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Integrity-Focused Geohazards Management for Pipelines

Yong-Yi Wang, Banglin Liu, and Patrick Fleck

ywang@cres-Americas.com

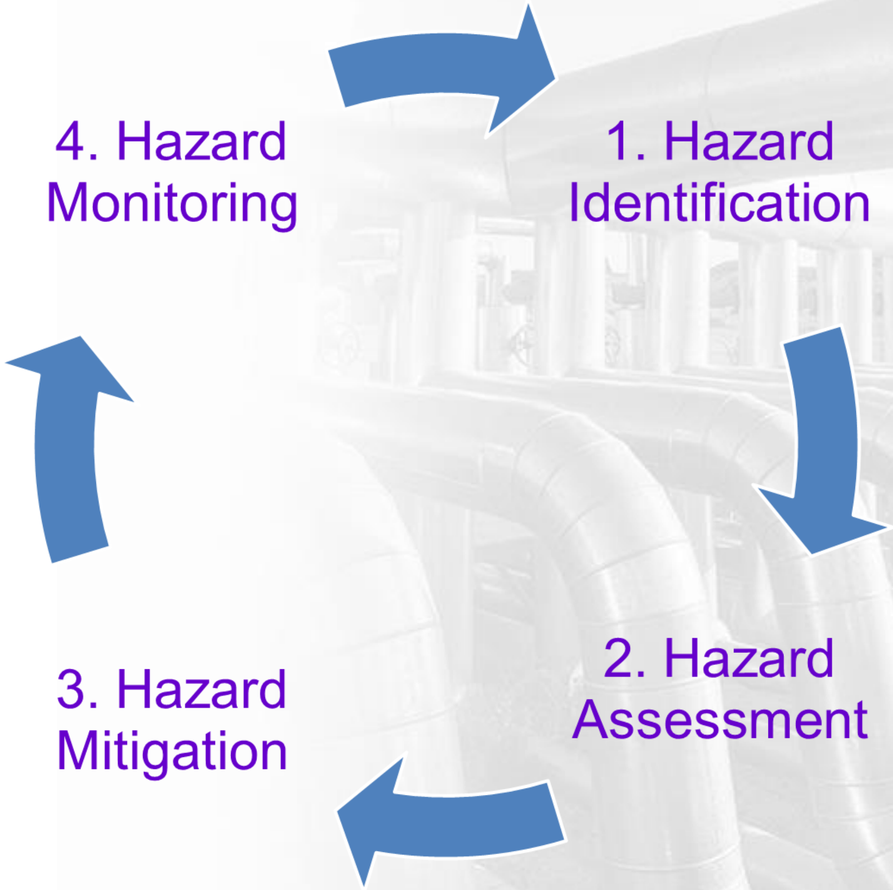
Center for Reliable Energy Systems, LLC

Overview

- "Traditional"- vs. integrity-focused geohazards management
- Integrity-focused approach, i.e., fitness-for-service (FFS) assessment
  - Framework
  - Strain demand
  - Strain capacity
- Examples of using FFS assessment to guide mitigation decisions
- Prepare for FFS-focused geohazards management
- Available resources

"Traditional" Geohazards Management

- Focus on the detection, characterization, mitigation, and monitoring of hazards
- Mitigation decisions are made based on the characteristics of hazards.
- The varying level of strain tolerance of pipelines is given limited consideration.



Don West, Golder

Integrity-Focused Geohazards Management

- Focus on pipe integrity
- Use integrity assessment to drive decisions about mitigation decisions, i.e., FFS assessment
  - Necessary?
  - When?
  - How?
    - Hazards
    - Pipe
- Two-step process
  - Screening
  - Site-specific analysis

Advantages of FFS-Focused Approach

- Only do what is needed
- Have a sense of safety margin
- Cost vs. safety
  - Traditional program
    - Pros
      - Don't need to know much about the conditions of pipelines
    - Cons
      - Could lead to unnecessary or overly-aggressive mitigation actions
      - Site work could introduce additional stresses
  - FFS-focused approach
    - Pros
      - Likely more cost-effective in the long term
      - Better understanding of the risk level associated with mitigation decisions
    - Cons
      - Need pipe, weld, and construction information which may not be readily available

FFS-Centered Approach

- Goal – understand the health of the pipeline at the time of interest
  - Present
  - Future
- Fitness-for-service assessment
  - Safe condition

$$\varepsilon_d \text{ (strain demand)} \leq \varepsilon_d^L \text{ (strain demand limit)}$$

$$\varepsilon_d^L = f \text{ (safety factor)} \times \varepsilon_c \text{ (strain capacity)}$$

Estimation/Determination of Strain Demand

- Quick strain demand estimation based on deformation profile
- Screening and analysis of IMU data
  - Blind spots
    - Strain adjacent to bends
    - Weld “bumps”
  - Correlation with geohazards at low level of bending strain
- Analysis of strain gage data
  - Resolution of bending plane
  - Separation of bending vs. uniform tensile/compression components
  - Temperature compensation
- Pipe-soil interaction modeling

Estimation of Tensile Strain Capacity

- Part 1 Use appropriate procedures/tools
  - PRCI-CRES tensile strain models (PRCI project ABD-1 co-funded by PHMSA)
  - PRCI SIA-1-7 model/tool – targeted application for vintage pipelines using the Level 4a procedure of PRCI-CRES models
- Part 2 Collect system/line-specific information
  - Weld strength mismatch, including HAZ softening if applicable
  - Weld profile
  - Type and dimensions of flaws
  - Toughness
- Part 3 Perform analysis under various possible field conditions
  - Interaction of various parameters

Estimation of Tensile Strain Capacity

- Understand evolution of key factors affecting TSC for pipelines of different vintage
  - Mechanical properties
    - Linepipe
    - Girth weld
  - Construction practice
    - Girth welding
    - Girth weld inspection
  - Characteristics of post-construction weld flaws
- Understand applicable range and limits of TSC tools

Compressive Strain Capacity

- Most published compressive strain models/equations are overly conservative for applications in many geohazards conditions involving buried pipelines.
- Alternative assessment method for buried pipelines is available.
  - Liu, M., Wang, Y.-Y., Sen, M., and Song, P., "Integrity Assessment of Post-Peak-Moment Wrinkles," Proceedings of the 11th International Pipeline Conference, Paper No. IPC2016-64654, September 26-September 30, 2016, Calgary, Alberta, Canada.

Example 1 - Using FFS to Make Mitigation Decisions

- Recommendations – Site 1
  - Site stabilization
  - No stress relief
  - Continued monitoring
- Recommendations – Site 2
  - Stress relief (low capacity, low margin)
  - Site stabilization
  - Monitoring

Landslide Site No.	1	2
Total Span (ft)	160	130
Max. Displacement (ft)	3.5	2.0
Strain Demand (%)	0.35-0.60	0.22-0.30
Strain Capacity (%)	0.90-1.45	0.55-0.65
Capacity - Demand (%)	0.55-0.85	0.15-0.35
Demand/Capacity	0.40-0.43	0.35-0.70
Allowable Additional Displacement (ft)	4.0	1.0

Example 2 - Using FFS to Make Mitigation Decisions

- A pipeline segment was displaced by a landslide.
  - Should normal operation be continued?
- Level 1 quick turn-around FFS assessment was completed
  - No immediate integrity concerns were identified.
  - The line remained in service with full pressure.
  - Site mitigation was planned in dry months.
- Leve 2 FFS assessment was completed while mitigation options were explored.
  - The margin of safety was good.

Example 2 - Using FFS to Make Mitigation Decisions

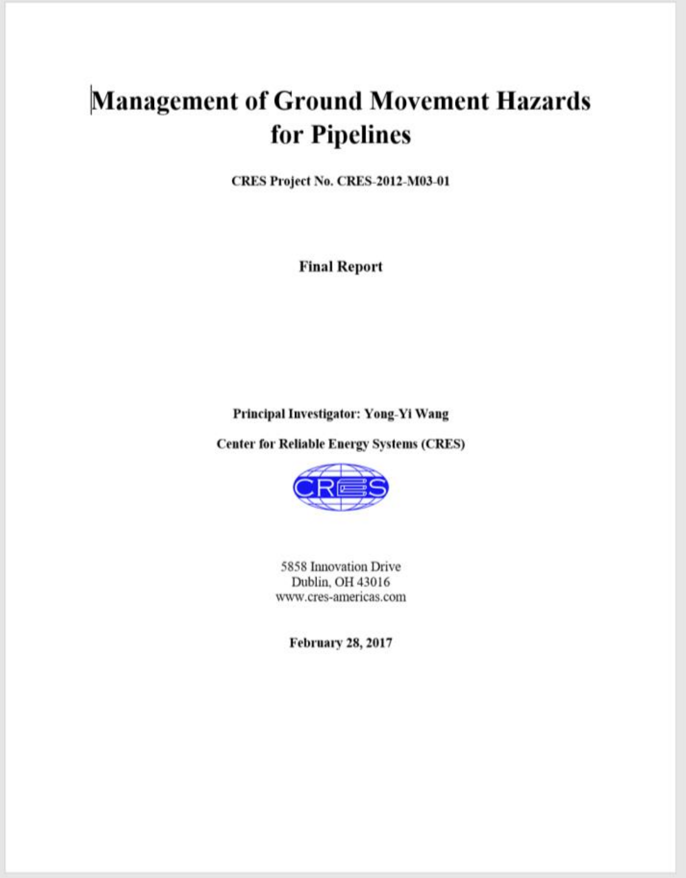
- Site work
  - No stress relief
  - Drains were installed.
  - Strain gages were installed in critical locations identified by the strain demand analysis
- Future integrity management
  - Strain threshold for future intervention/action
  - Monitoring/reporting processes

Enabling Integrity-Focused Geohazards Management

- Prepare data for FFS assessment
  - Vintage pipelines
    - Test pipes and girth welds (opportunistic testing)
    - Understand flaw characteristics of girth welds
  - Modern pipelines
    - Organize records
    - Perform targeted tests as needed
- Have a pre-defined framework
  - Overall geohazards management process (e.g., INGAA JIP)
  - Process to collect samples and conduct tests
  - Organize data in useable forms

References with Comprehensive Information

JIP 2017



Management of Ground Movement Hazards for Pipelines

CRES Project No. CRES-2012-M03-01

Final Report

Principal Investigator: Yong-Yi Wang

Center for Reliable Energy Systems (CRES)

CRES

5858 Innovation Drive
Dublin, OH 43016
www.cres-americas.com

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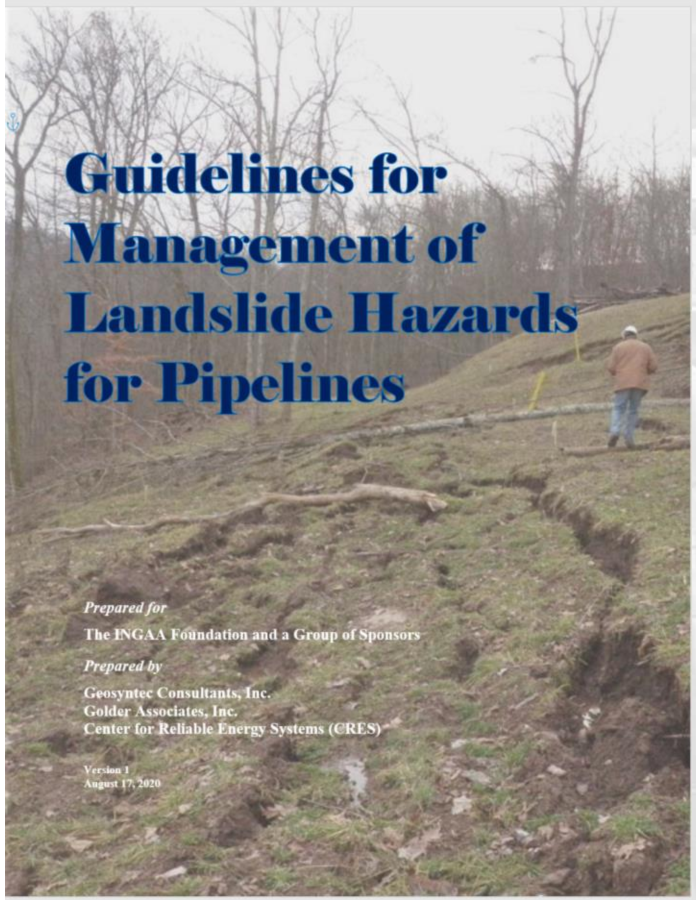
https://www.ingaa.org/Foundation/FDNreports/38774.aspx

INGAA JIP 2020



https://www.ingaa.org/Foundation/FDNreports/38063.aspx

Resources

- Response plan after a ground movement event
- Excavation and backfill in the area of geohazards
- Enhancement of girth weld strain capacity
- Assessment of interacting threats, e.g., corrosion and high strain, mechanical damage and high strain
  - Strain capacity
  - Burst pressure

Acknowledgement

- PHMSA and PRCI for funding the early development of the strain-based design and assessment methodology
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- Sponsors of the 2020 INGAA JIP
- Pipeline operators
- Staff at CRES
  - Dr. Dan Jia

Thank you!

Q&A

Use Strain Demand to Rank and Priotorize

- Overlaying geotechnical assessment with IMU
  - Geotechnical assessment
    - Location
    - State of movement
    - Risk of future movement
  - IMU strain reports
- Ranking and prioritization could be done based on strain demand alone.