp pitch down and all parameters going out of limits thereafter. The correlation between a slight bank to the left at high collective setting, when the helicopter is still partially in air, but with one wheel in contact with the ground leading to very significant increase in roll rate is seen. There is no doubt that this combination of factors had caused a 'dynamic roll over' causing the accident.

2.11.2 CVR Analysis

A CVR analysis is useful to assess the CRM practiced in the aircraft. The Co-Pilot was heard reminding/pointing out the height to the Captain at the beginning of finals. However, the call "clear up", probably on seeing the helicopter being below the helipad, had come too late.

2.11.3 Correlation of Data of Recorders

There is a complete correlation between the FDR readings of the engine and airframe parameters with the CVR recordings of crew conversations/actions. There was no dichotomy seen between the two.

2.12 Why Did the Accident Take Place?

The max AUW for the reported temperature at Tawang on that day should have been 10020 Kgs, as per the nomogram given in the Flight Manual. For the ease of Pilots this nomogram graph is converted into a tabular form and given in the SOP at PHHL. The Pilot being in cell-phone contact with

Tawang could have easily found out the temperature at Tawang, prior to take off, in order to have an AUW of about 10000 kg at Tawang. To achieve this, the AUW at Guwahati should not have been more that 10660 Kgs. In the instant case the AUW at Guwahati was 11478 Kgs. There have been no untoward happening right till the helicopter reached finals. The first indication was the comment by the Co-Pilot about the height on finals. Because the approach had become shallow, the closure speed had to be a little higher. The Pilot could have also chosen to level out till the correct perspective is reached and commence the descent. This was not done. Because the approach speed was higher, it did become a little difficult to wash-off speed towards the end of approach. Attempts to wash off speed would involve a nose-up attitude. A nose-up attitude close to the helipad changes the perspective of the helipad, giving an impression that the helicopter is a little higher than where it actually is. This is an optical illusion. If the helicopter has sufficient height above the helipad, this would not matter much. If the helicopter had been low on approach, this would certainly make a difference. Because of slightly faster speed on finals, there would be an attempt to get the helicopter fully under control before it enters the helipad. This would mean almost coming to a hover before the helipad. Tawang is a table-top helipad with a depression of 7-10 meters before the helipad. In order to come to a hover in this depression, one would require more power than a hover over the helipad. However, it would have been possible to hover even at this point if full power was used. The helicopter is capable of hovering at almost 11600 Kgs OGE at full power (dropping the main Rotor RPM to 93%). The PIC failed to raise power to this extent initially, resulting in a slight sink. The residual forward speed and the slight sink allowed the helicopter to travel forward below the height of the helipad and coming in contact with the vertical base of the helipad. The forward speed and the rate of descent were low. In spite of the low speed, the helicopter had high momentum as the AUW was around 11 tons. Because of this, the right wheel oleo buckled and cracked because it landed on a softer ground. The left oleo hitting the concrete face of the helipad had its oleos sheared off both from the top and the bottom. Had the rate of descent or the forward speed been more, the damage would have been far more extensive. The left oleo sheering off set up a moment tilting the helicopter to the left. The Pilot realizing that he was still a little low for the helipad, had raised the collective to 13.8^{o}. This was not a controlled raising of collective expected on a normal approach. The rolling due to oleo snapping and the raising of collective lever coincided, creating a classic case for a ‘dynamic roll over’.

In a dynamic roll over, the first condition is the helicopter should be light on wheels with rotor thrust equal to weight but with one wheel in contact with the ground. This was satisfied by the left wheel getting stuck at the wall of the helipad and the helicopter rotor thrust almost equal to the helicopter weight. The second condition to be met in a dynamic roll over is that there should be a tilt towards the wheel in contact with the ground. This was satisfied by the tilt developing due to the shearing of the oleo leg. Rest of the forces required to rotate the helicopter about the wheel would have been provided by the main rotor itself.

As can be seen, it was a violent turn where the bank increased from 5^{o} to 85^{o} in less than one second. It was not humanly possible to react to this rate of bank nor would the helicopter be capable of producing a force to counter this with the available controls. The only remedy is not to get into a situation of this nature. This is the cause of many helicopter accidents in the recent past. This accident is also caused by dynamic roll over due to improper flying techniques employed by the Pilot.

From the evidence on record, it also appears that there was a major gap in the oversight functions of the Pilots in Pawan Hans Helicopter Ltd (PHHL). This had led to a very lackadaisical approach in adhering to the various rules and regulations concerning flying. Such a situation could not have happened in a short time. The air crews were very casual about the actual AUW of the helicopter, about wearing shoulder harness, about leaving a copy of trim sheets behind, preparation of trim sheets etc. PHHL, whose duty it was as an operator, to check availability of crash and fire fighting equipments and crew at the landing bases had not taken adequate efforts to insist on the availability of such resources.

3. CONCLUSION

3.1 Findings

3.1.1 The Captain, the Co-Pilot, the Flight Engineer and the Cabin Attendant were all duly authorised to undertake the flight. The Captain and the Flight Engineer were flying under Rule 160 and the Co-Pilot held a CHPL. The Cabin Crew had due approval to fly as Cabin Attendant.

3.1.2 The crew was not subjected to pre-flight medical examination. However, based on the information supplied by the Captain and the Flight Engineer, there was no evidence indicating any adverse medical condition with the flight crew.

3.1.3 The flight crew had adequate rest prior to the flight.

3.1.4 Mi-172 VT-PHF had a current Certificate of Airworthiness. The helicopter had come out of a major inspection schedule just two days prior to the accident.

3.1.5 No evidence to indicate any malfunctioning of the engine or airframe or any other helicopter system. All helicopter systems were operating normally till the accident.

3.1.6 As indicated by the DFDR, the helicopter was fully serviceable throughout the flight till the actual accident. This is confirmed from the crew as well as from the CVR recordings.

3.1.7 Weather, navigational and landing aids and communication failure were not the cause of the accident.

3.1.8 There was no evidence of a bird hit on the helicopter.

3.1.9 There was no evidence to indicate any sabotage to have caused the accident.

3.1.10 There was no evidence of any pre-impact failure or in-flight fire.

3.1.11 The CRM in the cockpit was adequate and was not a cause for the accident.

3.1.12 This was a survivable accident. However, people died mainly due to inadequate fire services and non-availability of crash equipment and trained personnel.

3.1.13 The helicopter had been making routine flights from Guwahati to Tawang for more than two years. In all this period, the operator violated Indian Aircraft Rules, 1937, Rule 78(4) which states that operators should not knowingly operate to aerodromes without proper fire fighting facilities.

3.1.14 The Captain was at the controls during landing at the time of accident.

3.1.15 The Co-Pilot had cautioned the Captain to check the height on roll out to finals.

3.1.16 The helicopter was above the specified AUW for that elevation and temperature as per the SOP & Flight Manual.

3.1.17 The helicopter almost came to a hover but with slight forward speed and a very low rate of descent just before the helipad. It impacted the vertical face of the helipad. This resulted in damage to undercarriages. The left oleo leg sheared off leading to a slight roll to the left. At the same time, the Captain had reacted by raising the collective to a very high value resulting in a dynamic roll over.

3.1.18 Aircrews were not using the QNH and temperature readings given by Tango (Tawang) Control.

3.1.19 There was inadequate oversight over flying operations at PHHL. Many flight safety violations had gone unchecked and unreported.

3.1.20 Senior management positions in respect of pilots were not being filled for long periods of time, leading to this inadequate oversight at PHHL.

3.1.21 The maintenance and servicing records at PHHL were inadequate and suspect.

3.1.22 PHHL had agreed to certain clauses in contracts with the Govt. of AP, which it was not in a position to fulfil.

3.1.23 The DGCA, as an organization is not able to fulfil its task, because their manpower is extremely inadequate. This has a direct bearing on safety and commercial flying activities in the country.

3.1.24 Arunachal Pradesh Aviation Department is not adequately equipped to man the helipads safely.

3.2 Cause of Accident

3.2.1 Direct Cause

The accident was caused because the helicopter undershot the helipad by about 27 meters and sunk below the height of the helipad by about a meter. The forward movement and the slow rate of descent caused the left oleo leg to shear off. This gave a slight left bank to the helicopter. Around this time the collective was increased to 13.8^{o} in order to increase the rotor thrust. The slight bank and the increase in the rotor thrust increased the angular momentum of the helicopter to such an extent that the bank increased from 5^{o} to 85^{o} in a second. The rotors hit the beginning of the helipad causing the rotors to break. There being a steep slope adjacent to the helipad, the helicopter slid on this slope and almost turned over on its back after the accident. Subsequently, it caught fire and was totally destroyed.

3.2.2 Contributory Factors to the Accident

Inadequate use of Met resources had contributed to the accident. Aircrew had disregarded the local QNH and temperature given by Tawang Control.

The AUW was above the stipulated limit given in the Flight Manual for Category ‘A’ operation.

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4. RECOMMENDATIONS

4.1 For the Operator – Pawan Hans Helicopter Ltd.

4.1.1 Operations have to be given due importance. Flying Supervisors at the level of ED and GM should be appointed to oversee flying operations at the earliest. Where suitable candidates are not found within the organization, efforts should be made to get them from outside the organization.

4.1.2 Matrix may be prepared encompassing all the CARs.air safety and other circulars. Once made, periodic internal inspection is to be carried out by DGM (Air Safety) to ensure that all their personnel adhere to the rules.

4.1.3 Mi-172 Pilots are to be sent for Simulator Training Course as per the relevant CAR periodically.

4.1.4 Air Crew to undergo emergency evacuation of simulated helicopter in distress, periodically.

4.1.5 Maintenance oversight to be strengthened, with periodic audits utilising other fleet personnel/ DGM (Air Safety)

4.2 For DGCA

4.2.1 CARs.

As far as possible, each CAR should contain all the relevant information in the same issue. Cross references to ICAO and other publications may be avoided.

4.2.2 Concessions/Filing of Differences

Since most of the helipads do not conform to the 'Category A' specifications of helipads, concessions may be given to the helipads in hilly areas to let operations continue. If necessary, suitable differences may be filed with ICAO.

4.2.3 Inspection of Helipad Safety Services

Instructions may be given to Operators to list out the safety services available at the helipads where they are landing often. This is to be time bound programme. Even when the helipads are not licensed, operations may be permitted to helipads with requisite safety services under concession from the DGCA.

4.2.4 Rule 160

A time limit needs to be laid down for aircrew flying on Rule 160. A time limit of two years for flying under Rule 160 may be considered.

4.2.5 Category A Certification for Mi-172

India has certified Mi-172 as a'Category A' rotor craft. Doubts have been expressed on some issues of performance. It is recommended that the Certificate be revalidated / reviewed with the help of Indian test pilots.

4.3 For Government of Arunachal Pradesh

4.3.1 Periodic Interaction with DGCA

Personnel of the Department of Aviation of Arunachal Pradesh should periodically interact with DGCA to find out various requirements needed for flying operations. Where possible, DGCA should also conduct symposiums in the North East, for the personnel of Aviation Department of North East, on flight safety requirements and helicopter flying.

4.3.2 Training on Crash Fire Fighting

The Government of Arunachal Pradesh should identify personnel and have them trained in crash and rescue work in aircraft accidents and have them posted at major helipads.

4.3.3 Licensing of Helipads in the State

As the organization responsible for all the helipads constructed and manned in Arunachal Pradesh, the local Government should process the case for licensing the helipads within the State, at the earliest. At present, they are not fully aware of these requirements.

4.4 For Ministry of Civil Aviation

4.4.1 Licensing of Helipads in India

There may be more than 500 helipads in the country. It is not possible for the DGCA to carry out inspections and licensing of all the helipads within a short time. Co-ordination with Defence Ministry may be carried out to get specialists on short deputations of 2-3 months, at different regions, to inspect the helipads. A time bound programme may be made to license most of the helipads in the country. The licensed heliports should be made available on the DGCA website.

4.4.2 Flight Inspectors

Flight Inspectors who are experienced Pilots are difficult to be appointed at Government salaries. Again, the Defence Forces have Pilots at Government salaries who may be appointed. This would require co-ordination with Defence Forces to depute their personnel in rotation, for a period of 2 to 3 years.

(Ravi Krishan)
Air Commodore (Retd)

(Rabinder Singh)
Wing Commander (Retd)

(PP Rajkumar)
Air Marshal (Retd)

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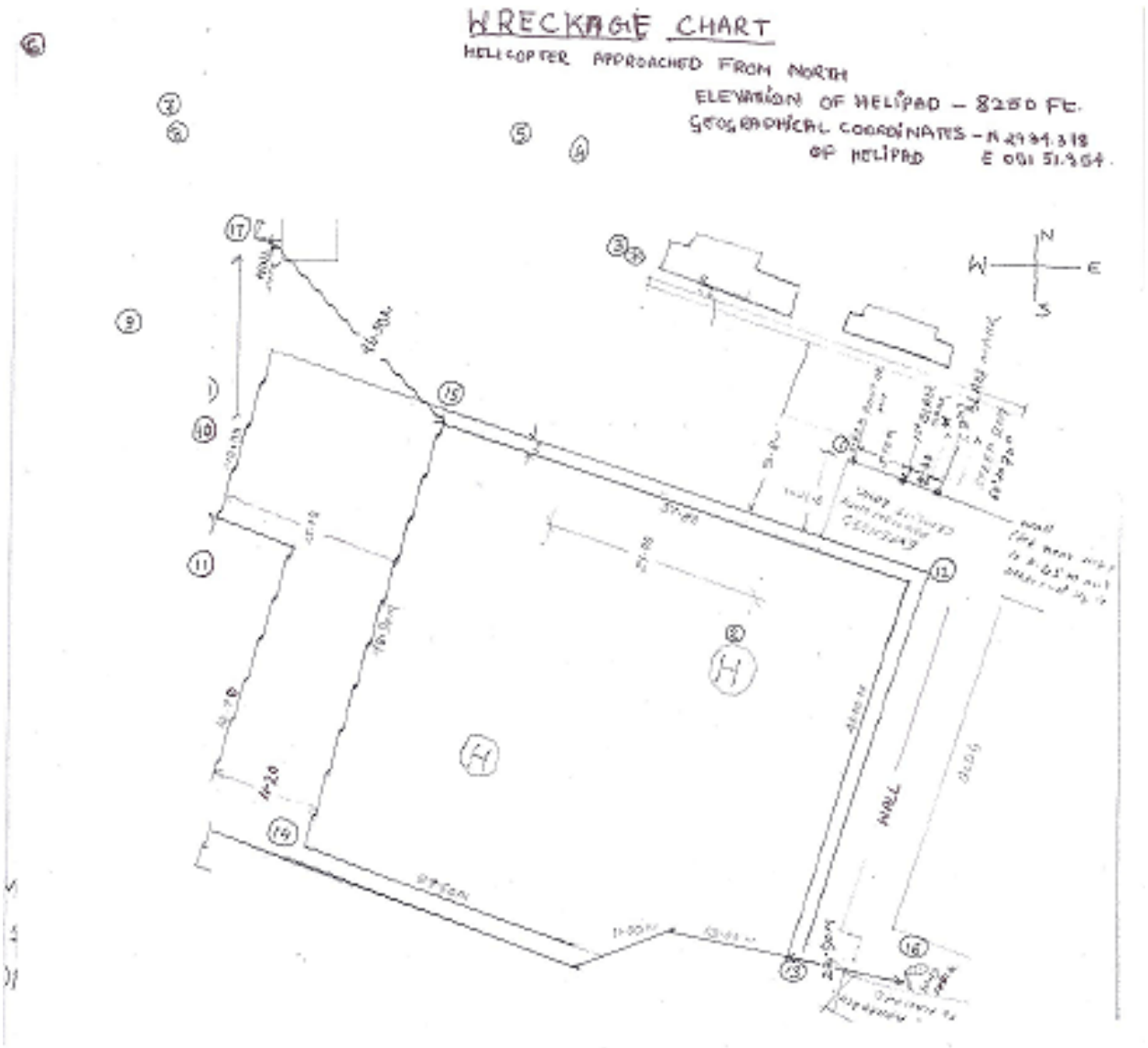
5. APPENDIX


WRECKAGE CHART
HELICOPTER APPROACHED FROM NORTH
ELEVATION OF HELIPAD – 8250 Ft.
GEOGRAPHICAL COORDINATES – N 27 34.318
OF HELIPAD E 091 51.964
N
W
E
S
H
H
WALL
OPEN

Wreckage Distribution Table VT-PHF

S/N	Interpretation of the point	Long, Lat	Distance (in meters)	Bearing
1	Touchdown point (**Reference point**)	N 27 34.389 E 091 51.965	-------	------
2	"H" Mark on the helipad	N 27 34.378 E 091 51.954	27.24	221°33'16"
3	Tail Rotor	N 27 34.402 E091 51.961	24.97	344°44'38"
4	Main Rotor (M/R) Blade Piece	N 27 34.432 E091 51.955	81.37	348°21'07"
5	Main Rotor (M/R) Blade Piece	N 27 34.431 E091 51.936	91.26	328°31'53"
6	Main Rotor (M/R) Blade Piece pierced in soil	N 27 34.555 E091 51.839	370.8	326°04'00"
7	Main Rotor (M/R) Blade Piece fell and cut a plant	N 27 34.448 E091 51.898	155.1	314°48'41"
8	Main Rotor (M/R) Blade Piece	N 27 34.436 E091 51.895	144.3	307°08'33"
9	Main Rotor (M/R) Blade Piece	N 27 34.395 E091 51.889	125.3	275°05'22"
10	Main Rotor (M/R) Blade Tip	N 27 34.383 E091 51.914	84.52	262°26'23"
11	Main Rotor (M/R) Blade trailing edge	N 27 34.372 E091 51.920	80.36	246°55'02"
12	Helipad point # 1(seen in direction to approach) Left side.	N 27 34.382 E091 51.970	15.35	147°39'35"
13	Helipad point # 2 (seen in direction to approach) Left side.	N 27 34.361 E091 51.960	52.54	188°59'41"
14	Helipad point # 2 (seen in direction to approach) Right side.	N 27 34.366 E091 51.930	71.57	233°26'56"
15	Helipad point # 1 (seen in direction to approach) Right side.	N 27 34.393 E091 51.939	43.35	279°50'46"
16	Wind Sock Left side, seen while approach	N 27 34.356 E091 51.974	62.92	166°24'34"
17	Wind Sock Right side, seen while approach	N 27 34.414 E091 51.929	75.13	308°04'34"

6. ACKNOWLEDGEMENT

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(PP Rajkumar)
Air Marshal (Retd.)
Chairman
Committee of Inquiry

New Delhi