Structural Reliability
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Lecture –04
Introduction (Part - 04)

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We next look at the de Havilland Comet series aircrafts. The Comet 1 was the first commercial passenger jet it was developed during the 1946 through 49 years using technology developed for the military. And it had its first commercial flight in May of 1952 from London to Johannesburg. It is this particular aircraft that you see on your screen the G-A-L-Y-P the Yolk Peter which held that distinction.

Now the comment one was an outstanding engineering marvel of the day. It had 4r jet engines it offered a quiet ride compared to the piston engines in those days. They were very fast 500 miles per hour which is almost as fast as today. The range was less than 2000 miles but they needed to fly above 30000 feet in order to gain fuel efficiency because they had jet engines. Now at that altitude the cabin had to be pressurized.

So, that the passengers could breathe and the pressure was something like 8 pounds per square

inch about 0.06 mega pascals and the shell of the fuselage was very thin aluminum less than one millimeter thick. So for a year or so, the comets flew wonderfully more than 100 million miles were flown. There were two accidents in that year one minor both during takeoff but one of them was fatal and killed all the passengers and crew. A flaw in the wing configuration was identified and it was fixed.

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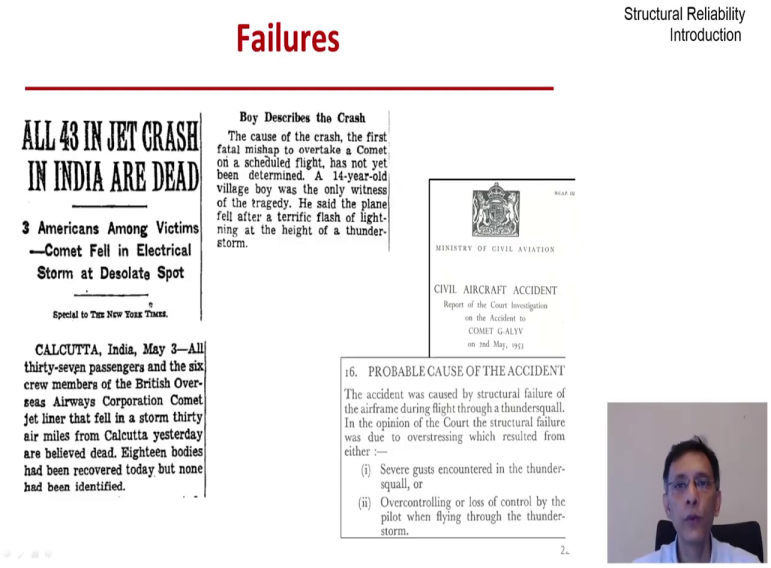

So, the Comet flew well for a year as I said but on the 2nd of may in 1953 one comment the G-A-L-Y-V flying from Calcutta to Delhi crashed just 24 miles from the airport from 10000 feet just 6 minutes after takeoff and killing all on board. The crash occurred at about 4.35 pm and during a major thunderstorm. So, the cause was attributed to structural failure caused by severe gusts and over controlling or loss of control by the pilot.

Now it is interesting to note that an extreme load rather than cumulative damage was identified as a potential cause. Anyway there was not much public outcry some design changes some structural reinforcements and operational protocol was changed and the Comets kept flying very popular.

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Failures

Jet Crash Off Italy Kills 35;

Chester Wilmot Among 29 Passengers on B. O. A. C. Comet Going to London

Special to THE NEW YORK TIMES.

ROME, Jan. 10 — Thirty-five persons were almost certainly killed when a British Comet jet airliner crashed into the sea this morning about halfway between the islands of Elba and Monte Cristo, off the Italian western coast.

British Suspend Comets' Flights For Study of Crash Fatal to 35

Special to THE NEW YORK TIMES.

LONDON, Jan. 11—The British Overseas Airways Corpora- "concurrence," but was not Government ordered.

Recovered fuselage section of G-ALYP

Until about eight months after the Calcutta crash on January 10th of 1954 GALYP the York Peter the very first Comet to fly flying from Rome to London this time near Elba crashed from 26000 feet into the Mediterranean sea. There was some speculation about sabotage all the Comets were grounded extensive inspection and retrofitting was done and the Coments again started to fly about 2 and a half months later on March 23rd.

Unfortunately in less than 3 weeks after that resumption on the 8th of April flying from Rome to Cairo another Comet 1e crashed from 35500 feet into the Mediterranean sea once again near Naples and the Comet 1 planes were grounded forever. The Comets 2 and 3 did not fly and the comet 4 flew again but never gained the glory by the time the 707 the Boeing 707 was found to be much better.

And de Havilland lost its preeminence and the passenger jet production by Boeing Lockheed and Douglas they took off in the other side of the Atlantic.

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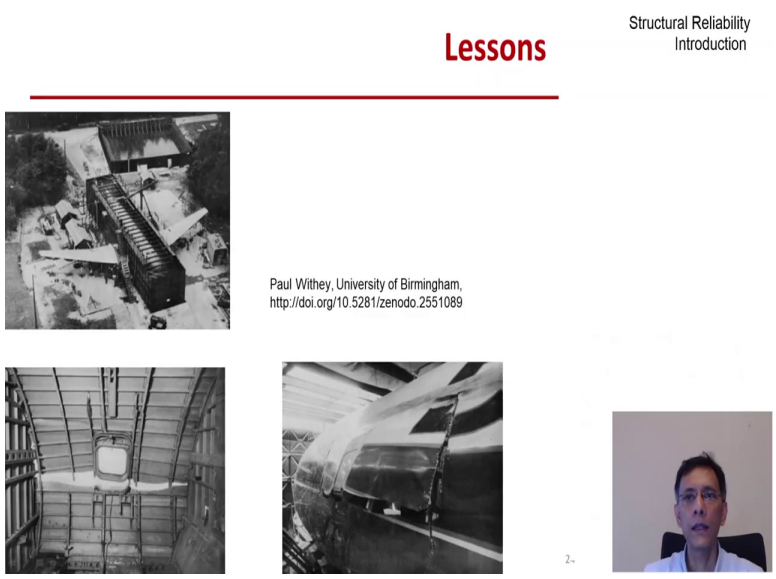

Now after these two back-to-back crashes of the Comet 1 in 1954 an intense and an unprecedented failure investigation was launched. And from tests and the study of recovered parts the origin of the failure was identified as a short fatty crack that started from a window and caused the fuselage to burst. And it was a violent explosion which was corroborated by the autopsy of the passengers.

Now metal fatigue was already known to be a problem it was known for almost 100 years at that time and was duly considered in design by the current standards of the day because the cabin would undergo repeated pressurization depressurization as the plane climbed and then descended. But the numbers were not adding up fracture tests on panels of the same aluminum alloy with the with fatty cracks comparable with those found on the recovered aircraft.

They failed to correlate with the stress levels experienced in service. So, even if the stress razor effect of the window corner was included.

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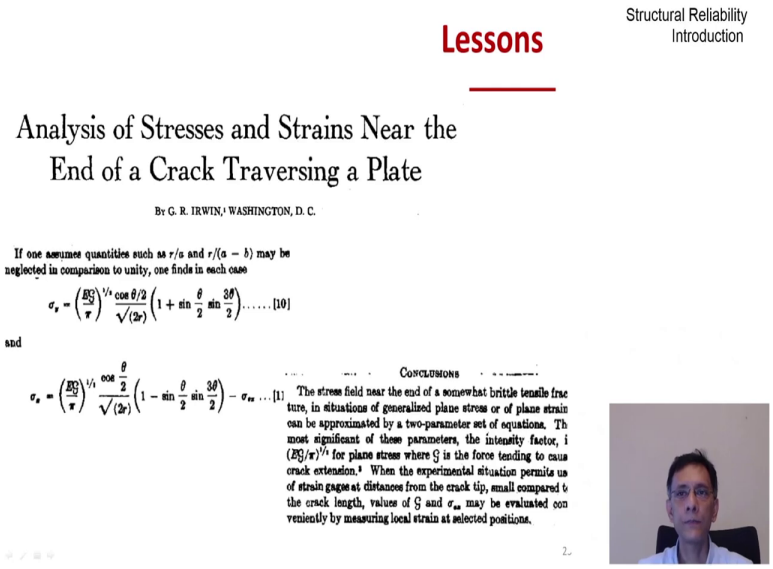

It would actually take another 3 years for LEFM linear elastic fracture mechanics to be fully formulated and that happened with the publication with of this paper by George Irwin and in which he introduced the stress intensity factor. So, Irwin and others at NRL in Washington DC they argued that the effective crack length should include the diameter of the window and using this larger value of the effective crack length you know finally resulted in critical stress levels that accounted for the failures.

And about three years later Paris and Gomez and Anderson published a very famous paper relating crack growth with stress intensity factor the following year in 1962 Paris submitted his doctoral dissertation at Lehigh university.

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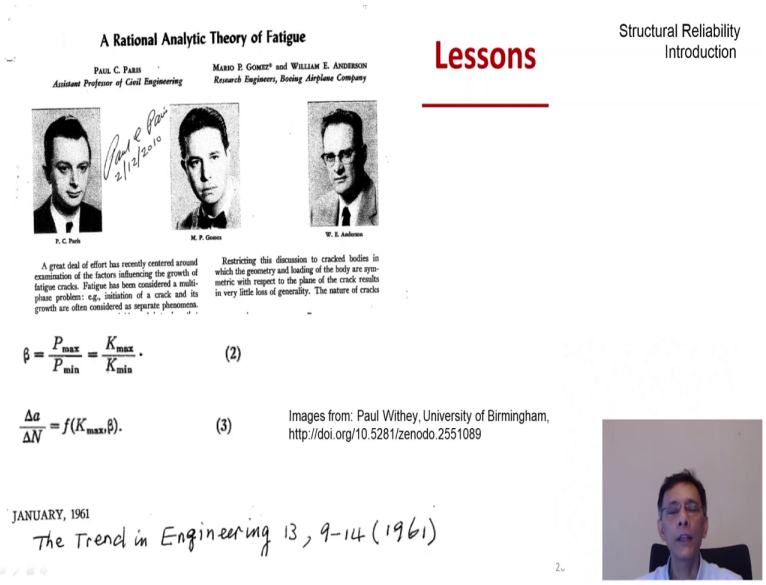

So, it took almost 7 to 8 years after the comet crashes to finally be able to relate fatigue with the fundamentals of mechanics and a comprehensive understanding of what went wrong finally was in place. So, during that time in the mid 1950s the shortcomings of safe life the design philosophy prevailing at that time became clear and this gave rise to the failed safe approach and about two decades later further to the damage tolerant approach.

So, this way the unfortunate Comet crashes expedited the development of the field of fracture mechanics which in turn allowed metal fatigue to finally be related firmly to mechanics after more than a century rather than phenomenologically. And later fatigue reliability became an integral part of the design and assessment of machines, buildings, bridges and all other structures.