Runway Safety
Area Slope Failure
Yeager Airport
Charleston, West Virginia

Terry Sayre, Airport Director
Nick Keller, Assistant Airport Director
History

• Runway Safety Area requirements caused a need for a fill at the end of Runway 5
• Reinforced fill was selected with a 408 foot long Engineered Materials Arresting System (EMAS) to rest on top
• Tallest geosynthetic reinforced 1:1 fill in North America – 270 feet
• Project was completed in 2008
• Built through the FAA Airport Improvement Program (AIP) which was comprised of 90% Federal funding
Before RSA Construction
After RSA Construction
EMAS

• Engineered Materials Arresting System (EMAS)
  • Provides an equivalent level of safety as full-dimension Runway Safety Area (RSA)
  • Made up of high-energy absorbing materials which will crush under the weight of an aircraft
• January 19, 2010
  • CRJ-200 aircraft aborted takeoff and came to a stop approximately 130 feet into the EMAS bed on the Runway 5 end
  • No injuries among the 30 passengers and 3 crew members

• EMAS is a critical component for a safe runway environment when a full-dimension RSA cannot be provided
Cracks Developed in 2013
Day of the Collapse – March 12, 2015
Emergency Planning

• The day before the failure, Airport officials convened a tabletop exercise with local emergency responders
  • Discussed worst case scenarios, flooding, evacuations, emergency public information, reverse 911

• The morning of the failure (March 12, 2015) Airport officials again conducted a tabletop exercise with local emergency responders

• Given the amount of movement emergency management officials took the threat of a collapse very seriously
• An Airport employee was stationed at the base of the fill in parking lot of the Keystone Apostolic Church to watch for movements
• At approximately 12:15 PM the employee noticed significant movement and notified Airport management
• The Airport immediately responded and closed Keystone Drive
Day of the Collapse – March 12, 2015 – Church is still standing
Day after the Collapse – March 13, 2015 – Church is destroyed and neighborhood flooding
Family Assistance

• 132 lives affected/approximately 60 households were evacuated after the collapse

• The Airport paid for hotel rooms and gave households a small cash disbursement for emergency expenses

• 38 persons were able to return home within a couple of days

• 56 were able to go home within a week
Cost to the Airport

- $72,759 total payments to residents – basic needs, storage, repairs, replacements (not including Red Cross initial assistance)
- $175,387 for hotel accommodations, apartment rentals
- $3,089,744 in property settlements
- $6,591,991 for remediation, mitigation, utility restoration, (and everything else)

Total - $9.9 Million
Before Remediation
Before Remediation
Remediation Complete
Remediation Complete
Slope Failure- Impact to Airport

- The slope failure resulted in a reduction in the runway lengths available for landings and takeoffs.
- An RSA Study was initiated in 2017 to identify short-term solutions to improve safety and increase operational capability for Yeager Airport.
Displaced Threshold Runway 5

- Runway 5 threshold was displaced 577 feet to allow for a safety area
- Navigational aids were turned off by the FAA
• Slope failure destroyed Runway 5 Runway Safety Area (RSA) and Engineered Materials Arresting System (EMAS)

• To provide additional RSA length while awaiting a permanent solution, Yeager Airport decided to decrease the declared distances on the runway

• These declared distances resulted in a 500-foot reduction in LDA and ASDA on the Runway 23 end and a 577-foot reduction in LDA on the Runway 5 end (shown below)

Declared Distances
Post Slope Failure

Notes: TORA=TODA in all scenarios
Distances are compared to condition prior to slope failure
TORA = Takeoff Run Available
LDA = Landing Distance Available
ASDA = Accelerate Stop Distance Available
RSA Study

- RSA Study was initiated in 2017 to identify short-term solutions to improve safety and increase operational capability for Yeager Airport.
- RSA Study Objectives:
  1. Short-term Solution: Achieve LDA of 6,000’ & ASDA of 6,300’ (Runway 5) and 6,800’ (Runway 23)
  2. Minimize Construction (fast implementation)
  3. Equivalent Level of Safety as Existing Conditions
  4. Re-establish Runway 5 Instrument Landing System (ILS)

Notes:
LDA = Landing Distance Available
ASDA = Accelerate Stop Distance Available
Runway Length Methodology

- Runway length requirements were calculated for landings and takeoffs to determine an existing runway length requirement for the Airport.
- Calculated for passenger, cargo, and general aviation aircraft.
- Fixed inputs and assumptions used to conduct runway length analysis include:
  - Density Altitude (temperature and elevation)
  - Runway Characteristics (slope and contamination)
  - Fleet Mix & Destinations (2016 & 2017 fleet)

### Aircraft Type

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Furthest Destination</th>
<th>Annual IFR Operations</th>
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<td></td>
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<td><strong>Cargo</strong></td>
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<td>B727</td>
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<td>B757</td>
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### Aircraft Type

<table>
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<tr>
<th>Aircraft Type</th>
<th>Representative Aircraft Used in Analysis</th>
<th>Annual IFR Operations</th>
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<td>Global Express</td>
<td>Global Express</td>
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<tr>
<td>Challenger (all series)</td>
<td>BD-100 Challenger 300</td>
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<tr>
<td>Citation (all series)</td>
<td>Citation Mustang and X</td>
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IFR = Instrument Flight Rules
Sources: Official Airline Guide and FAA data
Takeoff Length Requirements

**Passenger and Cargo**

- Three aircraft exceed Runway 5 Accelerate Stop Distance Available (ASDA)
- Four aircraft exceed Runway 23 ASDA
- Embraer-145 defines the takeoff requirement because it meets the FAA's substantial use threshold (500 annual operations)

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Notes:
- Hot day charts using 86°F were used to determine takeoff length
- Runway length requirements for Runway 23 include an additional 520 feet to adjust for a positive runway slope. See Paragraph 304 in Federal Aviation Administration Advisory Circular 150/5325-4B, Runway Length Requirements, for more details

Source: Aircraft Manufacturers' Charts; Landrum & Brown analysis
## Range of Alternatives

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Conclusions</th>
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<tbody>
<tr>
<td>Apply declared distances to reduce undershoot Runway Safety Area (RSA) and increase runway length</td>
<td>These alternatives do not sufficiently improve safety and runway length</td>
</tr>
<tr>
<td>Apply declared distances to reduce overrun RSA and increase runway length</td>
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<tr>
<td>Apply declared distances and add Engineered Materials Arresting System (EMAS)</td>
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<tr>
<td>Add a 100-foot extension with retaining wall and EMAS</td>
<td>Best balance of safety and runway length</td>
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<tr>
<td>Add a 200-foot extension with retaining wall and EMAS</td>
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</table>
Recommended Plan

Components
- 200-foot land extension
- 82-foot high retaining wall
- 352-foot EMAS bed
- Use 52’ of existing runway pavement for Engineered Materials Arresting System (EMAS)

Results
- Total Runway Safety Area (RSA) length = 387’ with EMAS
- RSA width – at least 200’ (irregular shape) up to retaining wall
- Best balance of safety and operational needs
## Recommended Plan Details

### Declared Distance Goals

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<tr>
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<th>Runway 5</th>
<th>Runway 23</th>
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<tr>
<td>LDA</td>
<td>6,000’</td>
<td>6,000’</td>
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<tr>
<td>ASDA</td>
<td>6,300’</td>
<td>6,800’</td>
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### Declared Distances Achieved with Recommended Plan

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<tr>
<th></th>
<th>Runway 5</th>
<th>Runway 23</th>
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<tbody>
<tr>
<td>LDA</td>
<td>6,015’</td>
<td>6,215’</td>
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<tr>
<td>ASDA</td>
<td>6,215’</td>
<td>6,715’</td>
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</table>

Notes:
- LDA = Landing Distance Available
- ASDA = Accelerate Stop Distance Available

Source: Landrum & Brown analysis

- **Although the recommended plan does not meet the ASDA goals, it provides the best balance of safety and operational needs.**
Geofoam is high compressive strength expanded polystyrene (EPS) or extruded polystyrene (XPS) manufactured into lightweight blocks (less than 1% of the weight of soil fills).

Primary function is to provide lightweight fill for soil substitute, slope stabilization, retaining wall or backfill.

Several types of geofoam can be used on a single project:
- Higher strength geofoam can be used in high applied stress areas while lower strength blocks are used in areas where the applied stresses are lower.
- Manufacturers of geofoam blocks design projects on a case-by-case basis.
Rebuild Funding Challenges

• The FAA said the Airport must rebuild the runway safety area
• FAA told the Airport the project was NOT eligible to be rebuilt with FAA money
• Lawsuits have been filed against companies involved with the design and construction
Congressional Action

• The Airport worked with Senator Capito, Senator Manchin and Congressman Jenkins to change Federal law so FAA would be able to use their funds for a rebuild

• Language was placed in the Omnibus spending bill and passed in May 2017

• Added: 49 United States Code 1142 – Use of AIP funds for runway safety repairs
Geofoam Block Details

- Can be used under airport runways or similar pavement to replace unsuitable soils without overloading the underlying subgrade materials.
- Capable of supporting Engineered Materials Arresting System (EMAS) and aircraft weight.
- Decreases construction time due to ease of installation.
- Examples: New Orleans taxiway and Tokyo Haneda runway.
  - Both of these applications reduced weight and lateral pressure on compressive soils.

Schematic Drawing of airport taxiway/runway using EPS geofoam:
Wall Rendering

Elevation of Wall at Base = 863 ft. MSL
Elevation of Wall at Highest Point = 945 ft. MSL
Height of Wall at Highest Point = 82 ft.
Overall Length = 400 ft.

Note: Dimensions are estimated and could change
• After several meetings in Washington, DC with FAA and Congressional staffers the FAA agreed to award a grant for the runway safety area

• Phase 1 grant in the amount $13.8 Million was awarded in Fall 2017

• Phase 2 grant for the remaining $6.7 Million will be awarded in Summer 2018
## Project Cost

### Runway 5 RSA Project

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<tr>
<th>Components</th>
<th>Cost</th>
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<td>Construction</td>
<td>$14,997,026</td>
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<td>EMAS Blocks</td>
<td>$4,793,308</td>
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<td>Design, Construction Admin and Inspection</td>
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<td><strong>FAA Reimbursable Agreement</strong></td>
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<td><strong>Total</strong></td>
<td><strong>$22,798,901</strong></td>
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### Project Schedule

- Draft Runway Safety Area (RSA) Study and Airport Layout Plan submitted to FAA in August 2017
- FAA approved plan and issued environmental approval in August 2017
- Engineer’s 60% Design Report submitted to FAA in November 2017
- Airport Board awarded contract to Orders Construction in March 2018
- Groundbreaking will in late March or early April
- Airport will obtain the final production run of Zodiac EMAS blocks in Fall 2018
- Construction will be completed in December 2018

<table>
<thead>
<tr>
<th>Duration-Years</th>
<th>Duration-Months</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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