An Advanced Technology for Aircraft Overrunning Runway—

Engineered Material Arresting System (EMAS)
Contents

- What’s EMAS?
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Runway Overrun and Veer-off -- One of the Major Challenges to Aviation Safety

- 1998~2007, number of accidents due to runway overrun and veer-off is in No.1 place in the global statistics.
- 2005~2008, number of incidents due to runway overrun and veer-off is also in No.1 place in Chinese statistics.
Tragic Consequence Resulted from Overrun

May 22, 2010, India, B737, overrun off the cliff, 158 fatalities

Dec. 22, 2009, Jamaica, B737, overrun, 40 injuries
Particular Threat to Aviation Safety in China

- In western China, there are many high altitude airports. Even having standard Runway End Safety Area (RESA) in place, beyond RESA always are steep cliffs, which poses particular threat to aviation safety in China.
- So do some airports near water bodies or residential areas.

250m away from runway end in an airport in western China
What’s Solution?

- What to do with an airport not meeting new standard, or with dangerous geography beyond RESA?
  - USA invented technology: Engineered Material Arresting System (EMAS) built within existing RESA, as an alternative method of compliance to the RESA standard.
What’s EMAS

- Foam concrete, laid on RESA ground, as wide as runway, up to 70cm high, up to more than one hundred meters long
- When overrunning aircraft travels in EMAS bed, the wheels crush the foam concrete, by which the aircraft is gradually slowed down to complete stop within the bed, without damage to aircraft or injury to occupants.
- Vehicle moving in the bed will damage it, but human will not.
Arresting Principle

- Compression Stress ($\sigma$)
- Plateau
- Energy Absorbed in Compression
- Compression Strain ($\varepsilon$)
- $\sigma_u$
- $\varepsilon_{\text{max}}$

Vertical Load Imparted
Drag Load Imparted
Direction of Travel

Material Initial Height
Material Compressed Height
Pavement Height

Energy Consumed Proportional to Volume of Material Crushed
Standard for EMAS

  - able to arrest aircraft with exit speed up to 70 knots for standard design, or up to 40 knots for non standard design
  - Not cause major structural damage to the aircraft or imposing excessive forces on its occupants
  - Enable safe ingress and egress of rescue and fire fighting vehicle
  - not cause control problems for aircraft undershoots which touch down in the EMAS bed
  - Validation may be based either on passage of an actual aircraft or an equivalent single wheel load through a test bed.
Applications Till Now

- At the present, USA’s product is only one product all over the world
- 55 sets installed in 35 airports in US and 8 aircrafts arrested
- Installed in Spain, South America and 2 sets in Jiuzhai-Huanglong Airport in Sichuan Province, China
ICAO’s Policy on EMAS

- In September 2011, in Proposed Amendment to the International Standards and Recommended Practices Aerodrome Design and Operations Annex 14, Volume I to the Convention on International Civil Aviation:
  - 3.5.5 Notwithstanding the provisions in 3.5.3 and 3.5.4 a) and b), the length of a runway end safety area may be reduced where an arresting system is installed with demonstrated performance that provides a level of protection at least equivalent to the prescribed runway end safety area.
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R&D of the Hangke Company

- Since 2010, Hangke Company based in Beijing China has been conducting R&D on EMAS in accordance with the FAA AC.
- Both military and civil actual aircraft validation tests were conducted.
In April 2011, CAAC Certification Team was constituted, working at theories, material performance, simulation model, single wheel load tests, actual aircraft tests, production quality assurance system etc. in compliance with the relevant standards.
Key Techniques

- 2 key techniques in EMAS:
  - Manufacturing process producing foam concrete meeting mechanical property and durability requirements
  - Simulation model capable of calculating stopping distance and evaluating safety of occupants and aircraft landing gears.
    - Calculating aircraft speed decay curve, deceleration curve, stopping distance, loads imposed on landing gears and their strengths, based on material properties, bed geometry, aircraft type, exit speed, weight of aircraft and so on.
- The Hangke Company developed these 2 techniques.
Achieved 2 Key Techniques

- Block of the foam concrete
- Mechanical performance
- Bed geometry and speed decay curve
- Deceleration curve
- Drag load, vertical load and limit loads of nose gear
- Drag load, vertical load and limit loads of main gear
Single Wheel Load Validation Test

- A single wheel load test device built, actual wheel, actual weight, actual bed and load measuring system incorporated
- A number of tests conducted, the simulation model greatly improved by the test results
Photos After Test
Actual Aircraft Validation Test

- Venue: the second runway in Tianjin Airport
- Type of test aircraft: B737-300
- Material: 24cm and 31cm high
Measuring Devices on Board
Calibration of the Load Measuring System
After Arrestment
Results of the Tests

- 6 tests conducted, 2 short beds, 4 full scale beds up to 145m long
- Entrance speeds ranged from 24 ~ 61 knots
- Neither injury to people on board nor damage to the landing gears as revealed by detailed visual inspection and nondestructive inspection after each test
- The actual stopping distances differ from the simulated ones by less than 5%
- The maximum deceleration <2g vs. limit of 4g for human safety
- Load peaks imposed on landing gears < the ultimate loads
- Fire fighting vehicle is able to move in, move out and move inside the beds
- Bed withstands a jet blast produced by the aircraft at distance of 25m away at takeoff power
Standard Design Scenario per the FAA AC

- After validated, the simulation model can be used to design EMAS for individual airport
- Standard design scenario per the FAA AC
  - Aircraft weight: MTOW
  - Exit speed: 70 kts
  - Engine thrust: no
  - Reverse thrust: no
  - Braking: poor braking with the braking coefficient of 0.25
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Application prospect

- EMAS can enhance airport safety, particularly for the airports with short RESA or dangerous geography beyond RESA, at a reasonable cost.
- Based on the outcome of the certification, CAAC has issued an approval to the EMAS of the Hangke Company, as the first one developed in China.
- Tuofeng Airport in Yunnan Province, China, has been chosen for experimental installation of the EMAS of the Hangke Company. The installation is expected to start in May and to be completed in June this year.
- ~50 airports in China may need EMAS as a rough estimate.
Other Airport Related Business of the Hangke Company

- Performance based navigation (PBN) program design and its operation support
- Airport capacity evaluation
- Contracted energy management
- Technique for airport bird strike prevention
- Detection technique for foreign object debris (FOD)
Thank you

Question or comment?
Q&A

- **Contact point of the Hangke Company?**

- **What’s the price?**
  - Roughly 10 million US$ per set

- **What technical standard does the EMAS comply with?**
  - FAA AC 150/5220-22A