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“Anatomy of a Fall” Simultaneous & Sequential Falls on Horizontal Lifeline Systems

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What happens in multi-worker falls on flexible horizontal lifeline systems?

- **Brief summary of HLL testing**
- **Analysis with the aid of high-speed video and electronic measurement and test instruments**
- **Sequence of events and effects of multi-worker falls**
- **Consequences for modeling the behavior of these systems and practical considerations for safe use**



Behavior of Flexible Horizontal Lifeline Systems in Fall Arrest

■ Physics of Fall Arrest

- ◆ The Energy Balance Model

■ Simultaneous and Sequential Fall Events Defined

◆ Simultaneous

- ◆ Falling bodies start their free-fall together
- ◆ Behave as a “lumped mass”

◆ Sequential

- ◆ Falling bodies start their free-fall separately
- ◆ First body comes to rest before second body begins to decelerate





Testing Flexible Horizontal Lifeline Systems

■ Reference Standards

- ◆ ANSI Z359.1-1992(R1999)
- ◆ CSA Z259.13-04

■ Test Structure

- ◆ Rigid
- ◆ Natural Harmonic Frequency > 200 Hz

■ Measurement and Test Equipment

- ◆ Load Cells with sampling rate of 1000 sample per sec
- ◆ Digital Acquisition System with signal conditioning
- ◆ Calibrated Test Weights and Quick Release Mechanism

Testing Performed by MSA

■ Test Structure

- ◆ Edmonton, AB trestle structure with 70 ft clearance
- ◆ 10 ft to 300 ft span length

■ Rigging

- ◆ Single and multiple spans
- ◆ 1 to 4 independent test weights
- ◆ Load cells at each end of span and at each test weight

■ Test Methods

- ◆ Procedures in compliance with CSA protocols
- ◆ Supervised and witnessed by an independent, registered professional engineer

■ Test Matrix

- ◆ Each HLL configuration
- ◆ Multiple dynamic tests of each configuration

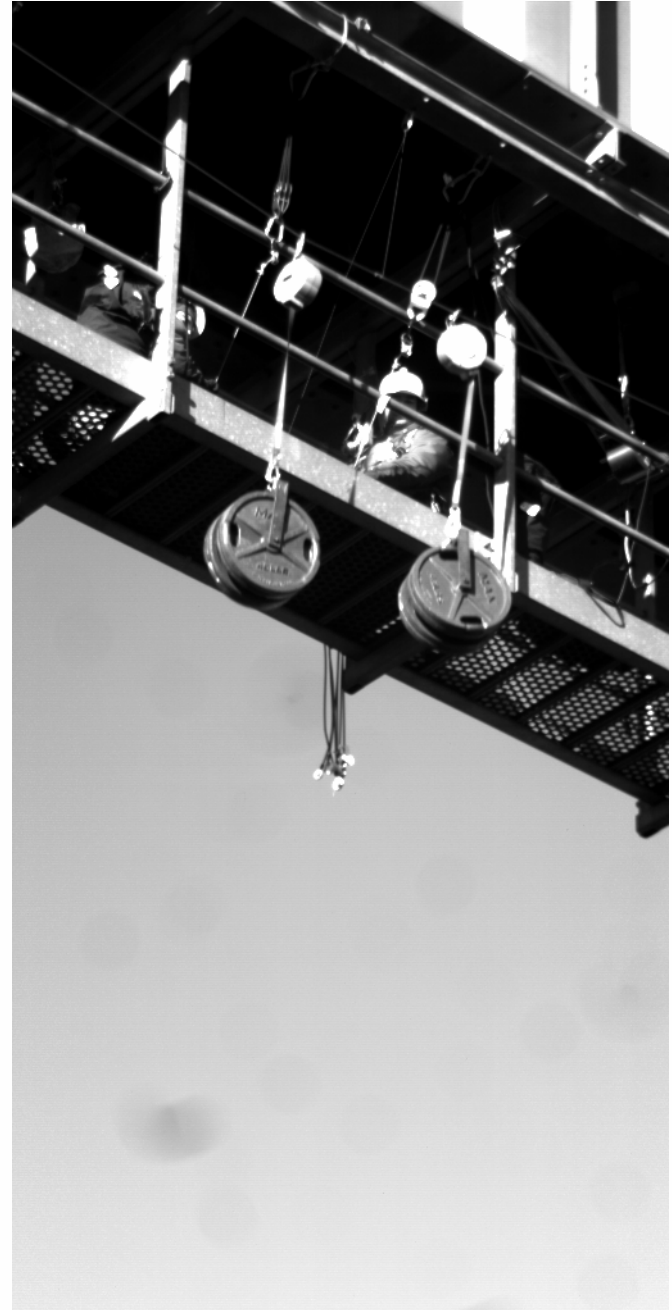


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Simultaneous Fall Testing

- Cable lifeline with in-line energy absorber
- 60 ft single span
- Two test weights, 220 lb each
- Self-retracting lanyards

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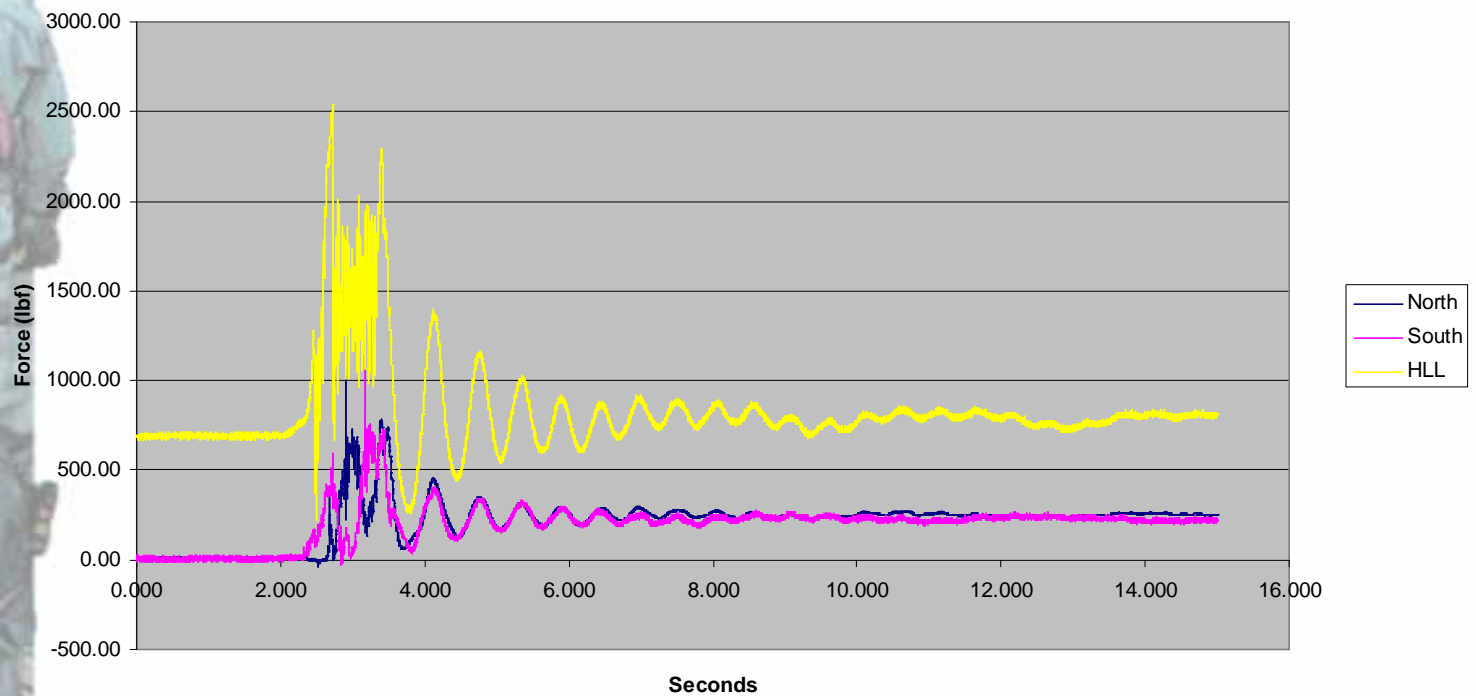
Analysis of Test Data

- **Statistical evaluation of test data**
 - ◆ Range and mean values
 - ◆ Dealing with outliers
 - ◆ Establishing statistical significance of results
- **Creating a mathematical model**
 - ◆ Developing an algorithm
 - ◆ Interpolation and extrapolation
- **Verifying model results against test data**
 - ◆ Back-checking agreement between actual versus theoretical results
 - ◆ Adjusting the algorithm
 - ◆ Goal: prediction within 10% of actual results



Graph of Simultaneous Fall – Or Is It?

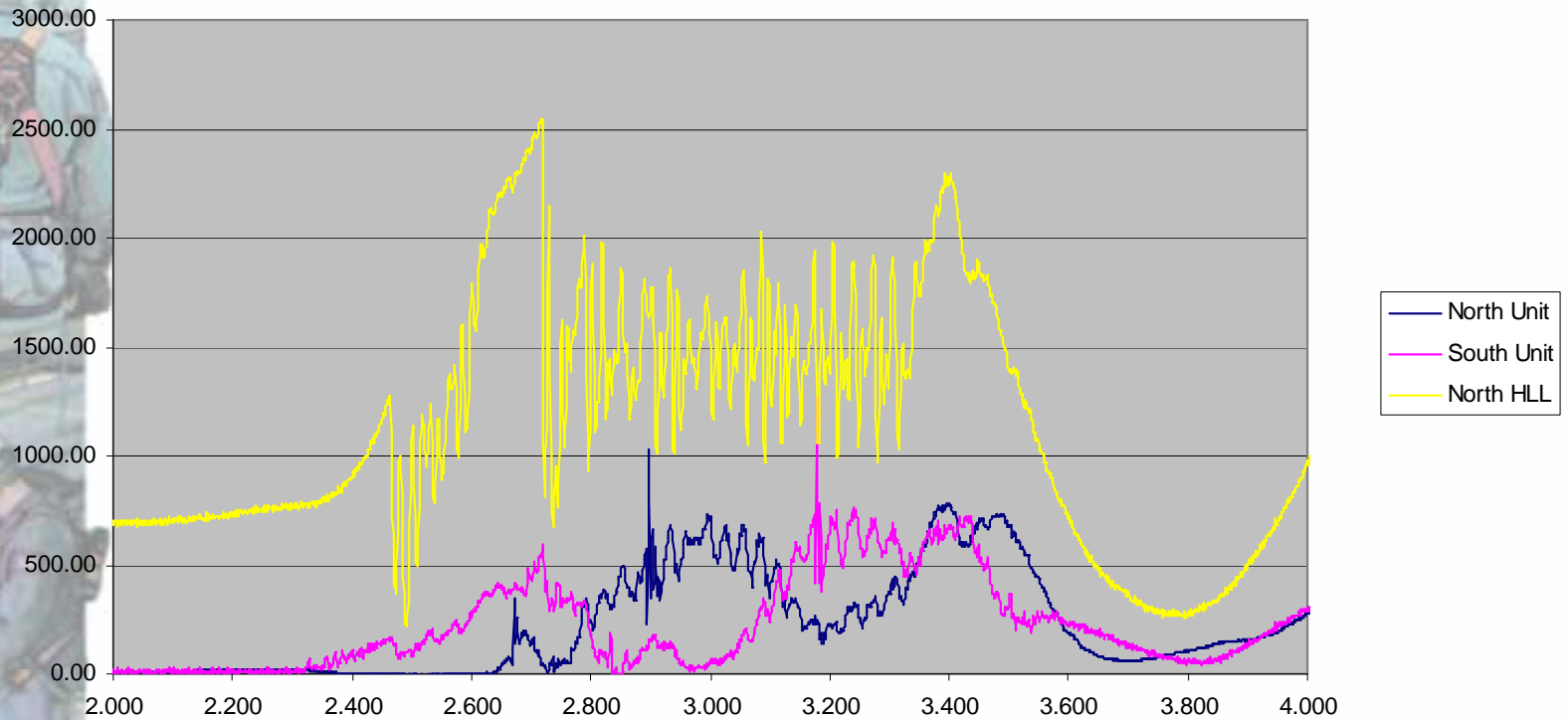
HLL 2 Worker Simultaneous Fall





Anatomy of a Fall

Test 18 - Cable HLL with Energy Absorber, 60 Foot, 2 Worker, 30ft SRL



Anatomy of a Fall

- **Sequence of the Fall Event**

- ◆ Lifeline energy absorber deploys
- ◆ PFAS shock absorber on Unit 1 deploys
- ◆ PFAS shock absorber on Unit 2 deploys

- **Maximum Arrest Forces**

- ◆ Peak forces occur when PFAS shock absorbers deploy together

- **Line Loads**

- ◆ Line load spikes, stabilizes and spikes again to reach a peak at point when energy absorber is depleted and both PFAS shock absorbers are in action

- **Clearance Requirements**

- ◆ Further deployment of Unit 2 PFAS shock absorber creates added deceleration distance for second worker



Using a Mathematical Model in HLL System Design

- **Defining System Parameters**
- **Accounting for Variation in Multi-Worker Falls**
 - ◆ Simultaneous and Sequential Falls
 - ◆ Performance of a variety of PFAS equipment
- **Taking the “Worst Case”**
 - ◆ Line Load
 - ◆ Clearance
- **Factors of Safety**
 - ◆ Mandatory 2:1 factor
 - ◆ Clearance safety factors

Conclusions

- Sequential falls make prediction difficult
- Rely on calculations developed from verified test data
- Limit the number of personnel to one worker per span whenever practical
- Recognize that fall clearances can increase when two or more workers are on a horizontal lifeline span



Your Questions are Welcome





Thank you for your participation

- **MSA Horizontal Lifeline Calculator**
- **Coming soon to <http://msanet.com>**

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