ONLINE INTERACTIVE SESSION WITH PROF. B. DATTAGURU

28 September 2020

On September 28, 2020, the regular batch of Class 11 students at Mushtifund Aryaan higher Secondary School had the marvellous opportunity of interacting with Professor B. Dattaguru, B.Sc, B.E, Ph.D.

Professor B. Dattaguru had his school education at different board schools in the district where his father worked as a teacher and a headmaster. He has had a long association with Andhra Loyola College, where he did his Intermediate and B.Sc degree. A great lover of science, Professor Dattaguru joined the Indian Institute of Science, Bangalore for higher studies, where he completed his B. E. in electrical engineering and M. E. in aerospace technology. He acquired his Ph.D, too, from the IISc.

Prof. Dattaguru worked closely with visionaries like President A. P. J. Abdul Kalam, Kota Harinarayana, Kasturi Rangan and R. Chidambaram. As a full professor at the IISc, Prof. Dattaguru guided a number of research scholars. He visited the USA, Australia, Hong Kong and several other countries as visiting professor. An untiring scientist, Prof. Dattaguru became an emeritus professor of the IISc after his retirement and now he is a visiting professor at Jain University, Bangalore. Professor Dattaguru taught Sir Vyankatesh Prabhudesai, Director of Aryaan Study Circle, his first course in Structural Mechanics during his M. E. in 1991.

Prof. Dattaguru was Chairman of the Department of Aerospace Engineering at the IISc, Chairman of the Council for Scientific and Industrial Consultancy at the IISc, President of the Institute of Smart Materials, Structures and Systems, President of the Advanced Computing and Communications Society and Associate Editor of the Journal of the Aeronautical Society of India. Besides these, he has held many other eminent positions.

Prof. Dattaguru has been conferred innumerable awards and honours, for instance, the Aerospace Gold Medal for best paper by the Institution of Engineers in 1988, the ARDB Silver Jubilee Award for best sponsored research project in 1996, the Prof. Rustom Choksi Award for Excellence in Engineering Research, the DRDO Academic Excellence Award in 2002. He was conferred the prestigious Padma Shri Award for Science and Engineering by the Government of India for the year 2005. He was conferred the Award of Senior Scientist by the World Congress on Computational Mechanics (WCCM) and Asia Pacific Congress on Computational Mechanics (APCOM), Australia, in 2010–11.

Professor Dattaguru began the session on a note of appreciation of the fact that an alumnus of the IISc is taking the effort to train students for various examinations. Professor Dattaguru decided to deliver a presentation on Aviation Safety, which is a universally interesting topic. After a workshop on Aviation Safety, Prof. Dattaguru's colleague at the IISc held a workshop on handling ageing aircraft. Aviation Safety has been one of Prof. Dattaguru's main areas of interest. The IISc wanted to hold an international conference based on this, however, due to the COVID-19 pandemic, it had to be cancelled. Therefore, Aviation Safety has been a topic of great interest at the IISc, the Jain University and the aerospace community as a whole.

Professor Dattaguru pointed out that 'safety' is a word that holds an important place in every individual's mind. Every day, we go through a series of potentially unsafe events. Many people have conducted research and spent a lot of time analysing these events to make them safer. Out of these events, Prof. Dattaguru planned to discuss Aviation Safety, in particular. Aviation Safety has concerned scientists since the Wright Brothers flew the first airplane. Prof. Dattaguru then presented an image of a large transport airplane—the Boeing 777x. He explained its parts—the undercarriages, the tyres, the engines (which are prone to bird strikes and other failure), the wings, the fuselage and other structures which may become damaged during loading and unloading of the aircraft. The undercarriage is lowered during takeoff but is retracted during flight to prevent excessive drag. It must be lowered again during landing, the failure of which would require the aircraft to land on its belly. The next important component of safety is the aircraft's structure. During the construction of aircraft, the wings, the engine and the rear, centre and front fuselages are built separately and attached using bolts or rivets. Thus, joints are also crucial in maintaining the aircraft's structural integrity. Presently, there is a major ongoing project related to the development of joints to prevent safety issues.

The aircraft presented by Prof. Dattaguru

There are other problems related to aircraft safety, for instance, air traffic control. India aims to increase its airport count, which will cause the number of aircraft to increase. Collision avoidance, too, is an important aspect of aircraft safety. Air traffic collisions can take place during takeoff and landing, as well as in-flight, hence, aircraft are required to maintain specified altitudes. Engine health monitoring is a crucial step in preventing in-flight engine failure. Airport design is also a key factor in ensuring smooth operation of various types of aircraft, because airport components must be

able to withstand the load borne by different aircraft. Besides, anti-terror activities are also required to prevent hijacking of aircraft. Out of these, Prof. Dattaguru planned to focus on Structural Integrity during the session. Prof. Dattaguru noted that issues relating to structural integrity have greatly decreased in recent years and accidents due to structural failure have been minimised. Aircraft are subject to variable structural load because of factors such as atmospheric turbulence, changing height, etc. Fighter aircraft are subject to even greater variations due to manoeuvres. There are a few important terms relating to structural integrity. ‘Safe life’ indicates the time span for which a component may be used before it must be disposed of. ‘Fail safe’ indicates that a component may be used for a given time span after which it must be inspected before resumption of use. ‘Damage tolerance’ is a very important attribute of a component which describes its tolerance to minor as well as major damage and abuse, as well as its potential condition after being subject to such damage. ‘Structural health monitoring’ means inspection of the structure to ensure that any structural damage does not grow with time.

Professor Dattaguru presented a slide explaining the different joints present in aircraft, that are used to attach the wings, undercarriage and fuselage. These joints must be designed in such a way that they remain in excellent condition even after extensive use. The fuselage is pressurised hence, any deformation in the skin will lead to a drop in pressure in the fuselage, which is detrimental to passenger safety. The aforementioned team that worked on ageing aircraft also studied how multiple small cracks can move closer to form larger cracks. Hence, there are still issues in structural integrity which have not been completely solved.

Another crucial aspect in ensuring Aviation Safety and structural integrity is maintenance. This includes periodic scheduled inspection of components as well as non-destructive inspection, either visually, or using dye penetrant, ultrasonic inspection and X-rays. Any damages/cracks present and their growth must be inspected periodically and repaired if necessary as specified. Damages in composites must also be inspected. Prof. Dattaguru presented an image of an important example of structural failure in aircraft—in 1988, a portion of the fuselage of Aloha Airlines Flight 243, flew off. All passengers and crew but one were rescued. The first example of an aircraft accident in the 1940s occurred when the fuselage of a de Havilland Comet aircraft failed due to high stressed due to the squarish windows. This is the reason aircraft windows are no longer square-shaped, but are elliptical instead.

Remains of the fuselage of Aloha Airlines Flight 243 after landing

Digital twins are modern-day digital replicas of model aircraft. Loads measured on real-life aircraft are applied on the digital twin and potential damages can be identified. This technology is still under development. General Electric has taken up digital twin development in a big way. Professor Dattaguru concluded by stating that there are several aspects in aviation safety which include flight safety, security, health monitoring and analysis. Military aircraft have much more stringent clearance requirements due to the higher loads they are subjected to. This concluded the presentation.

During the question and answer session, Sir Vyankatesh Prabhudesai asked Prof. Dattaguru whether inspection of the numerous complex joints in many Boeing and Airbus aircraft is possible before every flight. Prof. Dattaguru responded by stating that not all components require an inspection before each flight. Many components are designed keeping their 'safe life' in mind. They must be inspected or replaced only at the end of this safe life. Only important components like the undercarriage-wing joint, the wing-fuselage joint and the tail-fuselage joint must be inspected extensively before each flight. Other joints are typically visually inspected.

Sir Vyankatesh Prabhudesai asked Prof. Dattaguru whether the non-destructive inspection techniques mentioned by him are applicable to all aircraft or only fighter aircraft. Prof. Dattaguru stated that they are used extensively for all aircraft. Transport aircraft like those manufactured by Airbus require extensive non-destructive testing, while small aircraft like the Pushpak by HAL typically undergo visual inspection. The type of non-destructive testing used is determined by the type of joint, safety and cost. Unmanned aircraft do not require extensive non-destructive testing.

Sir Vyankatesh Prabhudesai asked Prof. Dattaguru how often big aircraft must be checked for fatigue. Prof. Dattaguru stated that fatigue is the main cause of damages in joints and other places. Cracks grow in a particular way under fatigue. Sir Vyankatesh also asked about the time intervals between fatigue inspection for large modern aircraft like the Airbus A320. Prof. Dattaguru stated that a strip-down inspection is usually done approximately every ten years of flight. During this, every component is completely stripped down and inspected.

Then, Sir Vyankatesh Prabhudesai asked Prof. Dattaguru why Professors of his time usually study electrical engineering and then take up aircraft structures instead of other branches like avionics and instrumentation. Prof. Dattaguru explained his own situation by stating that in his time, aerospace engineering was primarily limited to structures and aerodynamics. Prof. Dattaguru’s reasons for choosing structures were

simple: he had the best marks in applied mechanics in his B. E. Today, avionics and electronics are the de facto fields of choice. In fact, at the Jain University, a student with a background in avionics was not allowed to join Structures.

After that, Sir Vyankatesh Prabhudesai asked Prof. Dattaguru to narrate a few experiences he had with Dr. A. P. J. Abdul Kalam. Prof. Dattaguru stated that Dr. Kalam had assigned him the problem of designing 2-3 caddies of air bottles in Prithvi. Then, the air bottles had to be checked very carefully by non-destructive testing, although NDT (non-destructive testing) inspection was imperfect due to the tendency to miss cracks. Years ago, there were many unexplained, unexpected failures due to NDT failing to identify cracks. This gives rise to an important part of NDT, called 100% detectability of a crack. Cracks with sizes in an extremely small order may not always be identified. Dr. Kalam asked Prof. Dattaguru what would happen if he missed a crack. Prof. Dattaguru suggested that the thickness of the bottles be increased from 6 to 7 millimetre. Dr. Kalam asked Prof. Dattaguru all sorts of questions about the maths involved and other areas. Finally, Prof. Dattaguru's analysis turned out to be right and Dr. Kalam accepted it. Adding 1 millimetre made a difference because it meant that smaller cracks could be identified accurately. Prof. Dattaguru used FEM analysis, hand calculations and fracture mechanics for this. Prof. Dattaguru also worked on the safety of the air bottle. He found that an air bottle built to withstand pressures upto 300 atmospheres started leaking at a pressure of 225 atmospheres. It was fortunate that the leak occurred at 225 atmospheres and not 300 atmospheres because this prevented the bottle from breaking completely. This saved INR 10 lakh at the time, whereas Prof. Dattaguru's project was allotted INR 2 lakh. Dr. A. P. J. Abdul Kalam was always present at every flight with the people and sat with them till flights were over, which made a big difference to the students' seriousness.

After that, Sir Vyankatesh Prabhudesai also asked Prof. Dattaguru to narrate a few experiences he had with Prof. Satish Dhawan, Director of the IISc for 19 years. Prof. Dattaguru stated that Prof. Dhawan was his teacher in experimental mechanics and boundary layer controls. He was a fantastic teacher and was great at interviewing. He would make students answer and give them sufficient hints so that they could do so. He was very friendly even while interviewing Prof. Dattaguru for his job. He narrated a story where him and his friend waited outside Prof. Dhawan's door for an hour because he was meeting someone, but he was extremely sympathetic when he found out that they had been waiting outside his door.

A student at Aryaan Study Circle asked Prof. Dattaguru whether it was better to set up fewer large airports or multiple small airports throughout India. Prof. Dattaguru said that it is required for people to travel long distances in a very short time. Therefore, numerous airports are important for

short-haul aircraft that carry a small number of passengers over a short distance. The student also asked Professor Dattaguru any solution to loss of cabin pressure in-flight, beside oxygen masks. Prof. Dattaguru said that such problems cannot be solved in-flight. The primary concern in such an event is the safety of the passengers, which is why it is important for the pilot to descend smoothly to a safer, lower altitude below 2.5 kilometre.

Another student at Aryaan Study Circle then asked Prof. Dattaguru how in-flight airframe icing affects aircraft. Prof. Dattaguru said that the shape of the external structure of an aircraft is very important for aerodynamics. Icing affects airflow adversely. Hence, de-icing technology is employed at all critical places to keep ice formation in check.

A student at Aryaan Study Circle asked Prof. Dattaguru about the aircraft landing on River Hudson when a flock of geese caused engine failure and the aircraft had to land on River Hudson, and what changes were made to Aviation Safety to prevent the reoccurrence of such an incident. Prof. Dattaguru said that this is the reason all big aircraft have four engines instead of two. In case of failure of an engine, the aircraft may be run on the other three with adjustments to the rudder. In single-engined aircraft, it is necessary to glide, during which the landing location is difficult to control. In such an event, it is important to avail of any opportunity for the people to exit the aircraft. 4-engined airplanes like the Boeing 737 and 747 can successfully reach their destination even with failure of one engine. The student also asked how the September 11 Attacks affected Aviation Security. Prof. Dattaguru noted that people are typically careless until a breach in security occurs. Since the September 11 Attacks, airport security has been tightened considerably.

Sir Vyankatesh Prabhudesai then requested Prof. Dattaguru to throw some light on smart materials and smart structures in aircraft. Using the illustration of a mosquito bite, Prof. Dattaguru mentioned how sensors in smart materials activate actuators which are used to perform movements, for example, during excessive vibration of the wings during flight. They are sometimes used in commercial aircraft. Rather than the materials themselves, their performance must be certified before they are used. Sir Vyankatesh Prabhudesai said that he believes structure is more important than aerodynamics in aircraft, but he asked why aerodynamics is typically given greater importance in aircraft design. Prof. Dattaguru pointed out that collisions often occur due to aerodynamics rather than due to structural failure. Hence, aerodynamics is extremely important. Efficient aerodynamics and lower structural mass allow for greater payload. Hence, Prof. Dattaguru concluded that both aspects are important. A student at Aryaan Study Circle then proposed the vote of thanks.

This interactive session gave us a deep insight into the various aspects of Aviation Safety and helped us view aircraft design from a whole new angle. Professor B. Dattaguru's immense knowledge and experience is indeed commendable, and his significant contributions to aircraft structure are testimony to his expertise. On behalf of the students of Aryaan Study Circle, I would like to thank Prof. B. Dattaguru for spending his invaluable time to share his experiences to us, as well as Sir Vyankatesh Prabhudesai for giving us the opportunity to meet such eminent personalities from time to time.

Written by
Ronit Kunkolienkar
Student, XI (Regular)