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FINAL REPORT ON ACCIDENT INVOLVING CESSNA CITATION 560XL AIRCRAFT VT-JSS OF M/s JINDAL STEEL & POWER LTD. ON 28.06.2020 AT JINDAL VIJAYANAGAR AIRPORT, KARNATAKA.

Amit Kumar
Investigator

Dinesh Kumar
Investigation-In-Charge

FOREWORD

In accordance with Annex 13 to the Convention on International Civil Aviation Organization (ICAO) and Rule 3 of Aircraft (Investigation of Accidents and Incidents), Rules 2017, the sole objective of the investigation of an accident shall be the prevention of accidents and incidents and not to apportion blame or liability.

This document has been prepared based upon the evidences collected during the investigation, opinion obtained from the experts and laboratory examination of various components. Consequently, the use of this report for any purpose other than for the prevention of future accidents or incidents could lead to erroneous interpretations.

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GLOSSARY	
AAIB	Aircraft Accident Investigation Bureau, India
AFM	Airplane Flight Manual
AME	Aircraft Maintenance Engineer
AMSL	Above Mean Sea Level
ARC	Airworthiness Review Certificate
ARP	Aerodrome Reference Point
ATC	Air Traffic Control
ATPL	Airline Transport Pilot License
AUW	All Up Weight
C of A	Certificate of Airworthiness
CB	Cumulonimbus Cloud
CAP	Crew Alerting Panel
CAR	Civil Aviation Requirements
CFT	Crash Fire Tender
COI	Committee of Inquiry
CPL	Commercial Pilot License
CVR	Cockpit Voice Recorder
DCU	Data Collection Unit
DFDR	Digital Flight data Recorder
DME	Distance measuring equipment
DGCA	Directorate General of Civil Aviation
EEC	Electronic Engine Controller
EMM	Engine Maintenance Manual
F/O	First Officer
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FRTOL	Flight Radio Telephone Operators License
FL	Flight Level
hrs	hours
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IPTM	Initial Pilot Training Manual
JSPL	Jindal Steel & Power Plant
JSW	Jindal South West
LLZ	Localizer
MEL	Minimum Equipment List
MLG	Main Landing Gear
NDB	Non-Directional Beacon
NLG	Nose Landing Gear
NSOP	Non-Scheduled Operator
NTSB	National Transportation Safety Board
Nm	Nautical Miles
OEM	Original Equipment Manufacturer
OM	Operations Manual
PAPI	Precision Approach Path Indicator
PIC	Pilot in Command
PM	Pilot Monitoring

PT	Power Turbine
QRH	Quick Reference Handbook
SB	Service Bulletin
SEP	Safety and Emergency Procedures Manual
TAF	Terminal Aerodrome Forecast
T/R	Thrust Reverser
TSN	Time Since New
VFR	Visual Flight Rules
VOJV	Jindal Vijayanagar Airport
VOR	VHF Omnidirectional Range
UTC	Coordinated Universal Time

FINAL REPORT ON ACCIDENT INVOLVING M/s JINDAL STEEL & POWER LTD. CESSNA CITATION 560XLS AIRCRAFT VT-JSS AT VIJAYANAGAR ON 28/06/2020

1.	Aircraft Type	: Cessna Citation 560XLS
	Nationality	: Indian
	Registration	: VT - JSS
2.	Owner/ Operator	: M/s Jindal Steel & Power Ltd.
3.	Pilot – in –Command	: ATPL holder on type
	Extent of injuries	: Nil
4.	First Officer	: CPL Holder on type
	Extent of injuries	: Nil
5.	Place of Accident	: Jindal Vijayanagar Airport, Karnataka
6.	Date & Time of Accident	: 28 June 2020, 1423 UTC
7.	Last point of Departure	: Hyderabad
8.	Point of intended landing	: Jindal Vijayanagar Airport
9.	Type of operation	: General Aviation
10.	Passengers on Board	: 06
	Extent of injuries	: Nil
11.	Phase of operation	: Landing
12.	Type of accident	: Runway Excursion

(ALL TIMINGS IN THE REPORT ARE IN UTC)

SUMMARY

On 28 June 2020, M/s Jindal Steel & Power Ltd. Cessna Citation 560XLS aircraft VT-JSS met with an accident while landing at Jindal Vijayanagar Airport. The aircraft was under the command of a pilot holding valid ATPL on type with first officer holding valid CPL on type. There were 06 passengers on board the aircraft.

The aircraft took-off from Hyderabad for Jindal Vijayanagar at 1344 UTC with 06 passengers on board. The enroute flight was uneventful. Aircraft came in contact with ATC Vijayanagar. Crew requested for landing clearance and runway in use. ATC cleared the aircraft and runway 13 was assigned for landing. Aircraft landed at Jindal Vijayanagar airport at 1423 UTC and after touchdown, aircraft started veering to left. During landing roll, aircraft was continuously drifting towards left. And after consuming approximately 889 m of runway, aircraft exited the runway surface from left and started rolling on the soft ground. Consequently, actions were initiated by crew to bring the aircraft back on paved runway surface. Subsequently, aircraft came to a halt at runway edge close to threshold of runway 31. Onboard passengers and crew did not receive any injury.

The occurrence was classified as Accident as per the Aircraft (Investigation of Accidents and Incidents) Rules, 2017. DG-AAIB vide Corrigendum No. INV-11011/05/2020-AAIB dated 03.06.2021 appointed Mr. Dinesh Kumar, Assistant Director as IIC and Mr Amit Kumar Safety Investigation Officer as an Investigator.

Initial notification of the occurrence was sent to NTSB, USA along with ICAO as per requirement of ICAO Annex 13.

1. FACTUAL INFORMATION

1.1 HISTORY OF THE FLIGHT

On 28.06.2020, a Cessna Citation 560 XLS aircraft VT-JSS belonging to M/s JSPL met with an accident while operating a non-scheduled flight from Hyderabad to Jindal Vijayanagar. The flight was under the command of an ATPL holder pilot (Pilot Flying) with a CPL holder pilot as Co-Pilot (Pilot Monitoring). There were 06 passengers on board the aircraft.

On the day of accident, aircraft had operated two flights uneventfully (First Sector was Mumbai-Vijayanagar & Second Sector was Vijayanagar- Hyderabad) before it met with an accident while operating the third sector Hyderabad-Vijayanagar. In pursuance to DGCA guidelines owing to Covid-19 pandemic, prior to operating the first flight of the day, both crew had submitted their undertakings at Mumbai airport for non-consumption of alcohol/psychoactive substance.

As per crew statement, the pre-flight checks were carried out at Rajiv Gandhi International Airport, Hyderabad. After clearance from ATC, aircraft was lined up for takeoff from runway 27L. Thereafter, aircraft took off at around 1344 UTC .Takeoff was normal and aircraft climbed to FL240 on the heading given by ATC. Subsequently, aircraft was given direct routing to VOJV. Later, aircraft was handed over to Mangalore Control. Crew obtained descent clearance from ATC Mangalore and subsequently descent was commenced.

While the aircraft was at approximately FL110, it was handed over to ATC Jindal Vijayanagar. During initial contact with ATC Jindal Vijayanagar, crew requested for ATIS. Subsequently, weather prevalent at 1400 UTC was communicated to the crew. Weather reported was winds variable 03 knots runway 13, Visibility 6 Km, CB W/SW. However, as per PIC statement weather radar was not showing any significant weather while the aircraft was at approximately 50 miles from Jindal Vijayanagar.

Aircraft was cleared to descent FL75 and to report 25 Nm inbound Vijayanagar. While the aircraft was at 15 Nm, it was further cleared for descent to 5000 feet and subsequently, weather information was again passed to the aircraft. Weather reported was passing rain shower overhead. Thereafter, crew requested for latest wind and information passed by ATC was "winds 200/05 Knots visibility 5 Km". Crew then asked about runway in use. Subsequently, ATC responded "It's a cross wind sir better to approach to 13 only 31 side there may be a lightning".

After visual contact with runway, aircraft joined left downwind for runway 13 as cleared by ATC. At end of downwind, aircraft turned for final approach. While the aircraft was at approximately 5 Nm, crew confirmed runway insight and thereafter, continued approach. While landing clearance was given, crew were updated winds as 270/06 Knots. As per crew statement, PAPI was followed till the aircraft touched down on the centreline of runway 13. Landing was performed under VFR and the runway lights, which are mandatory as per DGCA requirement, were active when aircraft landed at 1423 UTC. Consequently, ATC personnel stated "Excellent Approach Sir Good Landing".

As per the statement of crew, 7 seconds after touchdown, both thrust reversals were deployed simultaneously. Thereafter, brakes were applied. During landing roll, aircraft covered a distance of around 400 meters without showing any significant deviation in its heading. However, after rolling for around 222 meters, aircraft started deviating towards left. As per the statement from PIC, "On landing roll while decelerating, heavy downpour started and visibility became Nil, couldn't sight the centreline and runway edge lights." Pilot Monitoring also stated that "after touchdown on centreline, heavy rain started and resulted in visibility dropping to zero".

After consuming 622 meters of runway, aircraft started drifting significantly towards left from the runway centreline. Aircraft rolled for around 889 metres before it exited the runway surface from left. Subsequently, aircraft rolled for another 78 meters approximately on the soft ground almost parallel to runway. And to bring back

the aircraft on runway, PF had applied the right rudder. The aircraft started heading towards right and subsequently came to a complete halt on the paved surface of the runway near runway 31 threshold.

At 1425 UTC, crew transmitted to ATC that aircraft has exited the runway. Crash alarm and firebell were activated by ATC tower and fire control room was informed of the accident.

All passengers had deplaned normally by the time CFT reached the site. Both engines were shutoff and finally crew evacuated the aircraft after securing the cabin.

1.2 INJURIES TO PERSONS

There was no injury.

1.3 DAMAGE TO AIRCRAFT

The aircraft sustained substantial damage.

1.4 OTHER DAMAGE

One LH side runway edge light (L-18) was found broken.

Fig 1: Broken runway edge light

1.5 PERSONNEL INFORMATION

1.5.1 Pilot – in – Command

Age	: 39 years 10 months
License	: ATPL
Date of Issue	: 21st July 2015
Valid up to	: 20th July 2020
Category	: Aeroplanes
Date of Class I Med. Exam.	: 19th December 2019
Class I Medical valid up to	: 22nd December 2020
Date of issue FRTOL License	: 17th July 2009
FRTO License valid up to	: 16th July 2024
Endorsements as PIC	: Cessna 152 A, Cessna Caravan 208 B, CE-525, C-560 XLS Piper Seneca P A-34,
Total flying experience	: 2595 Hrs
Total flying experience on type	: 1006.1 Hrs
Total flying experience during last 1 year	: 160:55 Hrs
Total flying experience during last 6 months	: 66:55 Hrs
Total flying experience during last 30 days	: 17:30 Hrs
Total flying experience during last 07 days	: 07:35 Hrs
Total flying experience during last 24 hours	: 03:05 Hrs

1.5.2 Co-Pilot

Age	: 55 years
License	: CPL
Date of Issue	: 23rd February 1989
Valid up to	: 5th December 2023
Category	: Aeroplanes

Date of Class I Med. Exam.	: 2nd January 2020
Class I Medical valid up to	: 1st July 2020
Date of issue FRTOL License	: 23rd February 1989
FRTO License valid up to	: 5th December 2023
Endorsements as PIC	: Pushpak, Cessna 152A, Cessna Caravan 208 B, CE-525
Total flying experience	: 4242:40 Hrs
Total flying experience on type	: 91:55 Hrs
Total flying experience during last 1 year	: 87:25 Hrs
Total flying experience during last 6 months	: 34:50 Hrs
Total flying experience during last 30 days	: 23:20 Hrs
Total flying experience during last 07 days	: 09:00 Hrs
Total flying experience during last 24 hours	: 01:45 Hrs

Both pilots were not involved in any serious incident or an accident in the past as per the information made available by the operator. Both crew were current in all trainings and had adequate rest as per the Flight Duty Time Limitations (FDTL) requirement prior to operating the accident flight.

As per the records, PIC underwent Adverse Weather & Monsoon training on 16th March 2020.

1.6 AIRCRAFT INFORMATION

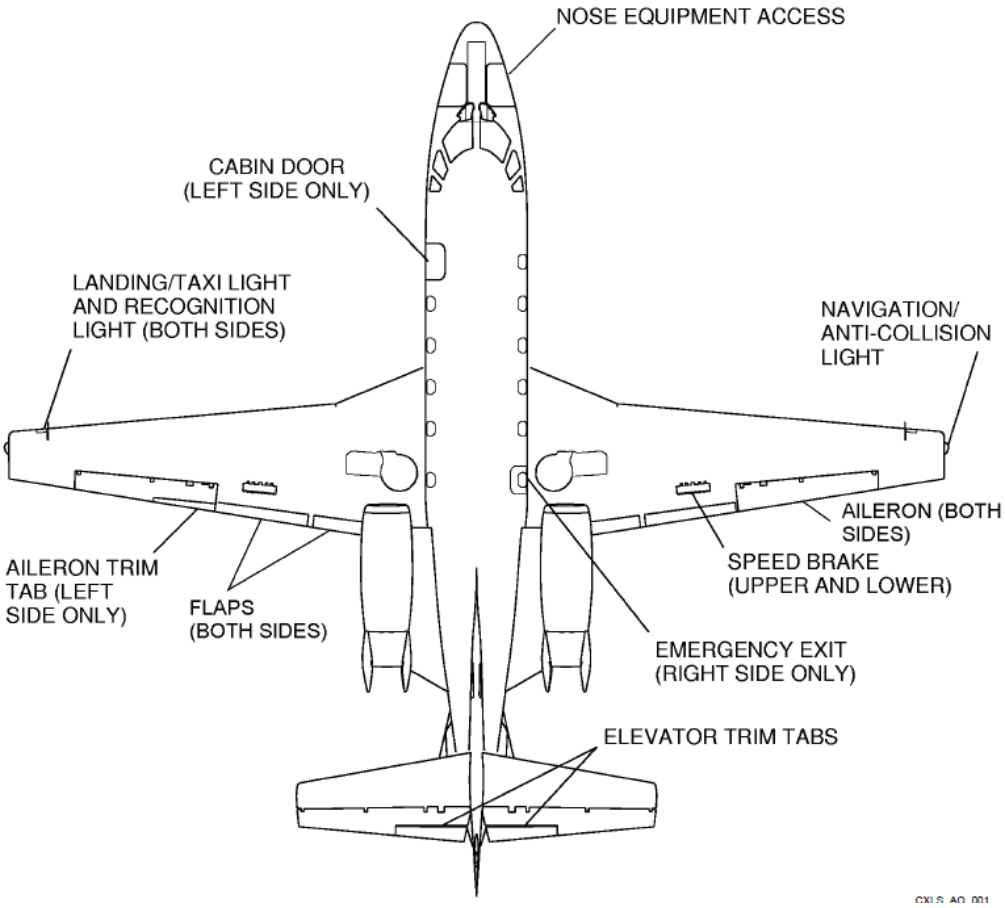
1.6.1 Cessna Citation 560XLS Aircraft Information

The Cessna Citation XLS is certified in accordance with FAR Part 25 airworthiness standards for two pilots, IFR, VFR, day, night, and flight into known icing conditions. The aircraft is eligible for aforesaid operations when the appropriate instruments and equipment required by the airworthiness and operating requirements are installed and approved and are in operable condition.

The aircraft has hydraulically powered landing gear, flaps, speedbrakes, two position horizontal stabilizer, and thrust reverser operation through an open centre hydraulic system. A separate closed hydraulic system operates the main gear wheel brakes. In addition, a backup pneumatic system can operate landing gear extension and braking.

The Citation XLS landing gear system is a standard tricycle design electrically controlled and hydraulically actuated. Each gear assembly has a single tire. The nose tire is chined to deflect water and slush on the runway away from the aircraft's engines.

The XLS is powered by two Pratt and Whitney Canada Inc. PW545B turbofan engines. Conventional piggy-back controls on the throttles operate target-type thrust reversers.



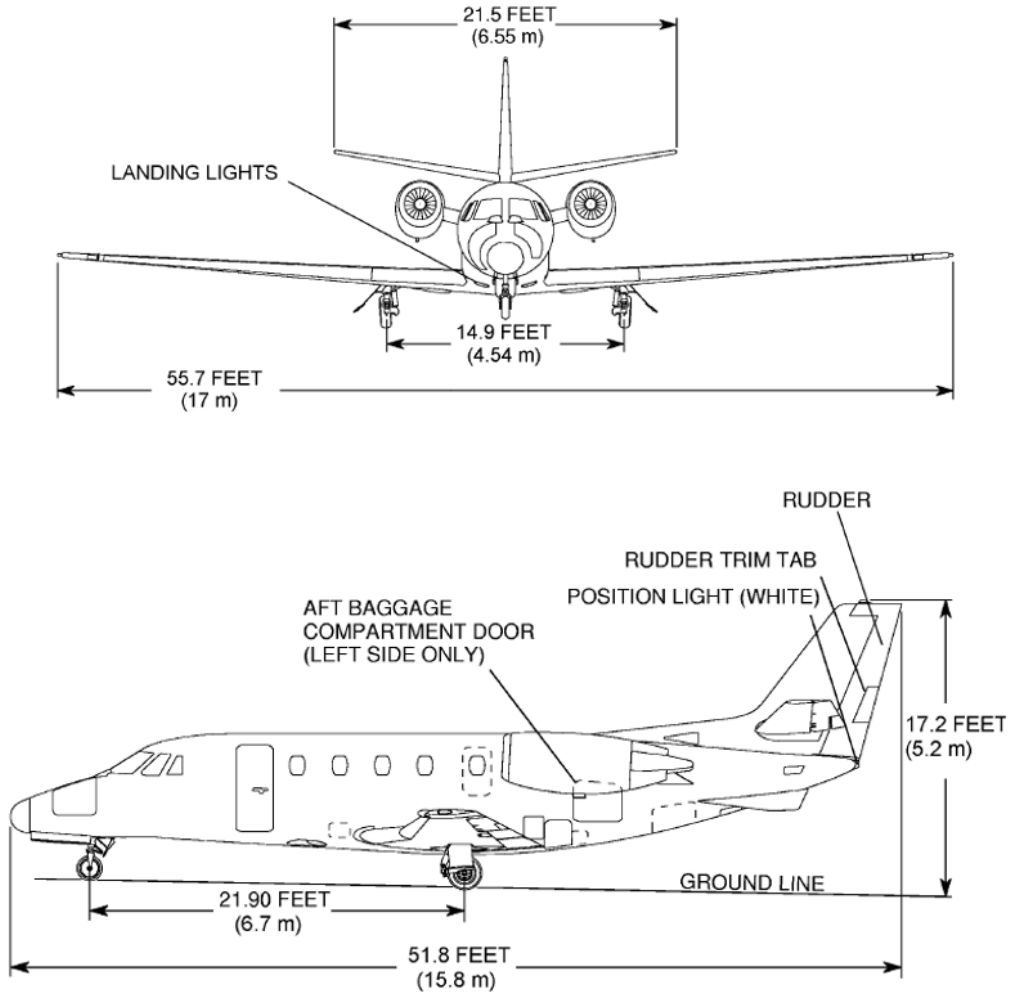


Fig 2: Three-view Drawing

Aircraft Systems:

I. Nosewheel Steering

The nose wheel steering is accomplished by cables and a bungee connected to the rudder pedals. The nose wheel steering turning limit is limited by the rudder stops. The turning limit is approximately 20 degrees either side of centre. The bungee is a spring loaded rod which transmits steering control to a steering arm, universal joint and steering gear mounted atop the nose gear strut. Additional steering of the nose wheel can be achieved against the bungee by application of differential power and braking.

II. Brakes and Antiskid System

Main landing gear wheels have hydraulically and pneumatically operated multiple disc brakes. The pneumatic braking system provides a backup if hydraulic braking fails. During normal braking, an antiskid system provides maximum braking efficiency and prevents skidding on wet, dry, or icy runways.

Brake cables are installed from the pilot and co-pilot rudder pedals aft to the brake mixer assembly. The brake mixer assembly connects the pilot and co-pilot pedals and gives a single output to a brake metering valve. Hydraulic pressure at the brake metering valve is sent to each of the brake assemblies as a result of the input that is received from the brake mixer assembly.

Antiskid System

The antiskid system provides power-assisted braking with skid protection. It is designed to provide maximum braking efficiency on all runway surfaces.

The system senses the deceleration rate of each of the main landing gear wheels and decreases the brake pressure to any wheel that starts to skid. Pressure is then increased until the most efficient braking power is found.

The power brake system is in operation at all times independent of the position of the Antiskid switch. The power brake system operates any time the DC bus is energized and the landing gear handle is in the DOWN position. System operation is conventional with power braking available at all speeds while antiskid protection is available at speeds above approximately 12 knots.

A test circuit is installed in the digital antiskid control unit that can be used to test the system on the ground. When the rotary test switch is turned to the ANTISKID position, the test circuit monitors the electrical operation of the antiskid system. The test circuit is also used when the landing gear handle is in the DOWN position during flight and the Antiskid switch is in the ON position. The ANTISKID INOP annunciator on the annunciator panel will illuminate to tell the crew of an antiskid system fault.

The antiskid system has two safety features which are as follows:

i. Touchdown protection which prevents landing with hydraulic pressure applied to the brakes. The antiskid valve will not send hydraulic pressure to the brake assemblies until the left main landing gear squat switch shows that the airplane is on the ground.
ii. Locked wheel crossover protection which operates at wheel speeds of more than 40 knots. If one of the wheel speed transducers shows a speed of more than 50% less than the other wheel, the pressure will be fully released from the brake assembly on the slower wheel.

The antiskid protection feature is designed to operate with maximum pilot-applied brake pressure and suggests not to modulate brake pressure when maximum braking is desired.

As per the AFM, to ensure proper braking on water, snow, and ice-covered, hard-surface runways and all unimproved surfaces, it is necessary for the pilot to apply maximum effort to the brake pedals throughout the braking run. When the system anticipates a skid and releases the applied brake pressure, any attempt by the pilot to modulate braking can result in an interruption of the applied brake signal and may increase stopping distance significantly.

Wheel Brakes

Braking can be accomplished by either of two independent systems: the power brake hydraulic system or the backup pneumatic system.

Normal braking can be applied from either cockpit seat. The emergency brake control is installed under the left instrument panel only.

Power Brake Control System

The brake control system is actuated by the brake pedals. Brake cables are used to send the movement of the brake pedals down to the brake mixer assembly. The power brake system starts when the brake metering valve is actuated by the brake

cables in the brake control system. The brake mixer assembly takes the input from each of the four brake pedals and mixes them to make a single output for each of the left and right pedals. The brake mixer also gives indication at the brake pedals so that the pilot and co-pilot can feel the brake application that the other has applied. The output movement of the left and right sides of the brake mixer is sent to the brake metering valve through cables. At the brake metering valve, the linear movement of the cables is changed to hydraulic pressure.

When electrical power is supplied to the brake system, the hydraulic pump assembly activates and charges the accumulator and pressurizes the brake system. This pressure stays upstream of the brake metering valve until the pilot or co-pilot actuates one of the brake pedals.

The brake control system moves the correct cables to actuate the left or right lever on the brake metering valve. When the levers are actuated, the pressurized fluid is sent to the antiskid valve and out to the wheel at a pressure that is determined by the amount of pressure applied by the pilot or co-pilot. If the antiskid senses a skid in one or both of the wheels, the antiskid valve will receive a signal from the antiskid controller to reduce the fluid pressure to that wheel.

Emergency Braking System

In the event of normal hydraulic braking system failure, a pneumatic system is available. The pneumatic pressure required is contained in the emergency air bottle and is controlled by a lever with a red knob located to the left of the AUX GEAR CONTROL T-handle. Pulling the lever aft will apply equal pressure to both main landing gear brake assemblies. Releasing the back pressure on the lever and allowing it to move forward will relieve the pressure. The air pressure to the brakes may be modulated to provide any braking rate desired, but differential braking and antiskid will not be available.

The emergency air bottle, when fully charged, contains sufficient pressure for six or more full brake applications. For the most efficient use of the system, apply sufficient air pressure to the brakes to obtain the desired deceleration rate. Maintain

that pressure until the airplane stops. When the handle is released, residual air pressure from the brakes is exhausted overboard.

III. Thrust Reversers

The thrust reverser system features external target-type reversers that direct exhaust gases forward to provide deceleration force to assist in braking. The thrust reverser is a hydraulically actuated, four-bar linkage, target-type reverser, mounted on the aft end of each engine over the fan duct assembly. The fan duct assembly is a component of the thrust reverser assembly. When deployed after landing and during roll out, the reverser doors actuate from the stowed position and join behind the exhaust nozzle cone to deflect engine exhaust forward, over and under the nacelles.

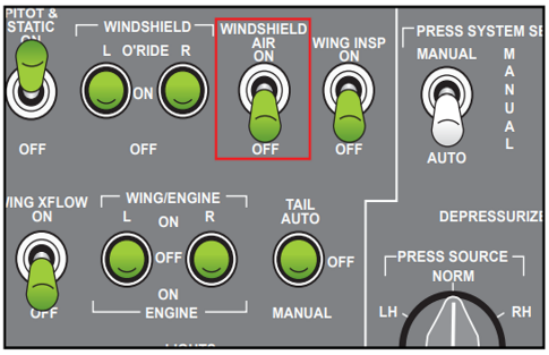
The pilot activates the thrust reverser system by operating thrust reverser levers that mount “piggy-back” on engine throttle levers. The reversers can be deployed only when primary throttle levers are in IDLE position and the aircraft is on the ground. Landing gear squat switches activate at touchdown to complete the electrical circuit necessary for reverser deployment. The Left and Right buses power the left and right thrust reverser control circuits respectively.

The hydraulic power required for operation is provided by the standard airplane system through the thrust reverser isolation and control valves.

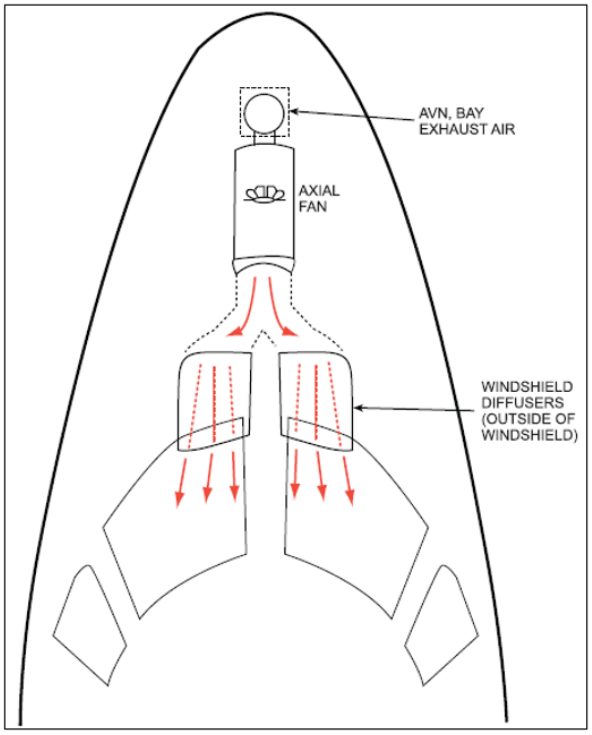
An erroneous sequencing or a delay in the thrust reverser lights indicates a failure in the thrust reverser system. Either or both conditions require a maintenance check before further flight.

After deployment, power may be increased by moving the thrust reverser throttle levers aft for maximum reverse thrust. For convenience, stops have been installed on the thrust reverser levers and are set to limit the reverse fan speed to 75% of takeoff thrust. This will allow the pilot to keep attention on the landing rollout instead of diverting attention to the reverse thrust settings.

IV. Windshield Rain Removal System



Windshield Air Switch



Blower Fan location

Fig 2: Switch position and Blower Fan location

The windshield rain removal system utilizes a two-speed blower fan located in the nose avionics compartment that is routed to the windshield through a dual duct. The fan is controlled by an ON/OFF switch, labelled WINDSHIELD AIR. Placing the WINDSHIELD AIR switch in the ON position will operate the fan at high speed. With the windshield air ON, the blower will direct high velocity air onto the windshield to assist in clearing rain or mist. The system is primarily for ground use, but does provide some benefit in flight. The primary rain removal in flight is provided by airflow in conjunction with a windshield treatment.

During investigation, PIC stated that he is unable to recall whether the system was activated when heavy rain was encountered after landing at Jindal Vijayanagar.

V. Cockpit Voice Recorder (CVR)

The CVR system is protected by a 5-ampere circuit breaker located on the left circuit breaker panel in the cockpit.

The recorder is energized any time the battery switch is in the BATT position. The control panel, located low on the right side of the copilot's instrument panel, contains a TEST button and an ERASE button.

Fig 4: Location in cockpit

Fig 5: CVR Test Button

System operation is checked by pressing the TEST button. When the TEST button is held down for five seconds, illumination of the green light on the control panel indicates correct functioning of the voice recorder system. To erase the CVR, the airplane must be on the ground with the landing gear squat switch compressed and the cabin door open. Pressing the ERASE button for approximately 2 seconds will cause the entire recording to be erased.

As per the regulatory requirements of DGCA, the ERASE function was kept in deactivated mode in the aircraft.

1.6.2 VT-JSS Aircraft Information

Aircraft Model	Cessna Citation 560XL
Aircraft S. No.	560-5594
Year of Manufacturer	2005
Name of Owner	M/s Jindal Steel & Power Ltd.
C of R	Valid (issued on: 09.12.2013)
C of A	Valid (Re-issued on: 09.12.2013)
Category	Normal (Passenger)
A R C issued on	14.02.2020
ARC valid up to	13.02.2021
Aircraft Empty Weight	5648.42 Kg
Maximum Takeoff weight	9162.57 Kg
Date of Aircraft weighment	19.11.2015
Max Usable Fuel	3058.00 Kg
Max Payload with full fuel	286.15 Kg
Empty Weight C.G	336.09 inch
Next Weighing due	On or before 19th Nov 2020
Total Aircraft Hours	3667 :48 Hrs as on 28.06.20
Last major inspection	12 Months Inspection on 15.01.2020 at 3590:48 airframe hours.
List of Repairs carried out after last major inspection till date of accident	Nil
Engine Type	PW 545B
Date of Manufacture LH	13.09.2005
Engine Sl. No. LH	PCE-DD0191
Last major inspection (LH)	12 Months Inspection on 15.01.2020
List of Repairs carried out after last major inspection till date of accidence	Nil
Total Engine Hours/Cycles LH	3613:49 Hrs / 2800 Cyles
Engine Type	PW 545B

Date of Manufacture RH	27.08.2005
Engine Sl. No. RH	PCE-DD0193
Last major inspection (RH)	12 Months Inspection on 15.01.2020
List of Repairs carried out after last major inspection till date of incidence	Nil
Total Engine Hours/Cycles RH	3647:22 Hrs/ 2835 Cycles
Aero mobile License details	A-068/002/-RLO(NR) valid till 31.12.2020
AD, SB, Modification complied	Complied

The aircraft remained parked from 20.03.2020 to 28.05.2020 owing to suspension of flying activities by the government during nationwide lockdown to contain COVID-19 pandemic. Since no maintenance action was carried out between 20.03.2020 to 28.05.2020. Hence, as per OEM advice, certain tasks were performed on the aircraft and Engines to bring back them into the service on 29.05.2020.

As per Tech log entries, nil Snag was reported by the Pilot on previous two sector of the same day i.e., 28.06.2020.

Aircraft was holding valid two weight Schedules for Normal and Medical Configuration, duly approved by the office of Director of Airworthiness, DGCA, New Delhi.

The aircraft had logged 77:00 Hrs since last scheduled inspection. Prior to the accident flight, the aircraft had flown for 02:19 Hrs. with 03 landing on the day of accident. Water droplet check for windshield effectivity was carried out in Jan 2020 and found satisfactory.

The aircraft was maintained as per the approved maintenance schedules and all concerned Airworthiness Directives& Mandatory Service Bulletins; DGCA Mandatory Modifications on this aircraft and its engine were complied with as on the date of accident.

1.7 METEOROLOGICAL INFORMATION

The accident occurred at 1423 UTC. The METAR of 1415 UTC was intimated to the crew by the ATC. As per the available Met records, following MET information was reported between 1300 UTC – 1430 UTC at Jindal Vijayanagar airport:

Time (UTC)	**Winds (Direction/ Speed)**	**Visibility (m)**	**Clouds**	**Temp (°C)**	**Dew Point (°C)**	**QNH hPa**
1300	280/05	6000	SCT 1500 FT SCT 2500 FT FEW CB 2500 FT	32	21	1010
1400	270/05	6000	FEW 1500 FT SCT 2000 FT FEW CB 2500 FT	29	20	1006
1415	200/05	5000	SCT 1500 FT SCT 2500 FT FEW CB 25000 FT	29	20	1006
1430	270/07	6000	SCT 1500 FT SCT 2500 FT FEW CB 2500 FT	29	20	1007

Data pertaining to trend was not present in any Met report made available to the investigation team. However, MET report of 1415 UTC for Vijayanagar clearly forecasted about rain.

Moreover, as per the Flight Plan filed by crew at Hyderabad, visibility reported at destination airport i.e Jindal Vijaynagar was 6 Km, however, lighting with CB was also recorded in the Flight Plan.

The TAF provided to crew before operating the flight is given below:

280500z 2806/2815 **23010**KT 6000 SCT012 SCT020 TEMPO 2809/2812 400 SCT020 FEW025CB BKN080=

1.8 AIDS TO NAVIGATION

Navigation aids available at Jindal Vijayanagar airport are PAPI for Non-Precision approach procedures at both ends of runway.

1.9 COMMUNICATIONS

The aircraft contacted Jindal Vijayanagar ATC at 1410 UTC and remained in positive contact with the ATC on frequency 129.225 MHz.

Following was the communication held between ATC Tower and the aircraft when it came in contact with Jindal Vijayanagar ATC:

TIME (UTC) HH:MM: SS	TRANSMITTED BY	TRANSMISSION/COMMUNICATION
141051	TWR	VTJSS ROGER AFTER 110 CONTINUE DESCEND 75 REPORT 25 NM INBOUND VN
141053	TWR	VTJSS VN REPORT ESTIMATE
141126	TWR	ROGER
141515	VTJSS	FURTHER DESCENT 15 NM IN
	TWR	DESCENT TO 5000 FEET ON QNH 1006 REPORT LEFT DOWNWIND FOR RWY 13.
141622	TWR	VTJSS 5 KM RAIN SHRA OVERHEAD NOW START PASSING RAIN
	VTJSS	OK JUST LATEST WIND CHECK PLEASE
	TWR	200/05 KNOTS
141633	VTJSS	WINDS ARE FAVOURING 13 OR 31
	TWR	IT'S A CROSS WIND SIR BETTER TO APPROACH TO 13 ONLY 31 SIDE THERE MAY BE A LIGHTING
	VTJSS	COPIED SIR WE WILL BE COMING FOR RWY 13
141742	VTJSS	VTJSS APPROACHING OVERHEAD
	TWR	VTJSS INSIGHT REPORT FINAL RWY 13
142217	TWR	VSS CHECK 3 GREENS CELAR TO LAND RWY 13 SURFACE WIND 27006 KNOTS
	VTJSS	WEATHER COPIED
142326	TWR	EXCELLENT APPRAOCH SIR GOOD LANDING
142516	VTJSS	…….
	TWR	SIR WILL COME TO THE SPOT

1.10 AERODROME INFORMATION

Jindal Vijayanagar Airport is operated under private category by M/s Jindal South West Steel Ltd. The IATA Location Identifier code is VDY and ICAO location Indicator code is VOJV.

The ARP elevation AMSL is 508 m (1667 ft) and its coordinates are 15° 10' 30" N and 076° 38' 06" E. Rescue & Fire Fighting Services of Category 'V' is

available at the airport. The aerodrome operator has the capability for removal of disabled aircraft upto ATR-72-500 aircraft.

Aerodrome Dimensions and related Information

Rwy No.	TORA (M)	TODA (M)	ASDA (M)	LDA (M)	THRESHOLD	THR Co-ordinates
13	1475	1475	1475	1344	Threshold Displaced by 130 M	15° 10' 44.25" N 76° 37' 47.66" E
31	1498	1498	1498	1214	Threshold Displaced by 284 M	15° 10' 19.32" N 76° 38' 13.85" E

At both ends of runway 31/13, Runway End Lights of high intensity elevated type with 200W lamps 180^{o} Red filter on one side and 180^{o} Green filter on other side are installed. Precision Approach Path Indicator (PAPI) with configuration of 4 Units each having 3 nos. 200W halogen lamps are installed at both ends of the runway. Runway is also fitted with Threshold Lights (Elevated) of high intensity on both runways with spherical lamps and green filter. Runway Edge Lights of high intensity are also fixed on Runway 31/13. All lights are provided with stand by power supply too. As per Operations Manual, % Slope for runway 13 is 0.82 %.

Name of Aerodrome	**JINDAL VIJAYANAGAR AERODROME**		
The elevation of runway end and any significant high and low points along the runway.	***Runway***	***Thr Elevation***	***End Elevation***
	13	497.0 M (1630 ft)	496.0M (1627 ft)
	Significantly high points and low points on Rwy-Nil		

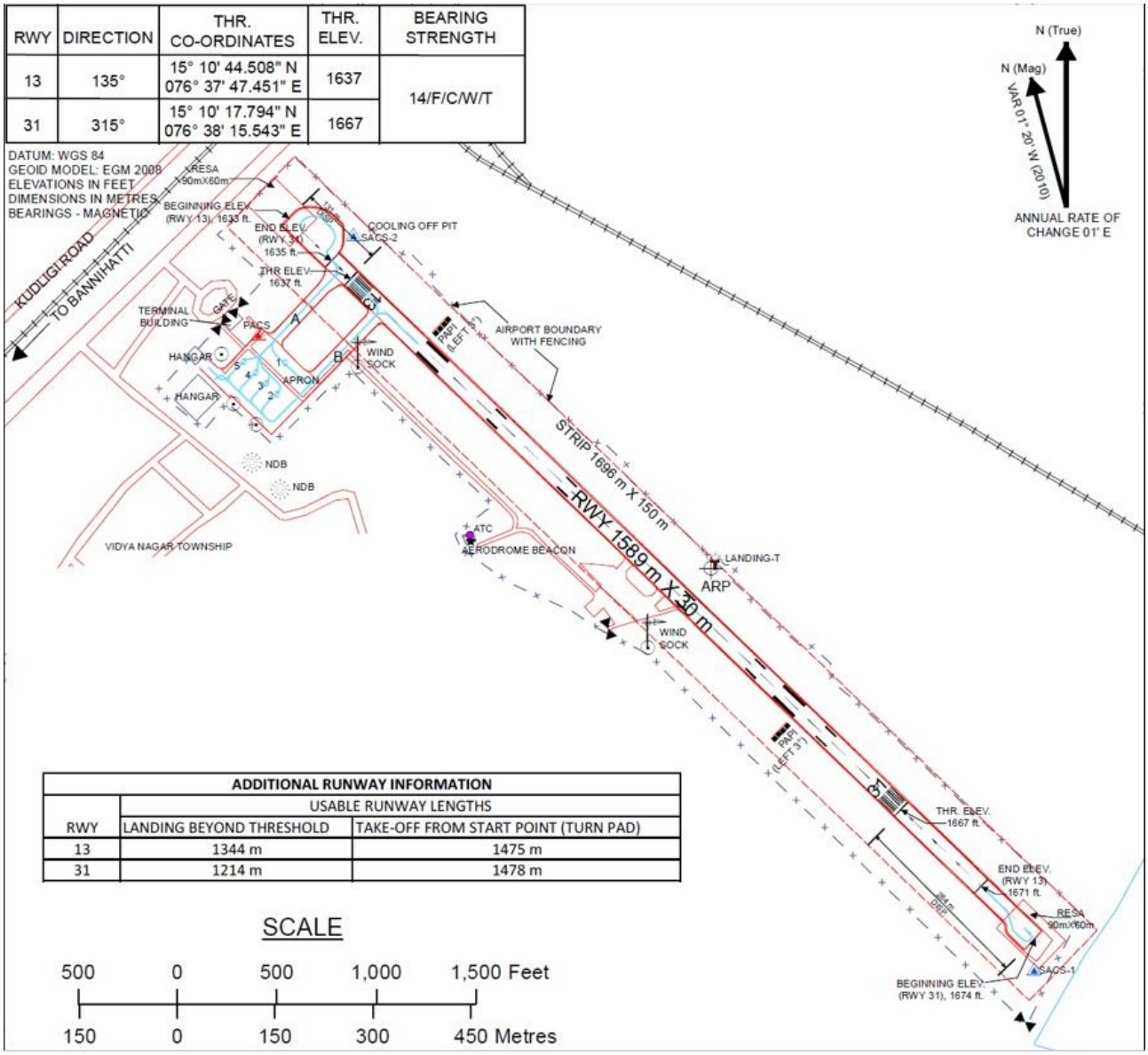


Fig 6: Grid Map of Jindal Vijayanagar Aerodrome

Runway surface friction test for Jindal Vijayanagar Airport was last performed on 11.12.2020 and all values of friction co-efficient for entire runway were within the prescribed limits. However, investigation team has come across following observations in the friction test report:

i. Runway section ‘C’ (from 740 m – 1270 m) showed least friction value while test was conducted at 95 Kmph at 9 metres (on both sides of runway centreline).

ii. In Section ‘C’ of the runway, at three locations, the friction value dropped upto Maintenance and even once crossed the Minimum Action level.

iii. At higher speeds, corresponding friction values dropped and least friction value for overall length of runway was found 0.74 μ at 95 Kmph.

During the course of investigation, operator was asked to provide the ATR on the aforesaid report but were unable to provide the same.

Friction file data summary along with the relevant graphs are placed at Appendix 'B' of this report.

1.11 FLIGHT RECORDERS

1.11.1 DFDR

The aircraft was equipped with a Solid State DFDR unit. The DFDR unit make is "L3 Communication" bearing Part no. S603-1000-00, Serial no. 000337136.After the accident, the raw data file retrieved from the unit was sent for analysis to NTSB. However, no productive data pertaining to accident flight was retrieved from the involved unit.

1.11.2 CVR

The aircraft was equipped with a Solid State CVR and DFDR unit. The CVR unit make is "L3 Communication" bearing part no. 2100-1020-02, serial no. 000246084 with total 02 hrs 04 minutes & 14 seconds capacity of recording. After the accident, CVR unit was downloaded and analysed. During CVR readout, it was observed that the CVR recording pertaining to preceding two sectors (including accidented flight from Hyderabad to Jindal Vijayanagar) was not captured in the CVR unit. The final recording captured by the CVR unit was while the aircraft was on ground (approximately 17 minutes) and both crew were on board preparing for the next flight from Jindal Vijayanagar to Hyderabad.

In order to identify the reason behind non-recording of CVR, it was checked with the operator when was the last time CVR unit was removed and installed. As per the work order raised, to comply with the applicable regulations of DGCA contained in CAR Section 2 Series I Part VI, CVR unit bearing part no. 2100-1020-02, serial no. 000301799 was replaced with the other serviceable CVR unit bearing

part no. 2100-1020-02, serial no. 000246084 capable of 2 hrs recording on each channel on 12 June 2020. However, readout of all 4 channels, retrieved from the involved unit, was of 30 minutes each only.

Further, scrutiny of maintenance documents established that on the day of accident no maintenance activity was carried out on the aircraft before CVR stopped recording.

1.12 WRECKAGE AND IMPACT INFORMATION

1.12.1 Subsequent Events after touchdown

Due to the non-availability of the DFDR data analysis, the touchdown and subsequent events were analysed with the help of aircraft tyre marks on the runway and soft ground (unpaved surface).

Aircraft made a touchdown at approximately 143 meters ahead of threshold (on centreline) of runway 13. During initial landing roll, aircraft was directionally controlled and no significant deviation in aircraft heading was observed. The aircraft had covered a distance of about 400 meters before it started veering towards left. Thereafter, a slight drift towards left in aircraft heading was observed. The aircraft gradually started veering towards left, upto 222 meters.

Fig 7: Aircraft Tyres marks on paved surface

Although, the deviation was slight but it was continuously moving towards left. Thereafter, deviation had increased due to which aircraft's MLG left tyre first exited

the runway edge after rolling on paved surface for around 817 meters. Eventually, after rolling further for around 72 meters, Right MLG tyre also exited the runway and aircraft came on soft ground. Thereafter, aircraft travelled for around 78 meters on soft ground before it hit the edge of runway and came to a halt on paved surface near runway 31 threshold.

As per PIC statement, after comprehending that aircraft had already left the paved surface, right rudder was applied to steer the aircraft back towards the runway. Consequently, it resulted into sudden change in aircraft heading leading to skidding of aircraft. While the aircraft was skidding, nose wheel re-entered the runway first, thereafter, left MLG collapsed after hitting the runway edge. Eventually, the aircraft came to final halt travelling 967 meters after touchdown almost perpendicular to the runway (approx. 220º). The track followed by the aircraft is shown in the figure below:-

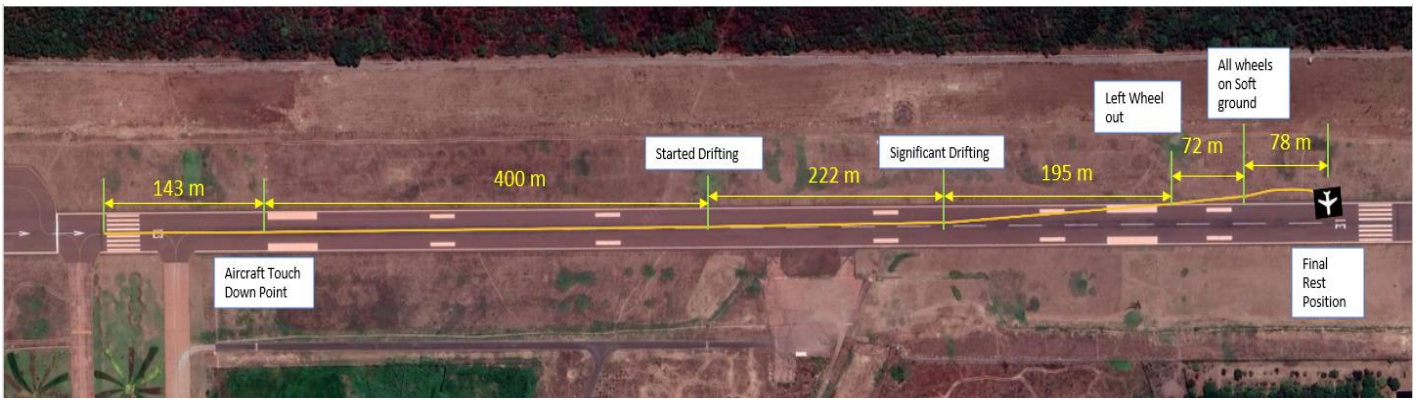


Fig 8: Ground marks plotted on Jindal Vijayanagar Airport

1.12.2 CCTV Footage

A CCTV video was made available to the investigation team covering last portion of the landing roll of the accidented flight. In the video, aircraft landing roll in rainy condition was captured. Thereafter, it was decided to physically measure the distance covered by the aircraft in actual which was captured by the camera. The physical distance measured was found to be around 121 meters (location was just before the aircraft left the paved surface) and frame time observed for aircraft coming in and going out was 19:45:15:382 & 19:45:20:382 (CCTV footage frame time) respectively. This shows that aircraft had covered a distance of 121 meters in around 5 seconds. This reveals that aircraft speed was around 24.2 m/s or 47 knots which

appears to be on higher side for an aircraft already had covered 622 meters of runway during landing roll.

Fig 9: Aircraft Final Resting Position

During onsite investigation following damages were observed on the aircraft:

Damages observed on Wings

A. LH Wing

Fig 10: Aircraft settled with left wing touching the ground

As a result of the LH main gear collapse, the LH wing sustained significant damage due to subsequent rubbing/dragging against the ground. Visual inspection revealed that flaps, speed brakes assemblies, ailerons, leading edges along with wing

fences showed sign of damages and an apparent puncture in the fuel tank was also observed.

Lower Wing Surface

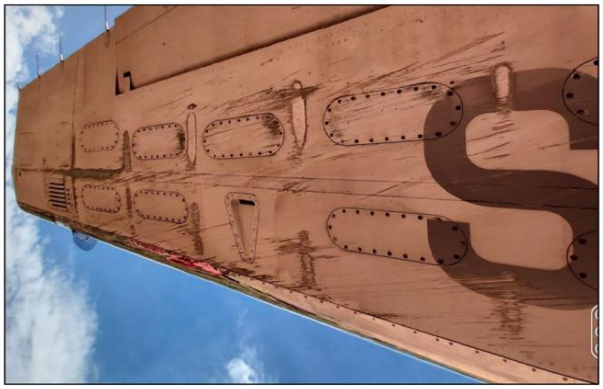


Fig 11: Lower LH Wing Surface

Fig 12: Skin separation on LH wing

The lower surface of LH wing was found extensively damaged in the form of deformation, gouges and scuffing ensuing rubbing against the ground. Lower skin was found detached from wing ribs, especially in proximity to flaps and supporting structure.

Fig 13: Holes on lower surface

Lower wing skin was found separated around LH aileron support structure due to fasteners got separated from the skin leading to holes elongation or cracks in nearby areas.

Fig14: Damaged Static Wicks

The LH wing static wicks were found damaged.

LH Flaps

Fig 15: Damages on LH Flap

i. LH wing inboard and outboard flaps were found damaged.

ii. Flap tracks and supporting wing structural components were observed bent.

iii. Upper as well as lower skin of LH flap was found separated and deformed.

Fig 16: Flap Bell crank & Pushrod

Bellcrank and pushrods of flap extension mechanism sustained severe damage. Pushrod was found protruded from upper wing skin.

LH Speed Brakes

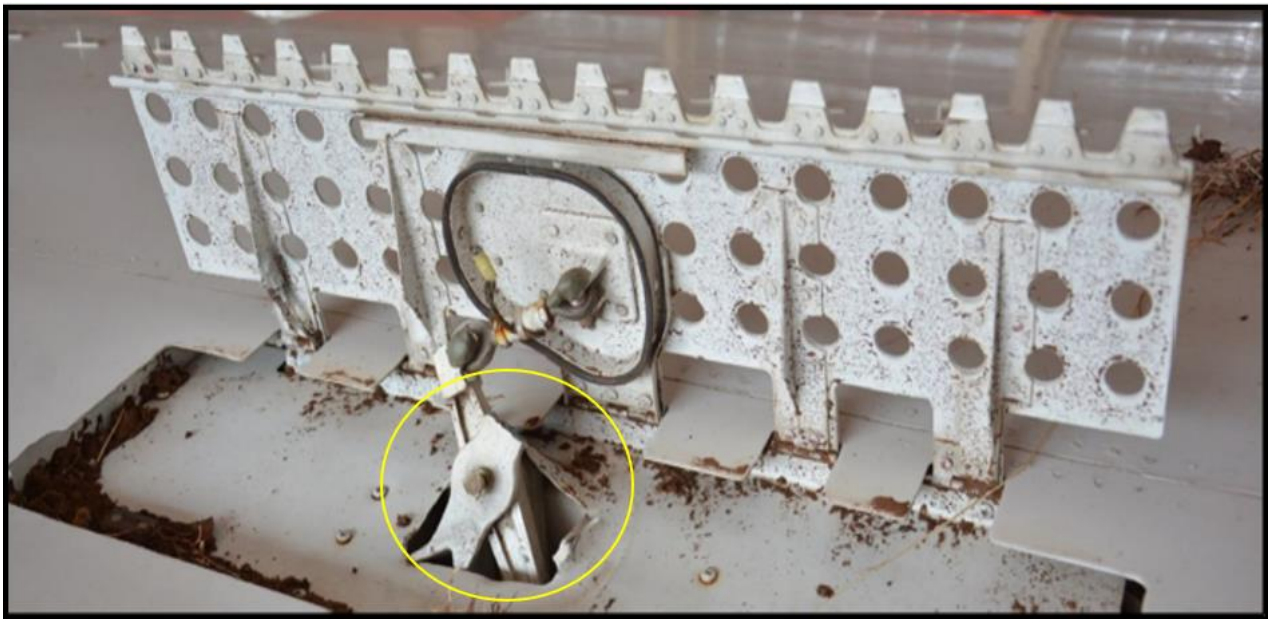


Fig 17: LH Speed Brake (failed bellcrank and damaged surrounding skin)

i. The LH speed brake assembly was found severely damaged.

ii. Trunnion support was found snapped and Bell crank forced through the skin.

Fig 18: LH upper wing skin bent in flap area (blue line for reference)

Lower Wing Surface

Fig 19: Lower Speed Brake

Lower LH speed brake heavily damaged and nearly stowed with extended bellcrank linkages

Leading Edges

Fig 20: Dent on leading Edge

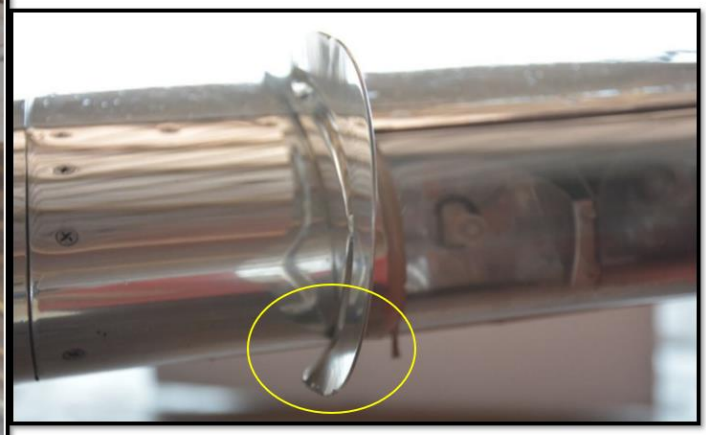


Fig 21: Leading Edge Fence

i. Dents and scratches were observed on leading edges.
ii. The outboard LH wing fence was found deformed & damaged as a result of contact with the ground.

Landing Gear

All landing gears sustained significant damage, as apparent from visual inspection. Most notable was the LH gear which suffered a collapse; however, all wheel assemblies showed signs of hub and tire damage.

LH Main Landing Gear

Fig 22: Collapsed LH MLG

Due to LH MLG hitting the edge of the runway, the left main landing gear collapsed.

Fig 23: LH MLG actuator eyelet broken off

Fig 24: Piston Rod bent

Fig 25: Detached Landing Gear Door (LH) and broken Actuator rod

Fig 26: Hole and crack on Wheel Well upper surface

RH Main Landing Gear and Nose Landing Gear

Fig 27: RH MLG tire

Fig 28: Nose Landing Gear

i. RH MLG was found torn out and deflated.
ii. NLG tire along with hub was found damaged.

Fuselage

Fig 29: Damage on Keel Beam Area

Signs of apparent FOD damage and rubbing marks were observed on keel beam area of lower fuselage.

Engines

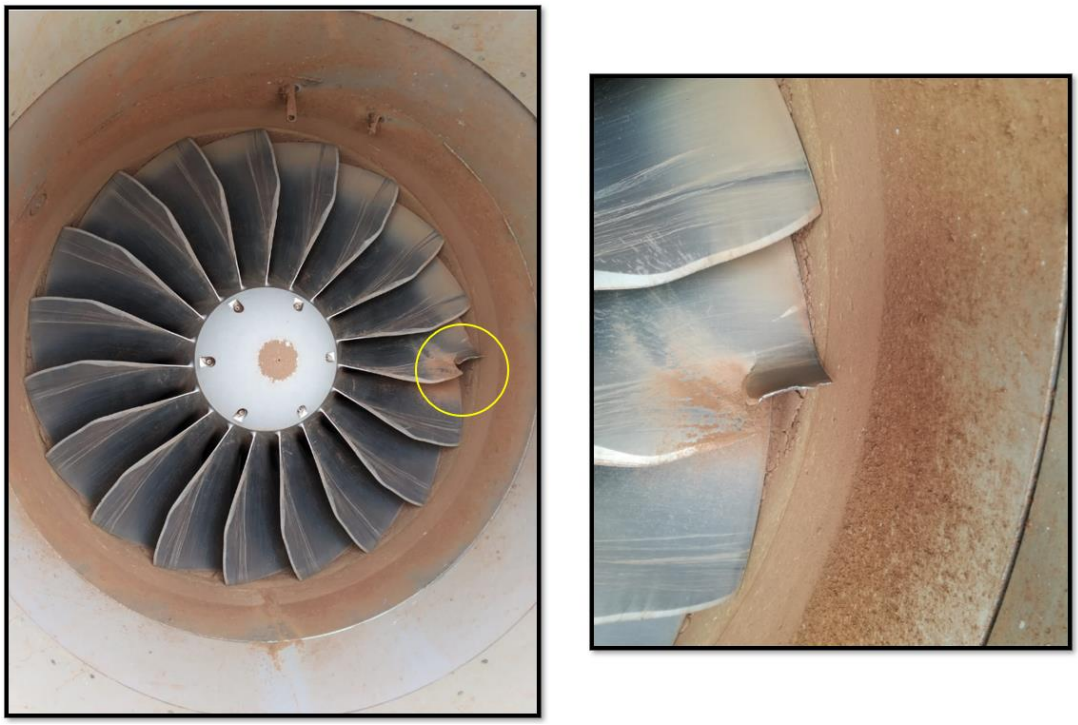


Fig 30: Left Side Engine

One fan blade of LH Engine was found damaged due to FOD ingestion resulting into Engine seize.

Fig 31: Fuel leaked from left Wing Tank

Fuel spillage was observed at the accident site due to left wing tank was punctured by collapse of main landing gear strut.

Scrutiny of Tech log revealed that before operating the flight from Hyderabad to Jindal Vijayanagar, fuel was not uplifted at Departure station but onboard fuel recorded by crew in both fuel tank was 2450 Lbs each. Total fuel consumed during the said sector was about 1000 Lbs. Therefore, fuel expected in each tank was approximately 1950 Lbs.

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

On the day of accident, both crew did not undergo preflight BA test which was in accordance with the DGCA Circular applicable on date issued in view of outbreak of COVID 19 pandemic. In accordance with the Circular, both crew had signed the undertaking form before operating the first flight of the day declaring that they are not under the influence of alcohol and have not consumed alcohol/ psychoactive substance in last 12 hours from time of reporting to duty.

Further, as per the requirement of DGCA CAR Section 5 Series F Part III, blood or urine sample of both cockpit crew were not collected for chemical analysis post accident. However, both crew underwent post-accident BA test for alcohol consumption at 1655 UTC and were found negative.

1.14 FIRE

During accident, the left wing of aircraft got punctured and fuel started dripping from the ruptured area. Immediately, fire tenders reached on the site and to mitigate the fire hazard, foam was sprayed on the left wing along with the fuel contaminated area. There was no fire.

1.15 SURVIVAL ASPECTS

The accident was survivable.

1.16 TESTS AND RESEARCH

1.16.1 Tyres Testing

Tyres of both Main Landing Gear assembly were sent to the government agency, IRMRA located at Pune, for testing and analysis. IRMRA has performed Shearography and DMA analysis on these tyres and following are the conclusions drawn through testing: -

1) Testing confirmed that both MLG tyres had no anomalies
2) No significant difference was observed between both tyres

Tyre testing report is attached as Appendix ‘A’ with this report.

1.16.2 Engine Performance

Each engine is equipped with a DCU. The purpose of this electronic device is to serve as a repository for various engine trim parameters, accumulated operation times, accumulated part cycles and specific operational exceedance excursion data. The EEC’s automatically store the data in the DCU in snapshot or trace format. A recording is taken when an event is triggered. This could be a One Engine Inoperative (OEI) rating range, ultimate limit that is exceeded, a fault or an event such as a commanded auto to manual mode changeover or unexpected flame out.

Data Collection Unit (DCU) installed on both engines were recovered and were sent to Pratt and Whitney Canada (P&WC) for extracting relevant data pertaining to accidented flight.

OEM has attempted to extract data from the PW545B engine's DD0193 and DD0191 Data Collection Unit's (DCU). The extract of the analysis report is given below:

The left-hand engine (serial number DD0193) or #1 position pilot-view had DCU 30J2673-01 with S/N DP05-3458. This DCU could not be downloaded as it would not communicate.

The right-hand engine (serial number DD0191) or #2 position pilot-view had DCU 30J2671-01 with S/N DP05-3395. There were two faults logged in the last recorded flight.

Engine DD0193

The blade is seen bent in the direction opposite to rotation indicating that this occurred with the engine running.

Fig 32: Bent fan blade

As per OEM, DCU could not be download, and thus no review of the data was performed. The DCU was identified as unserviceable. It is possible that the DCU was

electrically/internally damaged as a result of the collapsed landing gear or damage to the wing which may have in turn caused wiring damage to the unit.

Engine DD0191

As per OEM, there was a trend monitoring carried out, and then 36.6 minutes later, two faults occurred. These two faults were a TTO inlet fault and a WOW cross-check fault.

On the following Plot 1, the TTO fault activates first as seen by the step change in the maroon line (green arrow), followed by the WOW fault (blue arrow) which is seen by the step change in the red line. The peak temperature (ITT) observed was approximately 581degC.

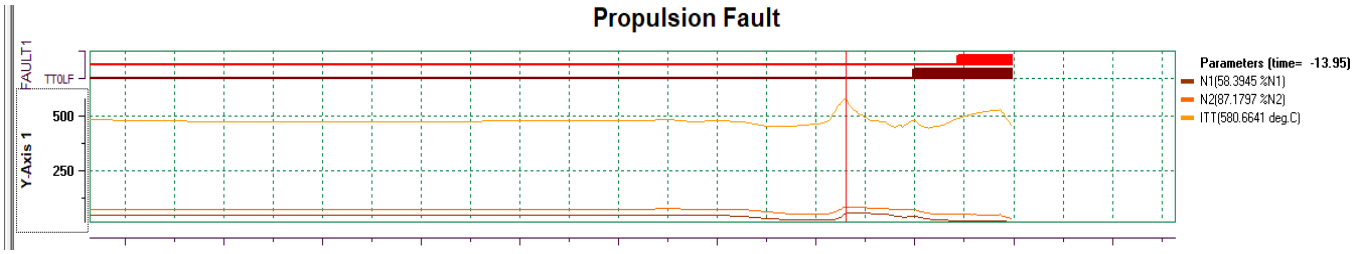


Fig 33: Plot 1

The following Plot 2 shows a closer up view of N1 and N2 where the peak N1 value and N2 value are seen to be approximately 59% and 87% respectively. These peaks occurred approximately 13s before the TTO fault appeared and 21s before the WOW fault appeared. It was reported to P&WC that during the runway excursion some foreign objects may have entered the engines inlet which, if these objects hit the inlet temperature probe causing damaged, could explain this fault. It was also reported to P&WC that the aircraft experienced landing gear damage during this event which could account for the weight on wheels cross-check fault which was observed.

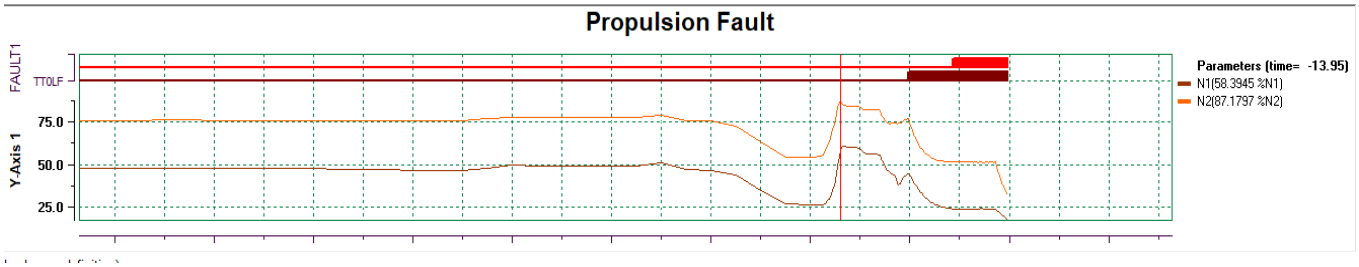


Fig 34: Plot 2

The following Plot 3 shows the two engine speeds as well as the TLA (yellow line). It shows that the engine was reacting and following the commands from the TLA. There were no speed nor temperature limit exceedences observed on this recording (Plot 3).

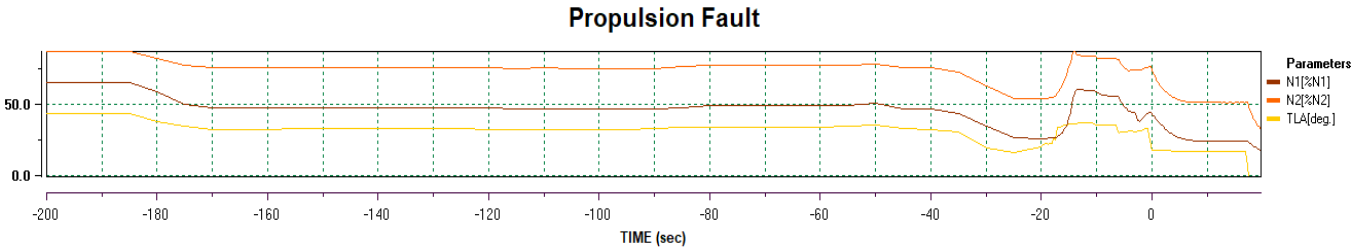


Fig 35: Plot 3

Conclusion:

"OEM believes that the DCU data captured by engine DD0191 during the last recorded flight, shows evidence of the engine running normally following the TLA when two faults occurred.

The DCU from engine serial number DD0193 could not be downloaded as it would not communicate, however the damage observed on the fan blade suggests the engine was producing power but the thrust level could not be determined".

1.16.3 Aircraft Systems

During visit to Vijayanagar on 19 Sep 2020, mainly 3 aircraft systems were examined and operational checks were performed on Thrust Reversal system, Anti-skid System and CVR system by the investigation team to check the condition and serviceability of these systems.

Visual inspection:

Initially, Thrust Reverser actuator access panels were removed by a approved AME. Inspected all the four T/R Actuators, found no leaks or damages. LH and RH Wheel Brakes assemblies visually inspected, found no external leaks or damages to the brake assemblies or the lines. Visually inspected the brake reservoir, brake accumulator and hydraulic pack assembly, no damages or leaks found. Brake accumulator was found holding pre-charge pressure.

Operational Checks/Tests:

BITE test carried out on the aircraft systems as aircraft could not be powered due to left fuel tank damaged at the time of accident. After completion of visual inspection, following BITE tests were carried out to check the aircraft systems.

i. Thrust Reverser

Test switch was rotated to T/REV. The LH and RH, ARM, UNLOCK, and DEPLOY lights illuminated. The master warning lights flashed approximately for two flashes per second. MASTER WARNING RESET pressed and verified light cancelled.

Conclusion:

Thrust Reverser System (Electrical) found satisfactory.

ii. Anti-skid

Test switch rotated to ANTI SKID. With the antiskid switch on, the ANTI SKID INOP annunciators flashed for 3 to 4 seconds then extinguish. The MASTER CAUTION RESET light illuminated steady during the self-test.

Conclusion:

Antiskid brake system (Electrical) found satisfactory.

iii. CVR System

1. With CVR removed, CVR TEST button pressed and hold for 5 seconds, no 'Pass' light appeared in the cockpit.
2. With CVR installed, CVR TEST button pressed and hold for 5 seconds, green CVR 'Pass' light appeared with tone on headset.

Thereafter, to check the serviceability of the system, spoke on Pilot, Co-pilot headset and in area mike. Same audio appeared on headset.

Conclusion:

Aircraft CVR system (Electrical) found satisfactory.

After checking the CVR system of the aircraft, investigation team conducted another test to check the serviceability of the involved CVR unit. Therefore, investigation team had visited on another aircraft on 08 July 2021 to check the

serviceability of CVR bearing P/N 21004020-02 S/N : 000246084 and following tasks were carried out :

As per AMM rev 46 task 23-70-00-2, an approved AME carried out removal of installed unit and subsequently, test unit was installed in the aircraft.

Thereafter, checked the serviceability of CVR for recording all three channels P1, P2 and Area Mic for 15 minutes. Operational test of CVR system and microphone was completed. Test unit was uninstalled from the aircraft.

CVR unit was taken to the bench lab and CVR readout was carried out as per approved procedure sheet Ref No.: BEAS/QAD/PPD-PS/CVR-11 issue 1 Rev 1 dated Mar,2019.

Conclusion:

CVR recording Quality, Audibility and Operational check found satisfactory.

1.17 ORGANIZATIONAL AND MANAGEMENT INFORMATION

Jindal Steel and Power limited is a Charter company and the aircraft are operated for frequent travel requirements of Company's officials and business purposes. JSPL has ventured into Non-scheduled operations since the year 2008 and has 02 aircraft, Global Express (BD- 700) and Citation XLS (involved aircraft), which are approved in NSOP category.

As the Company has a small structure, it does not have other associated Divisions or Departments. Hence, the organisation chart depicts the relationship within the Aviation Department only.

As per the DGCA approved Operations Manual, the Accountable Manager has the overall accountability to manage the affairs of the company. The organisational structure of the Company with regard to Aviation department is appended below.

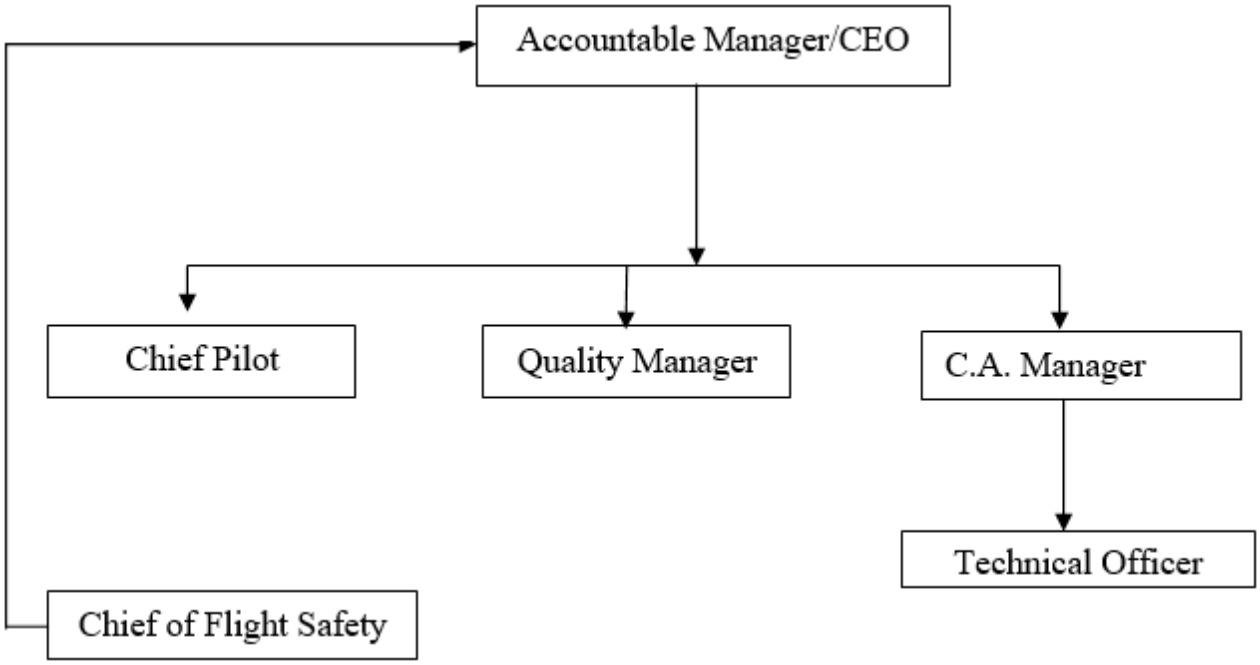


Fig 36: Organisation Chart (JSPL)

The maintenance of its aircraft fleet is looked after by M/s Airworks Pvt. Ltd. which is an approved maintenance agency.

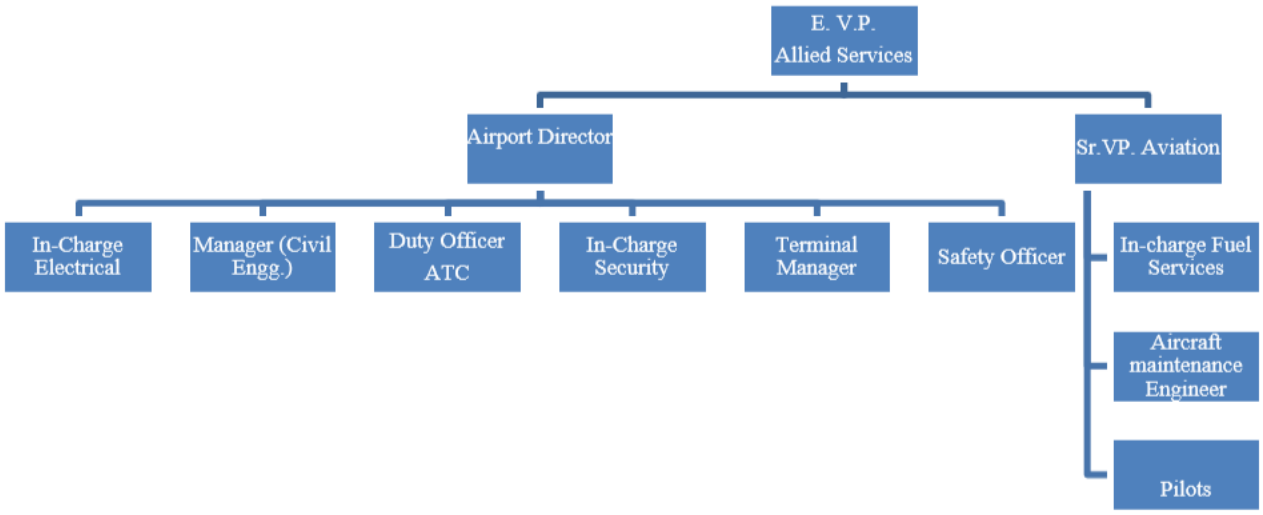


Fig 37: Organisational Chart (Jindal Vijayanagar Aerodrome)

Jindal Vijayanagar Aerodrome has one dedicated ATC Tower which is manned by its ATC personnel along with AAI officials deputed at Vijayanagar. All the operational services other than private flights of M/s JSW & M/s JSPL are monitored by AAI officials as per watch hours.

1.18 ADDITIONAL INFORMATION

1.18.1 Pilot's Abbreviated Checklist

As per the "Before Taxi" Checklist devised for crew to be followed during Normal Procedures states that CVR TEST must be carried out by crew before operating every flight. Checklist to be followed on "Before Taxi" is provided below:

BEFORE TAXI

1.	AVIONIC POWER/FMS	ON
2.	Flight Controls/ Speed Brake/Flaps	CHECK/SET
3.	Rudder Bias System	CHECK
4.	Anti-Ice/Deice	CHECK/SET AS REQUIRED
5.	ECS	AS REQUIRED
6.	PRESSURIZATION Controller	SET LANDING FIELD ELEVATION
7.	ATIS/Clearance/FMS	AS REQUIRED
8.	CVR/TCAS/TAWS	TEST
9.	Avionics Cooling Fans	CHECK OPERATING
10.	Avionics/Flight Instruments	CHECK/SET
11.	V Speeds and Takeoff N_1	SET
12.	Lavatory Door	LATCHED OPEN
13.	Annunciator Panel	CHECK

1.18.2 Challenge and response

As per Operations Manual of the operator, Chapter 18, Para 18.7 contains the guidelines on 'Challenge and Response' procedure to be followed by both crew. It is clearly mentioned that *crew members must follow the procedure of "challenge and response" while using the "Cockpit Check List" and the check list shall also indicate the function of each flight crew member vis-a-vis each item of the list, to avoid confusion.*

It is also emphasised in the manual that "***use of checklists is mandatory and Pilots must wear headset during all checklist and briefings".***

The content of the OM is reproduced below:-

Quote

"The pilot reading the checklist must not proceed further with the checklist if he has not received the proper reply, the right action is not completed, or an item has been postponed or omitted.

After required checklist items are completed, the pilot reading the checklist shall

always call: "...checklist completed".

Individual duties shall be carried out in accordance with the checklist. This is the most positive way to proceed through a checklist, as it allows both pilots to remain aware of all checklist related activities".

Unquote

1.18.3 DGCA Regulations CAR Section 2 Series I Part VI

In DGCA CAR Section 2 Series I Part VI regulations on Cockpit Voice Recorders (CVR) are laid down about applicability, duration of recordings and predeparture check for monitoring of CVR installed in the aircraft.

As per DGCA regulations, all aero planes of a maximum certificated take-off mass of over 5700kg for which the individual certificate of airworthiness is first issued on or after 1 January 1987, shall be equipped with a CVR.

As per Para 3 Sub Para 3.3.1 of said CAR, all CVRs shall retain the information recorded during at least the last 2 hours of their operation.

As per Para 7.2 Sub-para 7.2.1, CVRs shall not be switched off during flight time.

Para 3 of Annexure 'I' has guidelines on inspections of CVR which states that "Prior to the first flight of the day, the built-in test features for the cockpit voice recorders/Cockpit Audio Recording System and Flight Data Acquisition Unit, when installed shall be monitored by manual and/or automatic checks".

1.18.4 Touch and Go Procedure

The procedure for 'Touch and Go' is clearly defined in the AFM and Operations Manual of the operator. The content of the AFM is presented below:

- The Touch and Go procedure must be briefed prior to entering the traffic pattern or prior to takeoff.
- The runway length required must be at least twice the required landing distance and no less than 5,000 ft.
- The runway must be dry.

- The pilot flying will land the aircraft in the touchdown zone or the first 500 feet of the runway and steer the airplane down the centreline.
- The PM will reset the flaps, reset the trim and ensure the speed brakes are retracted. The PM will stand the throttles vertically to allow the engines to spool up and then set maximum thrust.
- The PM will CALL: 'Rotate' when everything is correctly set and the aircraft is at or above normal rotation airspeed.
- The pilot flying will only rotate to the takeoff attitude at the command of the PM.
- If either pilot applies the brakes, extends the speed brakes, or deploys the thrust reverser, or any other stopping device the airplane will be brought to a full stop.

1.18.5 Wet Runway

As per IPTM, a runway is considered wet when there is sufficient moisture on the surface to appear reflective, but without significant areas of standing water.

NOTE: The published limiting maximum tailwind component for this airplane is 10 Knots, however, landings on wet runways with any tailwind component are not recommended.

Fig 38: Photograph immediately after the accident

Photographs snapped immediately after the accident are clearly showing standing water on runway strip and even the runway surface appeared wet.

1.18.6 Serious Incident to VT-BRT

On 11 Sep 2019, one Cessna Citation 525A-CJ2+ aircraft VT-BRT belonging to M/s TAAL while operating sector Mumbai Nanded met with lateral runway excursion after landing at Nanded airport.

During that incident, while the distance to go was around 16 Nm, FO confirmed terrain in sight and they continued approach to land on assigned runway.

Aircraft landed on assigned runway, however, after touchdown aircraft started veering towards left and kept on deviating till it left the paved surface. And aircraft travelled around 1300 m from threshold before coming to a halt at a distance of 26 m from the runway edge on soft ground.

As per crew statements, both crew lost the visual references as the aircraft experienced heavy downpour immediately after touchdown.

During probe, PIC admitted that no repellent was applied on the windshield before operating the flight. Further, PIC stated that the Rain removal system of the Cessna Citation CJ2+ was not found effective during some preceding flights and therefore did not rely on the system based on past experiences.

1.18.7 Incident and Accident Reporting

Content of Chapter 4 on Aircraft Accident/Incident Investigation from operator's approved Flight Safety Manual Issue 2 with Nil revision is presented below:-

Quote

"**4.2 Investigation of serious incident and accident**

4.2.1.3 On receipt of accident information and other details, the *Inquiry officer* appointed under Rule 2017 of the Indian Aircraft should immediately proceed to the site of the accident to conduct the investigation. In case a *Committee of Inquiry* under

Rule 2017 or the formal investigation (Court of Inquiry) under Rule 2017 is ordered by Government to carry out a particular accident investigation which normally takes some time to set up after accident date, the *Inquiry officer* who had already commenced onsite investigation work shall proceed with the investigation as is required on instructions from Committee or Courts of Inquires and shall assist the Committee or the Court as the case may be with all the relevant factual information.

4.2.1.4 Depending on the size & complexity of the investigation, nature of accident and investigation skills available, *DGCA Hqrs* may constitute appropriate groups as contained in the guidelines on ICAO Doc 9756 Vol I after obtaining information from site and analysing the preliminary information and evidences on the accident. The groups so constituted would assist *Inspector of Accidents* appointed under Rule 11 of Aircraft Rules 2017 and render their report on involved aspects in writing to him including evidences in original.

The final investigation report shall be submitted by the *Inspector of Accident*, taking into consideration the reports of the various groups assisting him in the investigation. During the investigation there would be continuous liaison between the *Inspector of Accident* and group (leaders). The *inspector of Accident shall be responsible for submitting the final report to DGCA (Hqrs)* within the time schedule laid down in the order of appointment of Inspector of Accidents. In the event the report submission is delayed the Inspector of Accidents shall in advance submit a report giving present status of investigation and reasons for delay.

4.2.1.5 In addition the Director General may order the investigation of any *serious incident* involving an aircraft or a person associated with the maintenance and operation of aircraft, or both, and may, by general or special order, appoint a competent and duly qualified person having experience in aviation accident / incident investigation as *Inquiry Officer* under *Rule 13 of Aircraft Rules 2017* for the purpose of carrying out such investigation.".

Unquote

1.18.8 Disabled Aircraft Removal

The operator's Flight Safety Manual has disabled aircraft removal procedure defined in Chapter 12 on Emergency Response Procedure which has guidelines and deemed actions suggested for removal of aircraft from the accident/incident site.

Quote

"12.2 Disabled Aircraft Removal Plan.

Disable aircraft/ helicopter must be removed from the runway/helipad at the earliest as under:-

(a) Incident. The aircraft/ helicopter must be removed at the earliest;

(b) Accident. The aircraft/ helicopter must be removed at the earliest; once DGCA clear the same."

Unquote

1.18 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

NIL

2. ANALYSIS

2.1 Serviceability of the aircraft

The aircraft had a valid Certificate of Airworthiness and Certificate of Registration at the time of accident. The scrutiny of the Airframe Log book revealed that as on 28th June 2020, the aircraft had completed 3667:48 Hrs (TSN). LH and RH Engines had logged 3613:49 hrs/2800 cycles and 3647:22 hrs/2835 cycles respectively since new. The last major 12 months inspection was carried out on 15.01.2020. Thereafter, no repair action was carried out on either the aircraft or its engines. Subsequently, all lower inspections (Pre-flight checks, Service Checks, Weekly Checks) were carried out as and when due.

Scrutiny of the aircraft records revealed that all modifications on the aircraft were found to be complied with at the time of accident. Scrutiny of the Tech log revealed that there was no snag reported on the aircraft prior to the accident flight and was neither operating under any MEL.

Post-accident, aircraft systems mandatorily required to assist in deceleration of the aircraft were checked and their serviceability was found satisfactory. Further, testing of tyres concluded that they had no contribution in aircraft's drifting towards left.

From the above, it is inferred that serviceability of the aircraft has no bearing on the aircraft accident.

2.2 Weather Analysis

As per the Flight Plan filed at Hyderabad, visibility was well above the weather minima but some lightning activities with CB cloud was predicted at the destination airport. Initial weather information passed by ATC Vijayanagar was wind 03 Knots variable visibility 06 Km lighting SCT020 CB025 W SW 40 Km. Thereafter, information passed to crew was "runway in use 13". Later, when the aircraft was in approach, met information was again passed to the aircraft. Crew were updated with the latest weather information, visibility 5 Km and rain showers overhead. Subsequently, ATC transmitted "passing rain" and crew were updated winds 200º/05 knots which were favourable to approach and land on either runway 13 or 31. However, ATC suggested the crew to land on runway 13 as lightning was observed towards the other side of the runway i.e. runway 31. Subsequently, it was acknowledged by crew that they will come for runway 13. Before landing, ATC asked crew to report "Insight Final 13". Crew replied "Wilco". Thereafter, ATC had cleared the aircraft to land on runway 13. And the last weather update passed was winds 270/06 Knots.

As per the reported weather, weather was above minima at Jindal Vijayanagar airport while aircraft was coming for landing on runway 13. However, as per the crew statement, they lost all the visual references after touchdown due to passing rain and thereafter could not assess the outside situation resulting into loss of directional heading. Further, pictures captured immediately after the accident showing aircraft final resting position on paved surface with standing water on runway strip clearly

indicates that heavy downpour was encountered by the aircraft and runway was wet while the aircraft was on landing roll.

2.3 Violation of CAR "SECTION 2 SERIES I PART VI"

Post accident, the CVR from the involved aircraft was downloaded in CVR lab of the DGCA and while playing the retrieved recording from the unit, it was observed that 30 minutes of recording was only retained in each 4 Channels of the CVR unit. However, as per DGCA CAR Section 2 Series I Part VI it is a clear violation wherein it is laid down that aircraft with maximum certificated take-off mass of over 5700 kg for which the individual certificate of airworthiness is first issued on or after 1 January 1987, shall be equipped with a CVR and shall retain the information recorded during at least the last 2 hours of their operation.

In addition, guidelines laid down in CAR states that CVRs/CARS shall not be switched off during flight time. The CVR and its system was checked and found serviceable. Hence, the only possibility left was intentionally it was switched off which resulted into non availability of cockpit communication of said flight. Therefore, crew did not abide by the aforesaid regulation.

2.4 Flight Safety Manual of the Organisation

1) DGCA approved Flight Safety Manual of the operator did not mentioned that the in case of accident or serious incident, it is the obligation of AAIB to institute an investigation and the rules quoted needs to be updated as per Aircraft (Investigation of Accidents and Incidents) Rules 2017.

2) The Flight Safety Manual of the operator approved by DGCA has mentioned 'Inspector of Accident' or 'Inquiry Officer' instead of 'Investigator-in-Charge' or 'Investigator'. Therefore, operator needs to update their Flight Safety Manual as per Aircraft (Investigation of Accidents and Incidents) Rules 2017.

3) The Flight Safety Manual on removal of disabled aircraft has mentioned, in case of accident, clearance to be taken by DGCA which is not in line with the

rules contained in the Aircraft (Investigation of Accident and Incident) Rules 2017.

2.5 Non adherence to SOP

2.5.1 Non-Adherence to Normal Checklist

As per “Before Taxi” Checklist contained in Normal Procedures checklist, crew must carry out CVR TEST before operating every flight. It is evident that crew did not ascertain about serviceability through CVR TEST which is a part of Checklist before they had operated the last sector (Hyderabad to Jindal Vijayanagar). If the checklist would have been followed crew could have figured out about the CVR system serviceability. It implies that crew did not adhere to the ‘Before Taxi’ Checklist meticulously.

2.5.2 Non adherence to Operations Manual

As per company OM, ‘Checklist’ is mandatory and Pilots must wear headset during all checklist and briefings. It is also laid down in Manual that crew members must follow the procedure of "Challenge and Response” while using the "Cockpit Check List" and the check list shall also indicate the function of each flight crew member vis-a-vis each item of the list, to avoid confusion.

Further, Manual states that the pilot reading the checklist must not proceed further with the checklist if he has not received the proper reply, the right action is not completed, or an item has been postponed or omitted.

It can be concluded from investigation that crew did not adhere to the procedure of “Challenge and Response” leading to lapses in CVR system test.

2.6 Recurrence of similar incident

The incident briefed at para 1.18.6 of this report and present case is analysed as they both occurred under similar situations. Analogous conditions encountered during both these ocurrences are presented below: -

i. ATC informed well in advance about passing showers.

ii. Runway was insight while the aircraft was on approach.
iii. Both aircraft landed under VFR and visibility was above minima.
iv. After touchdown, aircraft experienced downpour.
v. Aircraft landed in tailwind conditions and runway was wet.
vi. Both aircraft landed inside the touchdown zone (near aiming point).
vii. Crew observed that suddenly outside condition deteriorated after T/R deployment.
viii. Both aircraft drifted towards left after loss of visual references.
ix. PIC in both cases were quite experienced on the type of aircraft.

Total Flying Experience of PIC on Type:

PIC (Cessna Citation 525A-CJ2+): 3222:45 Hrs.

PIC (Cessna Citation 560 XLS): 1006:01 Hrs.

Both occurrences took place under similar conditions wherein the flight crew lost the visual references immediately after Touchdown due to heavy rain.

2.7 Crew handling of Aircraft

Aircraft took-off from Hyderabad at 1344 UTC. The enroute flight was uneventful and no abnormality was observed by the crew. Aircraft came in contact with ATC Vijayanagar at 1410 UTC. Crew were informed by ATC about passing shower when the aircraft was at about 15 Nm from Vijayanagar.

The last weather update was visibility 5 Km and winds 270/06 Knots. Runway 13 was assigned for landing as lighting activities were observed by ATC Vijayanagar towards vicinity of runway 31.

Before landing, PIC anticipated wet runway and checked the runway length which was found sufficient. While the aircraft was at 5 Nm, FO confirmed terrain in sight. As per crew statements, they were maintaining correct approach profile while flying under VMC & non-precision approach and aircraft was stabilised till the touchdown. Aircraft landed near aiming point of runway 13 (within the touchdown zone).

Although aircraft was landing in tailwind conditions, but it was within the prescribed tailwind limitations of 10 Knots as per AFM.

As per the personnel manning the Jindal Vijayanagar ATC, aircraft was stabilised and landed in touchdown zone. Subsequently after landing, crew deployed the T/R and speed brakes were extended. However, both crew lost all visual references as they entered in heavy rain. Notwithstanding, crew could not comprehend whether the Windshield rain removal system was activated or not.

Immediately, right rudder was applied once the crew realised that aircraft left the paved surface and came on soft ground to bring it back on the runway. This resulted into skidding of aircraft and left MLG hit the runway edge before it settled on the paved surface close to runway 31 threshold.

During investigation, crew were inquired about the consideration of touch and go aspect after touchdown. Crew revealed that touch and go aspect was never taken into consideration due to following reasons: -

- Runway was insight till the touchdown
- Aircraft was stabilised on approach
- Both runway end lights and edge lights were visible
- Immediately after firm touchdown, thrust reversals were deployed
- Not feasible for crew to execute the touch and go once the T/R was deployed.

Further, outside conditions started deteriorating suddenly and both crew had already lost all the visual references. Crew discretion not to execute a “Go around” after firm touchdown was in line with the SOP laid down in 560XLS IPTM.

3. CONCLUSION

3.1 FINDINGS

1. The Certificate of Registration, ARC and Certificate of Flight Release of the aircraft were current/valid on the date of accident.

2. Both pilots were qualified on type to operate the flight and before operating the first flight of the day, they had submitted their undertaking forms to comply with the DGCA guidelines applicable on the day. However, post-accident both crew underwent BA examination and results were found satisfactory.
3. There was no pending snag on the aircraft prior to the accident flight and during preceding two flights no abnormality was observed by crew.
4. Initial MET information passed by ATC Vijayanagar was Wind 03 Knots variable Visibility 06 Km Lighting SCT020 CB025 W/SW 40 Km.
5. During descent, weather information passed for second time was Visibility 5 Km and rain showers overhead. Further, it was added "passing rain" and Winds 200º/05 knots which were favourable to approach and land on both runways i.e. 13 or 31.
6. Runway 13 was suggested by ATC for landing as lighting was observed towards runway 31 end side. At Finals, aircraft was cleared to land on runway 13 and before landing, last time winds updated was 270/06 Knots.
7. While the aircraft was at approximately 5 Nm from airport, PM confirmed runway insight and continued the approach for runway 13.
8. The approach was carried out for runway 13 under VFR condition.
9. As per ATC personnel, aircraft was stable on approach and landed within touchdown zone.
10. After touchdown, aircraft encountered rain as anticipated by the ATC and thereafter, crew had lost all the visual references.
11. Post-accident checks confirmed that all aircraft systems which contributes towards deacceleration of the aircraft had no abnormality.

12. After initial touchdown, no significant deviation was observed and crew were able to maintain the directional control of the aircraft. After consuming half of the runway, a slight deviation towards left was observed. Thereafter, a continuous veering was established and no corrective action was initiated till the aircraft left the paved surface.
13. Aircraft exited the runway on left after travelling approximately 817 meters on paved runway surface.
14. Aircraft came to a halt at approximately 1,110 m from runway 13 threshold. Before coming to a complete halt on runway surface, aircraft covered a distance of around 78 m on soft ground also.
15. Runway was found wet and standing water was observed on the runway strip after the accident.
16. The aircraft sustained substantial damage.
17. Normal deplaning of the passengers was carried out by the FO from the main door.
18. There was no injury to any of the occupants onboard the aircraft.
19. Fuel was dripping from the left wing due to damage on lower portion of the wing but there was no post-accident fire.
20. CVR readout contained 4 Channels of 30 minutes instead of each channel with 2 hours of recordings facility.
21. Data captured by involved CVR unit is void of consecutive two preceding sectors and therefore accidented flight data was not retrieved from the unit.
22. Before operating the flight from Hyderabad to Jindal Vijayanagar, CVR test as per the 'Before Taxi' Checklist was not carried out by the crew.
23. Post accident, CVR and inbuilt system serviceability check was carried out and were found satisfactory.
24. OEM observed that DFDR unit installed on the aircraft had no relevant data pertaining to the accident flight.
25. No abnormality was found during serviceability checks of T/R system post accident.

26. DGCA approved Flight Safety Manual of the operator has contained obsolete regulations pertaining to aircraft accident investigation.

3.2 PROBABLE CAUSE

After touchdown, aircraft encountered sudden downpour leading to significant reduction of visual reference for both crew and most likely resulted into loss of directional awareness, therefore, crew could not arrest the lateral movement or heading change of the aircraft before it left the paved portion of the runway.

Contributory Factor:

- Aircraft landed on wet runway in tailwind conditions

4. SAFETY RECOMMENDATIONS

4.1 DGCA may instruct the operator to update their documents/manuals in pursuant to current Aircraft (Investigation of Accidents and Incidents) Rules, to rectify the ambiguities presently existing therein.

4.2 DGCA may ensure that all Indian registered aircraft equipped with CVR are CAR complied.

4.3 DGCA may ensure that CVR and DFDR units installed in aircraft must record all the parameters and without fail must be kept in recording mode during the flight.

4.4 DGCA may issue instructions to all NSOP to meticulously follow all the checklists before operating the flight.

4.5 DGCA may issue instructions to all NSOP to encourage the flight crew to adhere to the procedures laid down in Company Manuals or guidelines laid down in OEM's Manual instead of non-utilizing any aircraft system based on their self-assessment.

4.6 OEM may collect the worldwide data to ensure that present system for Windshield Rain Removal is completely effective and is not a contributory factor in any occurrence under similar aforesaid stated situations.

Amit Kumar
Investigator

Dinesh Kumar
Investigator-In-Charge

Place: New Delhi
Date: 31.12.2021

APPENDIX A

Shearographical Analysis results for both MLG Tyres after scanning Crown and both sidewalls except at the region of failure are shown in the figures given below:

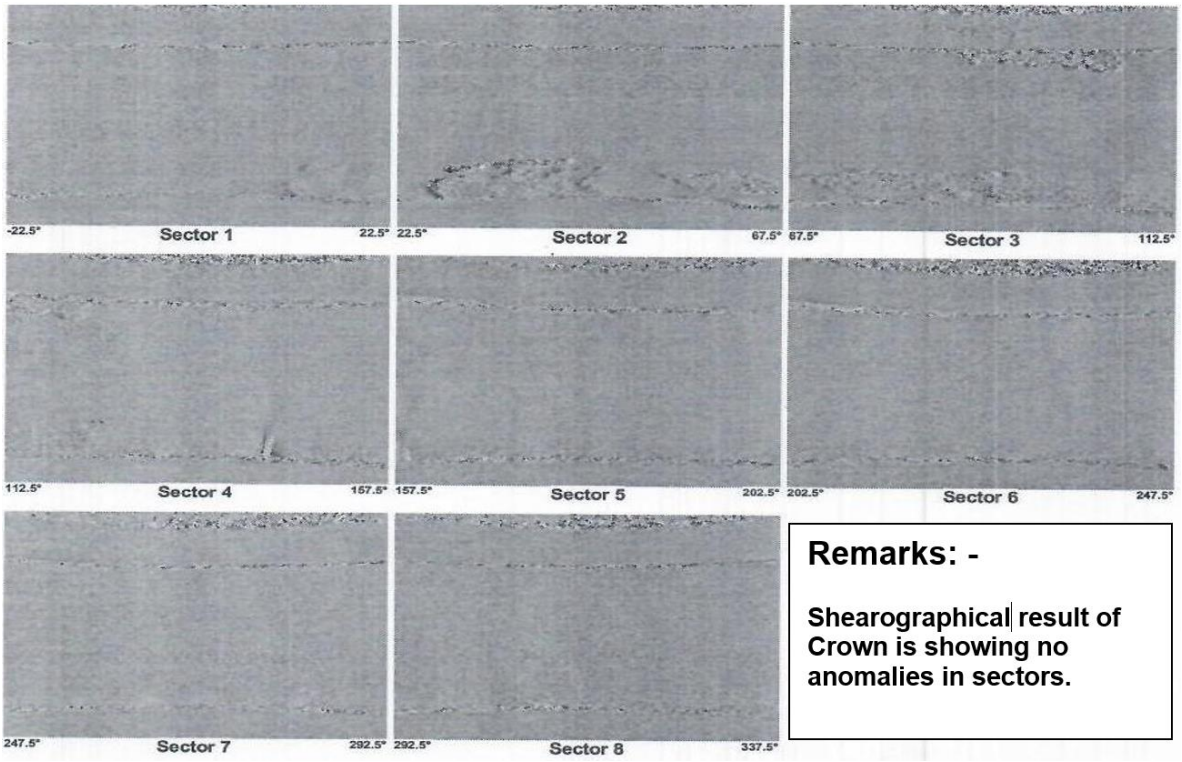


Figure 1: Crown (Tyre Sr.# 7355S236)

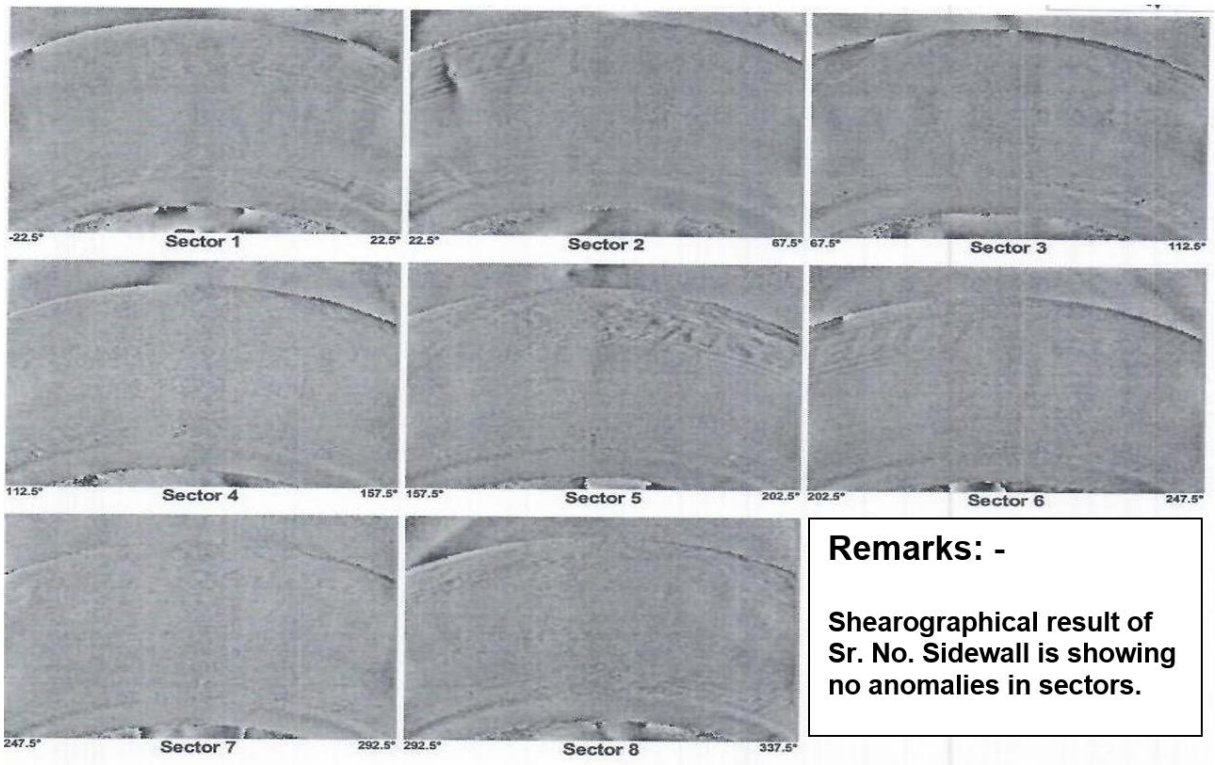


Figure 2: Sr. no. Sidewall (Tyre Sr.# 7355S236)

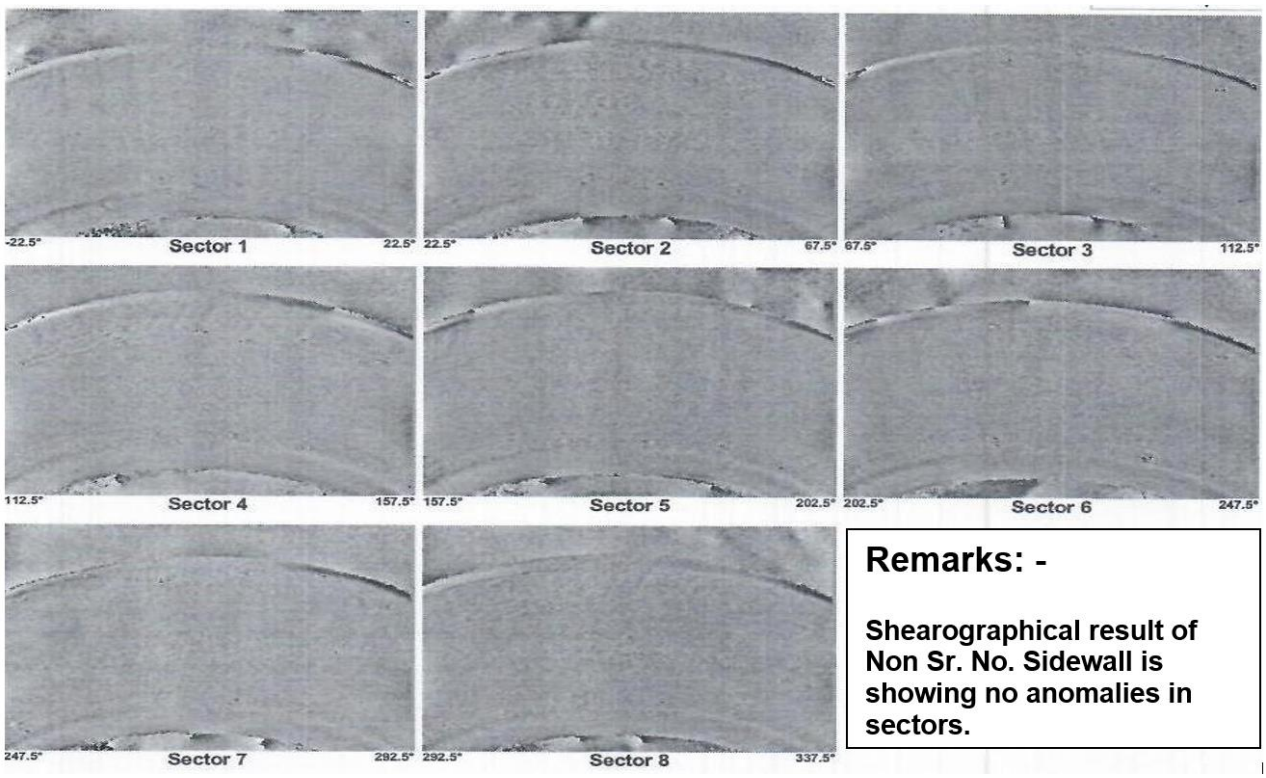


Figure 3: Non sr. no. Sidewall (Tyre Sr.# 7355S236)

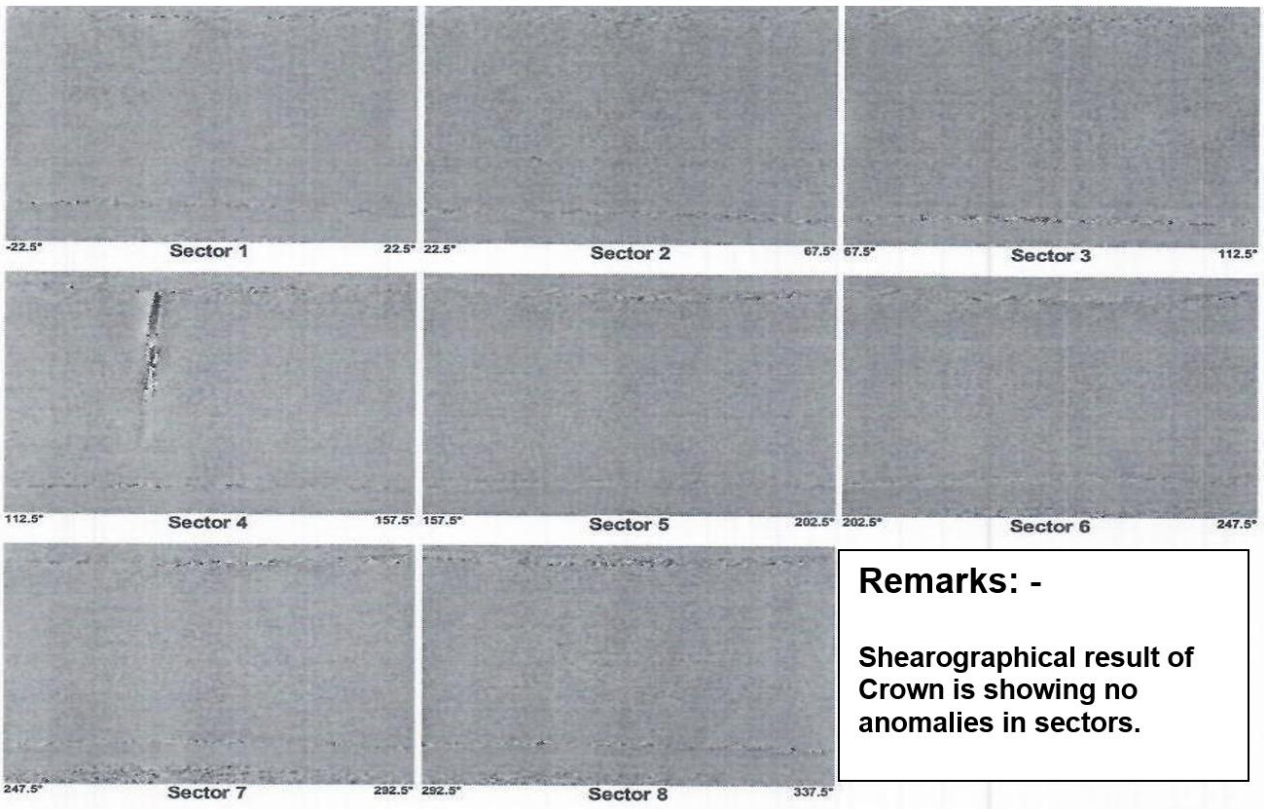


Figure 4: Crown (Tyre Sr. # 7355S246)

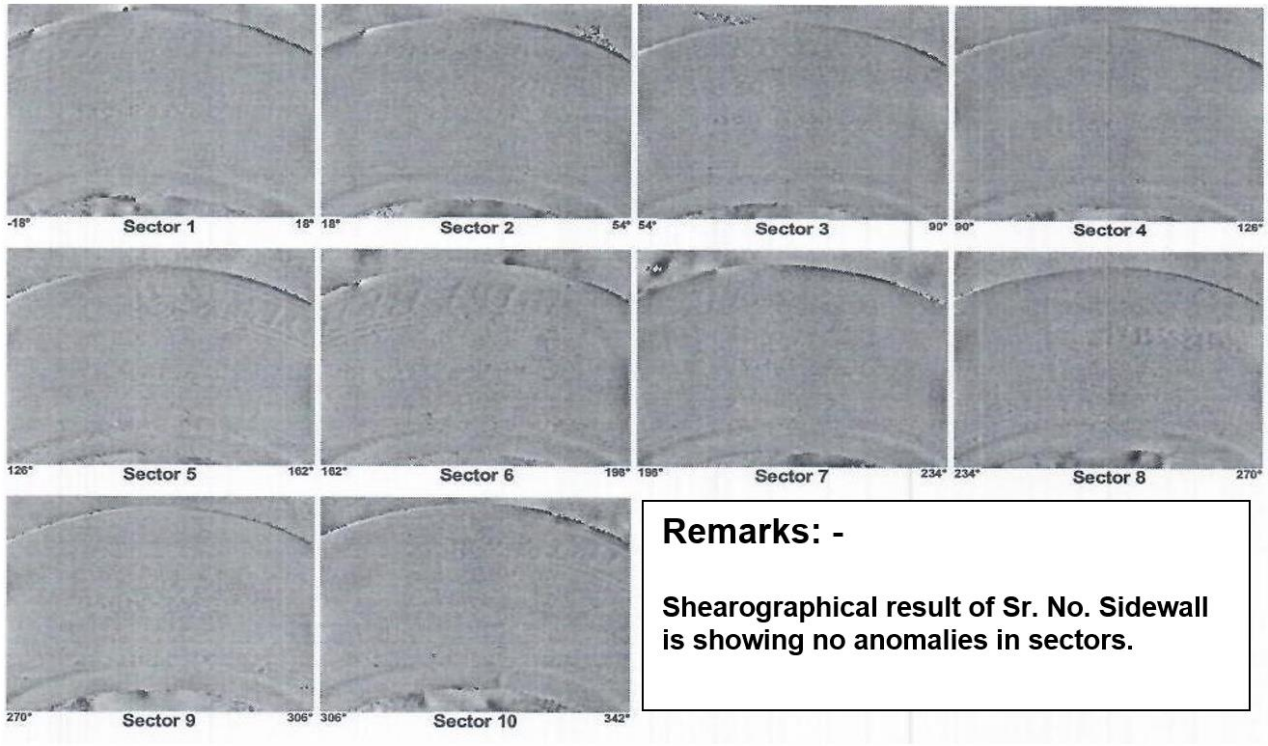


Figure 5: Sr. no. Sidewall (Tyre Sr.# 7355S246)

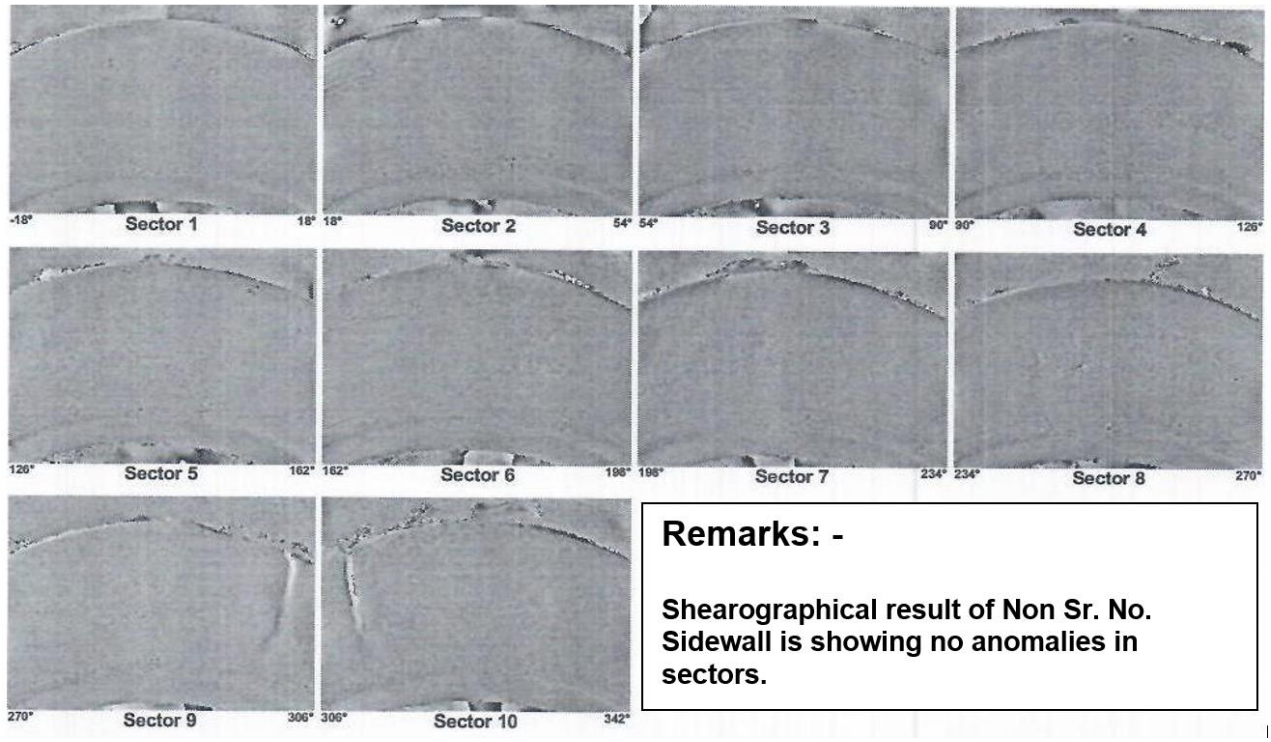
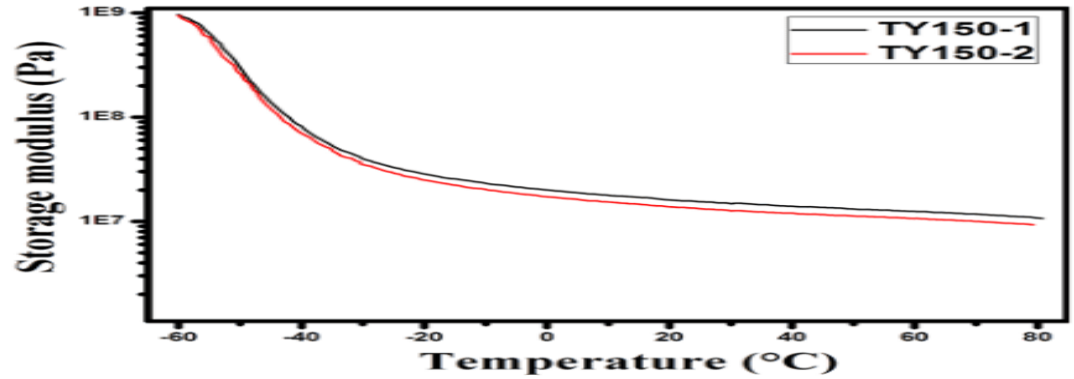


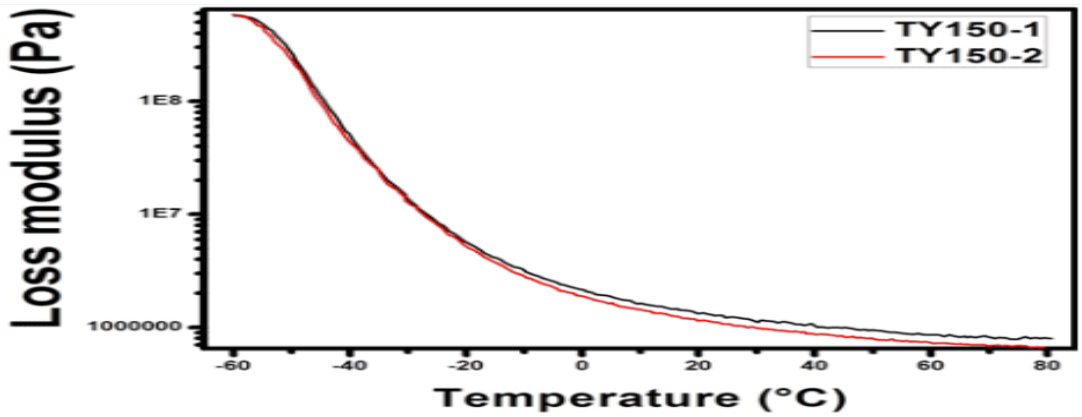
Figure 6: Non sr. no. Sidewall (Tyre Sr. # 7355S246)

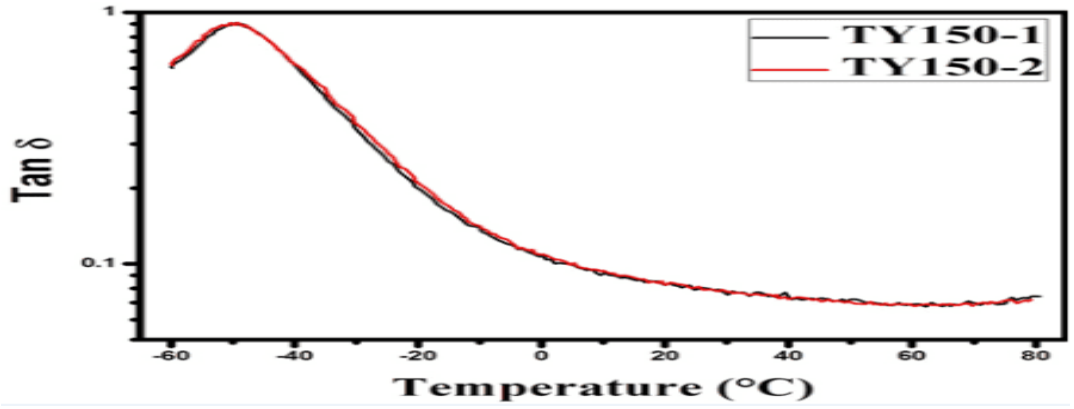
DMA Analysis

Sample	Temperature	Tan delta	Loss modulus	Storage modulus
TY150-1	-30.6 °C	0.363	1.52E +07	4.19E+07
	0.4 °C	0.107	2.13E+06	1.99E+07
	25.4 °C	0.0796	1.23E+06	1.54E+07
	60.4 °C	0.0691	860000	1.24E+07
TY150-2	-30.5°C	0.385	1.44E+07	3.75E+07
	0.3	0.109	1.89E+06	1.73E+07
	25	0.0802	1.07E+06	1.33E+07
	60.3	0.069	737000	1.07E+07

Internal properties of both tyres were examined after DMA analysis and the graphs obtained are presented below:







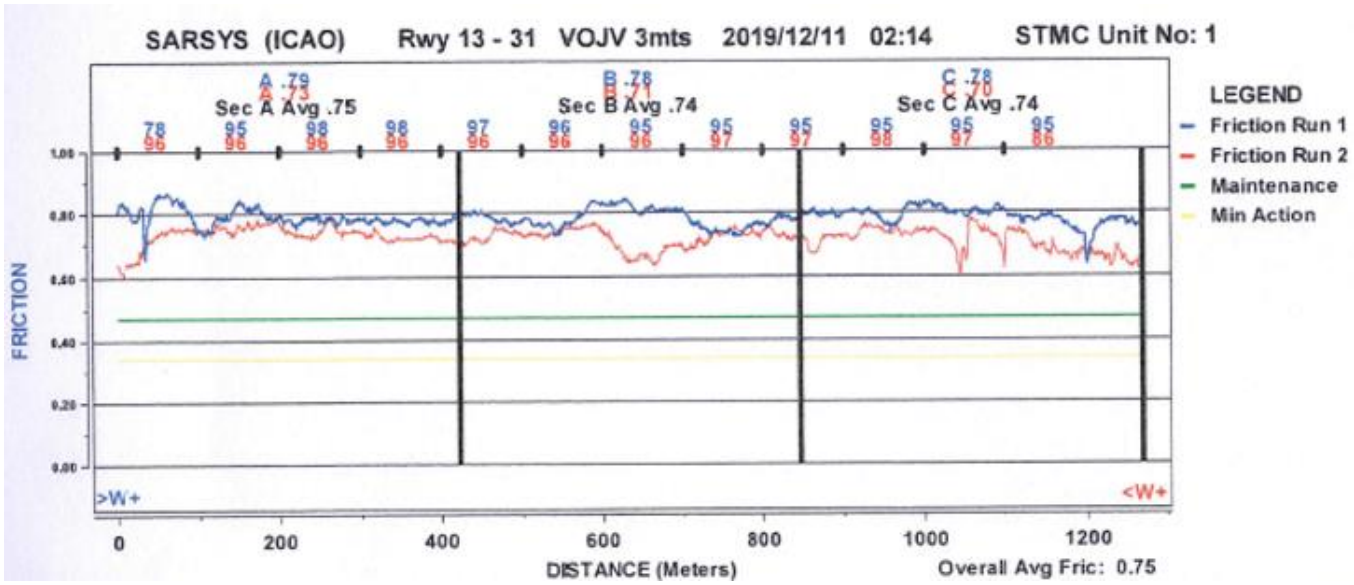
APPENDIX 'B'

Friction Measurement of Runway

The Friction Test for runway 13-31 at Jindal Vijaynagar Airport was carried out on 11 Dec 2019 by AAI, Chennai (Southern Region).

As per the report on friction measurement, the length of runway made available was 1270 meters and test was started 100 metres from Displacement from both ends. Three sets of friction readings mainly at 3 mtrs, 6 mtrs and 9 mtrs were taken on both sides of centreline (Run 1- Left from centreline & Run 2- Right from centreline). Runway length was divided into three equal parts namely A, B & C and average friction value for each part was calculated along with overall average.

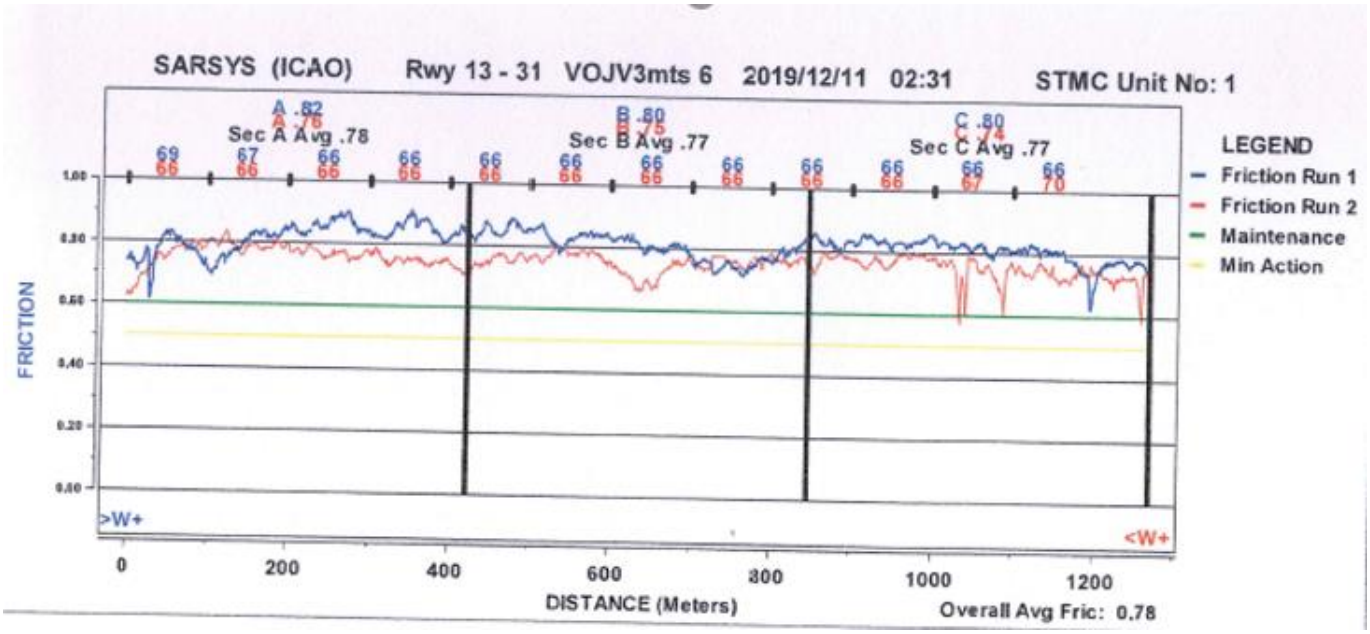
The average value for each section along with the overall average for runway 13-31 at 65 Kmph and 95 Kmph are shown in the below friction graphs:



Graph 1: Friction measurement at 3 metres at 95 Kmph

Friction measurement at 3 metres (95 Kmph)				
	Run 1 Data		Run 2 Data	
Distance (m)	Avg. Speed	Avg. Friction	Avg. Speed	Avg. Friction
000-100	78	0.82	96	0.71
100-200	95	0.79	96	0.76
200-300	98	0.78	96	0.74
300-400	98	0.77	96	0.72
400-500	97	0.78	96	0.72
500-600	96	0.78	96	0.74
600-700	95	0.82	96	0.68
700-800	95	0.75	97	0.72
800-900	95	0.79	97	0.72
900-1000	95	0.79	98	0.74
1000-1100	95	0.81	97	0.72
1100-1200	95	0.77	86	0.69
Average	94	0.79	96	0.72
Overall Friction Average: **0.75**				

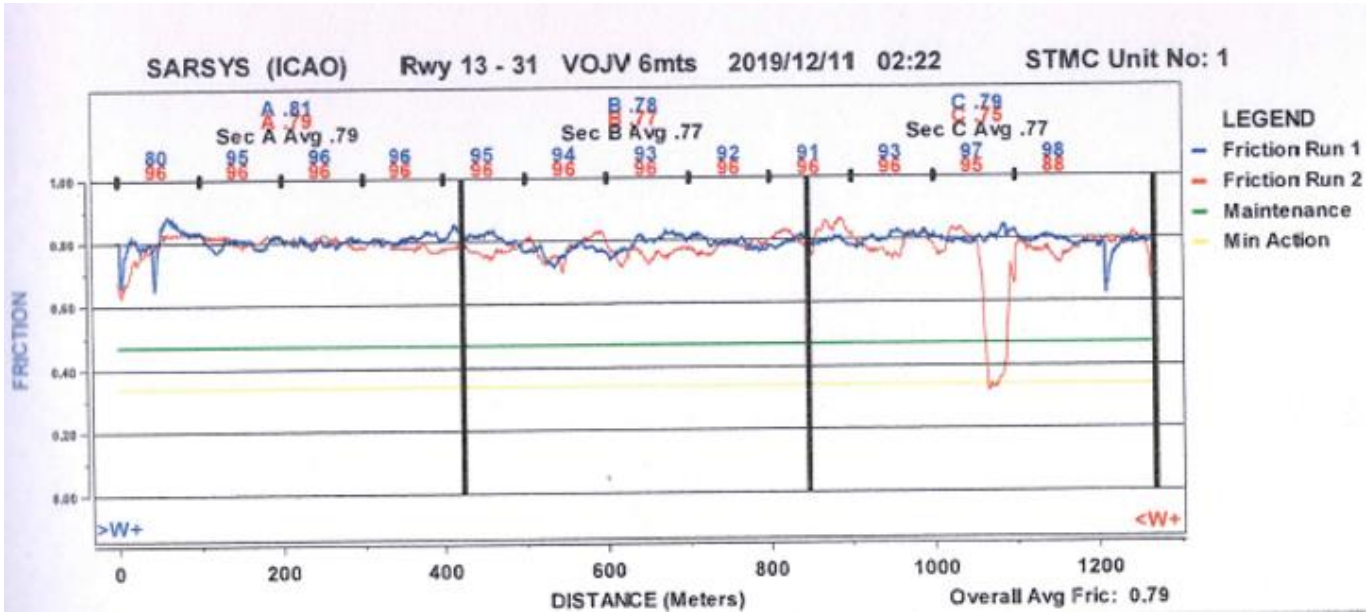
Section Friction Averages			
	Run 1	Run 2	Section Avg.
Section A	0.79	0.73	0.75
Section B	0.78	0.71	0.74
Section C	0.78	0.70	0.74



Graph 2: Friction measurement at 3 metres at 65 Kmph

Friction measurement at 3 metres (65 Kmph)				
	Run 1 Data		Run 2 Data	
Distance (m)	Avg. Speed	Avg. Friction	Avg. Speed	Avg. Friction
000-100	69	0.77	66	0.74
100-200	67	0.79	66	0.79
200-300	66	0.86	66	0.77
300-400	66	0.85	66	0.75
400-500	66	0.85	66	0.75
500-600	66	0.83	66	0.78
600-700	66	0.81	66	0.72
700-800	66	0.75	66	0.76
800-900	66	0.82	66	0.77
900-1000	66	0.84	66	0.78
1000-1100	66	0.82	67	0.74
1100-1200	66	0.79	70	0.64
Average	66	0.81	66	0.75
Overall Friction Average: **0.78**				

Section Friction Averages			
	Run 1	Run 2	Section Avg.
Section A	0.82	0.76	0.78
Section B	0.80	0.75	0.77
Section C	0.80	0.74	0.77

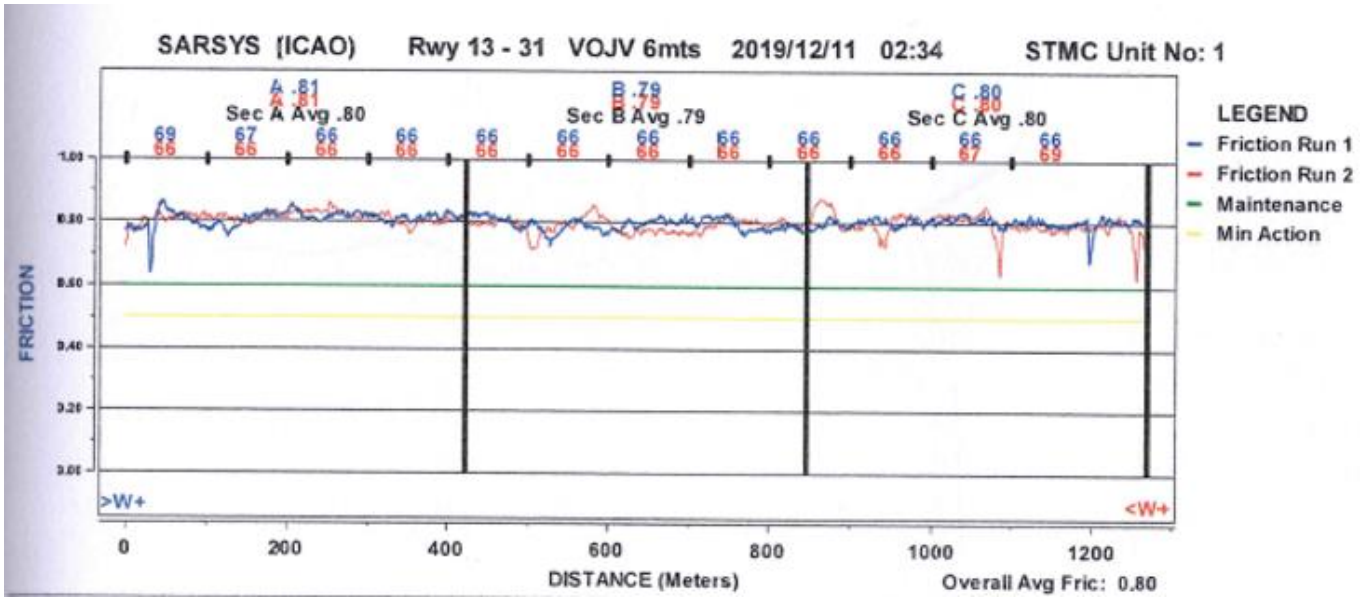


Graph 3: Friction measurement at 6 metres at 95 kmph

Friction measurement at 6 metres (95 Kmph)				
	Run 1 Data		Run 2 Data	
Distance (m)	Avg. Speed	Avg. Friction	Avg. Speed	Avg. Friction
000-100	80	0.81	96	0.78
100-200	95	0.80	96	0.81
200-300	96	0.80	96	0.80
300-400	96	0.81	96	0.79
400-500	95	0.82	96	0.77
500-600	94	0.77	96	0.78
600-700	93	0.80	96	0.76

700-800	92	0.79	96	0.78
800-900	91	0.79	96	0.82
900-1000	93	0.81	96	0.78
1000-1100	97	0.80	95	0.65
1100-1200	98	0.79	88	0.77
Average	93	0.80	95	0.77
Overall Friction Average: **0.79**				

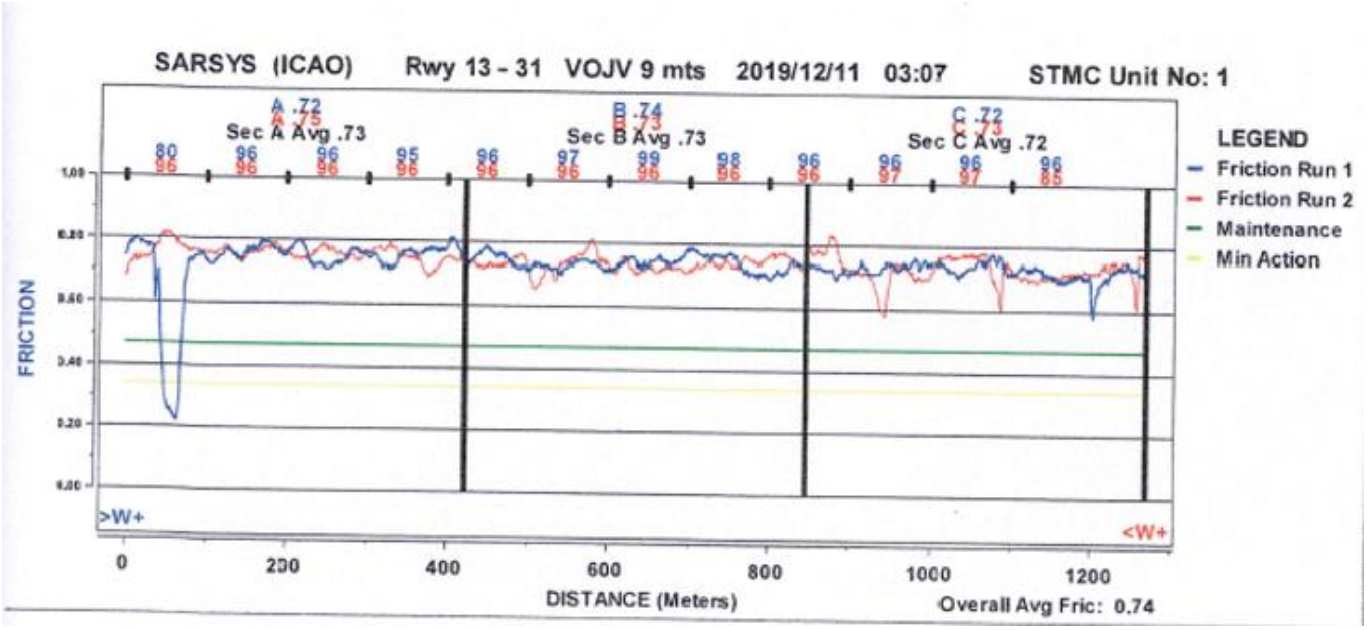
Section Friction Averages			
	Run 1	Run 2	Section Avg.
Section A	0.81	0.79	0.79
Section B	0.78	0.77	0.77
Section C	0.79	0.75	0.77



Graph 4: Friction measurement at 6 meters at 65 Kmph

Friction measurement at 6 metres (65 Kmph)				
	Run 1 Data		Run 2 Data	
Distance (m)	Avg. Speed	Avg. Friction	Avg. Speed	Avg. Friction
000-100	69	0.80	66	0.80
100-200	67	0.80	66	0.81
200-300	66	0.82	66	0.83
300-400	66	0.81	66	0.80
400-500	66	0.81	66	0.80
500-600	66	0.78	66	0.79
600-700	66	0.80	66	0.77
700-800	66	0.80	66	0.80
800-900	66	0.79	66	0.82
900-1000	66	0.81	66	0.80
1000-1100	66	0.81	67	0.81
1100-1200	66	0.80	69	0.79
Average	66	0.80	66	0.80
Overall Friction Average: **0.80**				

Section Friction Averages			
	Run 1	Run 2	Section Avg.
Section A	0.81	0.81	0.80
Section B	0.79	0.79	0.79
Section C	0.80	0.80	0.80



Graph 5: Friction measurement at 9 meters at 95 Kmph

Friction measurement at 9 metres (95 Kmph)				
	Run 1 Data		Run 2 Data	
Distance (m)	Avg. Speed	Avg. Friction	Avg. Speed	Avg. Friction
000-100	80	0.62	96	0.77
100-200	96	0.76	96	0.76
200-300	96	0.75	96	0.76
300-400	95	0.75	96	0.75
400-500	96	0.76	96	0.74
500-600	97	0.73	96	0.73
600-700	99	0.74	96	0.72
700-800	98	0.75	96	0.74
800-900	96	0.73	96	0.77
900-1000	96	0.73	97	0.70
1000-1100	96	0.74	97	0.75
1100-1200	96	0.72	85	0.71
Average	95	0.73	95	0.74
Overall Friction Average: **0.74**				

Section Friction Averages			
	Run 1	Run 2	Section Avg.
Section A	0.72	0.75	0.73
Section B	0.74	0.73	0.73
Section C	0.72	0.73	0.72