Bearing Upgrade: Split-Hopkinson Pressure Bar Experiment

Concept Generation

Group 1

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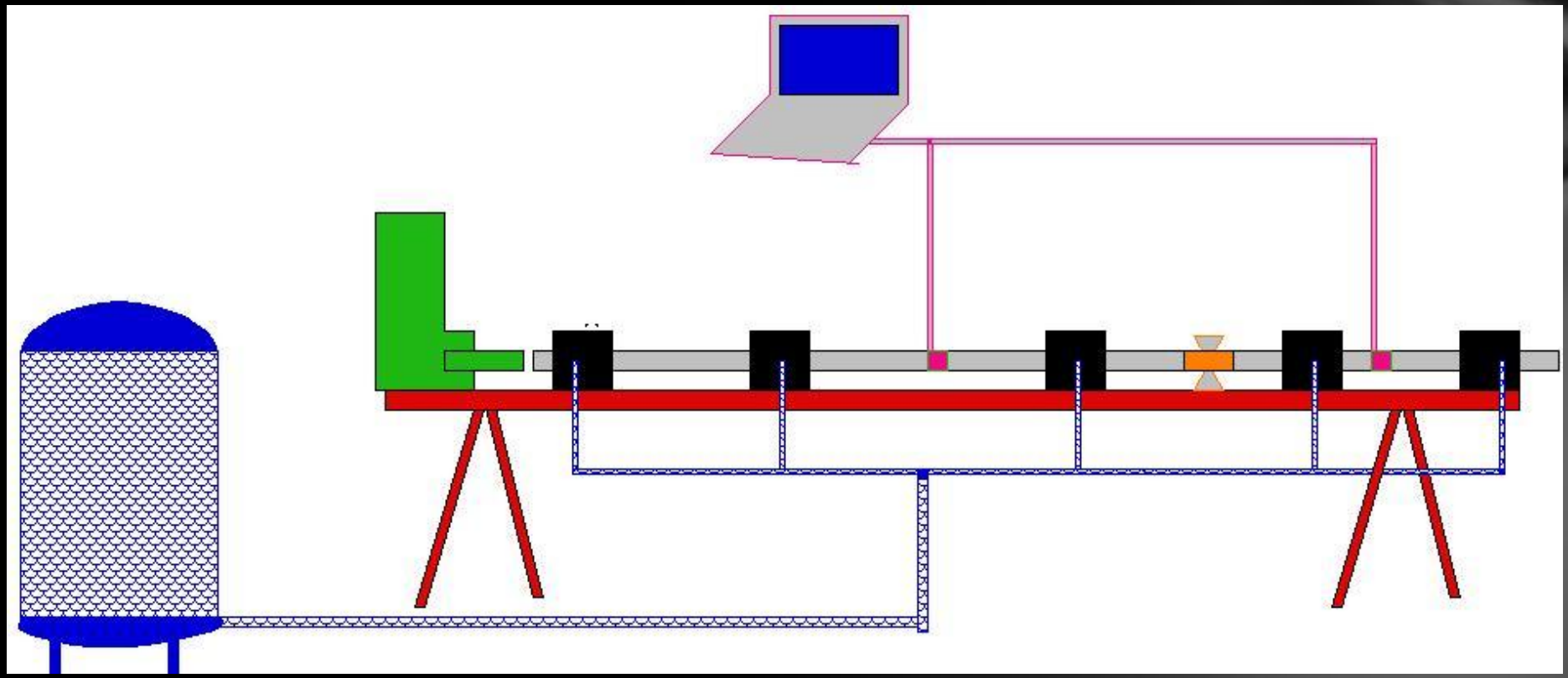
Sponsored by:

Eglin Air Force Research Base

Dr. Joel House

Split Hopkinson Pressure Bar System



Overview

Introduction

Striker bar Description and Concepts

Transmitted and Incident bars Description and Concepts

Air Bushing Housing/Air Supply Description and Concepts

Base Description and Concepts

Bushing Alignment Description and Concepts

Shock Absorber Description and Concepts

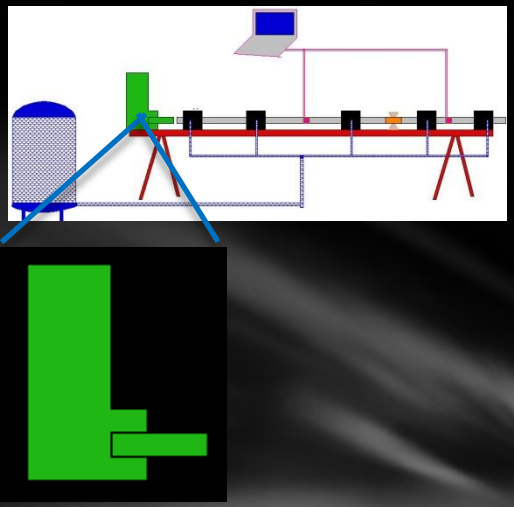
Strain Gauges Description and Concepts

Data Acquisition Description and Concepts

Decision Matrix

References

Striker Bar

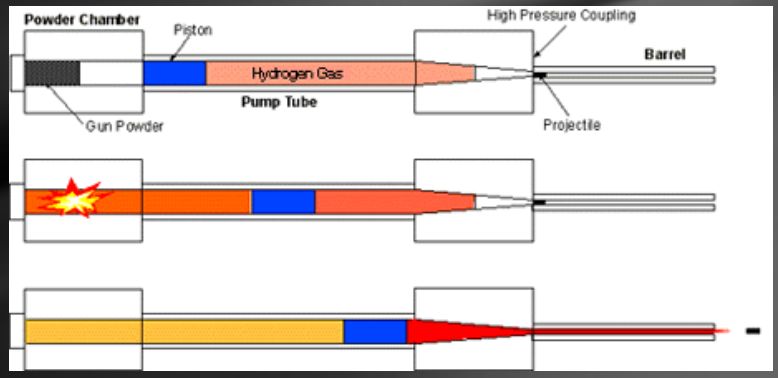


What is the striker bar?

- First component
- Sets everything in motion
- Should be same diameter and material as the transmitted and incident bars.

Current set-up

-light gas gun mechanism



generates high velocities

piston in chamber, hydrogen gas gets pushed by piston through chamber, chamber tapers off to a smaller diameter barrel where the gas is forced out, pushing the striker bar with a large force, generating a large velocity for high impact.

Striker Bar
Concept 1 – Modified Gas Gun Mechanism

Similar to the concept currently in use, but since this is small scale, a paintball gun type release could be used.

Compressed co2 build up at the base of the tube.

Trigger is pressed, pin released letting compressed co2 force the striker bar out of the tube.

Complex, somewhat costly

This concept most likely will not be used, but it is a viable option if cost were not a major factor in the decision making process.

Striker Bar
Concept 2 – Swinging Pendulum

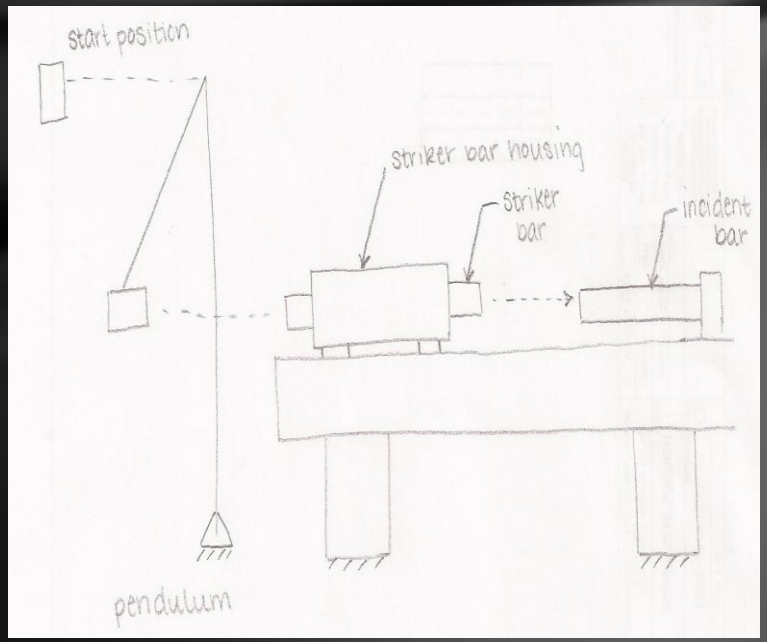
Pendulum as a striker mechanism to force the striker bar to hit the incident bar and set the process in motion.

Held at a 90 degree angle away from the structure before release.

Hand released.

Simple, easy and cheap to build and maintain.

Not completely accurate.



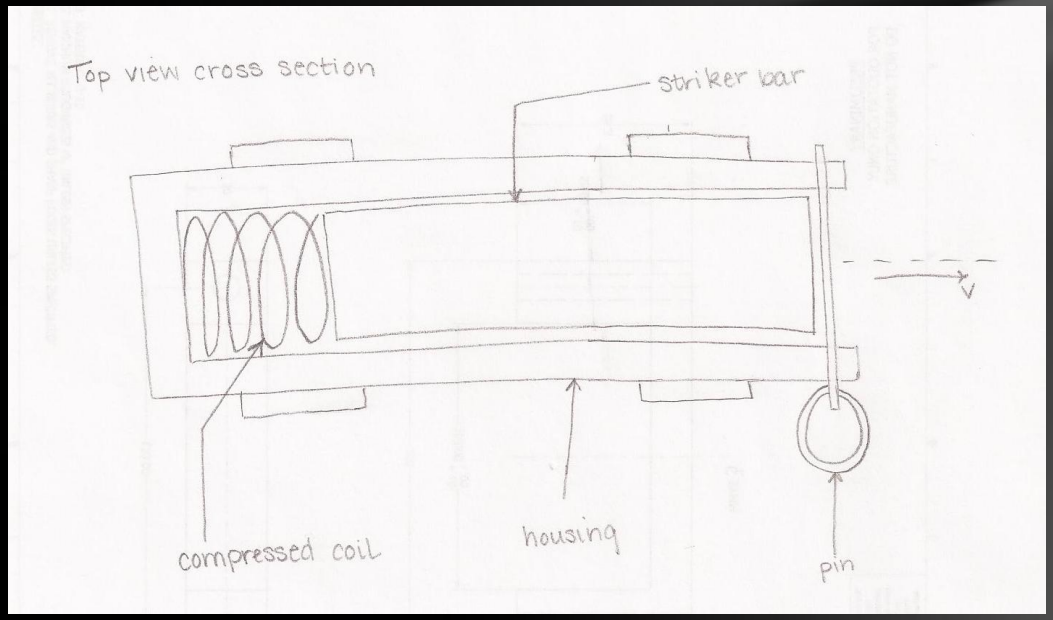
Striker Bar
Concept 3 – Spring Launcher

Spring at the base of a tube in line with the entire structure, striker bar placed in front of the spring with a pin to hold it in place.

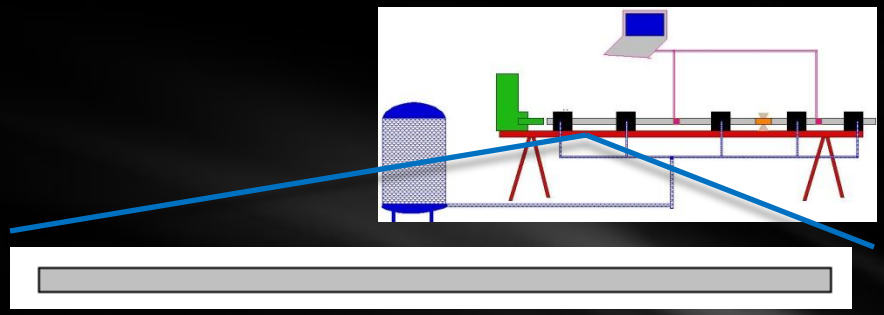
Pin release, compressed spring forces striker bar out of the tube.

Simple, easy and cheap mechanism.

May not provide enough force to produce the desired results.



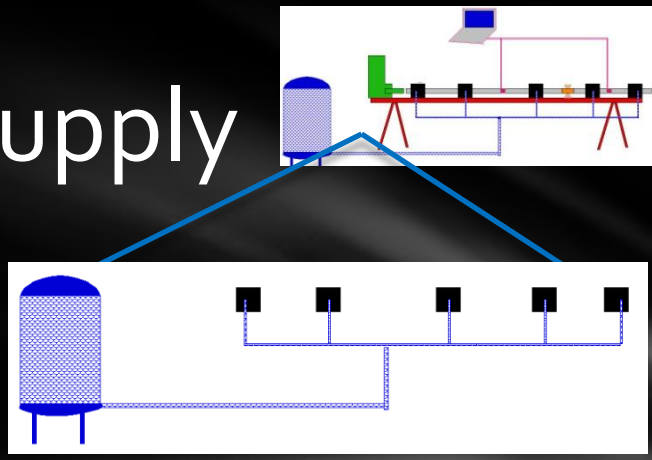
Bar Material & Size



- Yield strength of material must be high
- Bar material and size to be chosen
- Three possible materials:
  - Option 1: 1114 Cold Drawn Stress proof Steel
    - Yield Strength- 100,000 psi
    - Ultimate Tensile Strength- 115,000 psi
  - Option 2: 4340 (chromyl) Normalized Alloy Steel (Air Melt)
    - Yield Strength- 125,000 psi
    - Ultimate Tensile Strength- 186,000 psi
  - Option 3: 17-4 Stainless Steel
    - Yield Strength- 145,000 psi
    - Ultimate Tensile Strength- 160,000 psi

Steel Bar

Air Bushing Housing/Air Supply



- Air Bushing Housing encloses air bushing
- Common material: aluminum
- Possible housing diameter sizes:
  - Option 1: 0.25”
  - Option 2: 0.50”
  - Option 3: 0.75”

Aluminum block mounting/housing

Air Bushing Housing/Air Supply

Two ways of mounting air bushings in housings

- Option 1: o-ring Press Fitting (Flexible Mount):
  - uses 4 o-rings (2 Inner & 2 outer)
  - air supply hole
  - air bushing floats in housing
  - 2 outer o-rings for flexible mount
- Option 2: Bonded in Place (Hard Mount):
  - 4 o-ring configuration
  - forms 2 cavities
  - air supply hole
  - epoxy injected

Air Bushing Housing/Air Supply

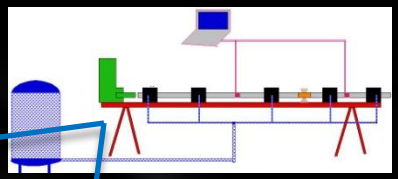
- Air supply comes from compressed air source
- uses polyurethane tubing
- 3 inner and outer (I.D. / O.D.) diameter tube sizes:
  - Option 1: .170/0.250
  - Option 2: 0.125/0.250
  - Option 3: 0.078/0.156

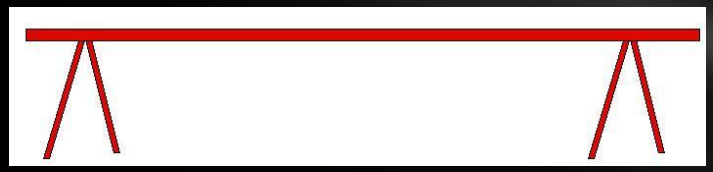
- Air bearings receive air from air supply fittings
  - 5 different air supply fittings
    - Option 1: straight air
    - Option 2: right -angle
    - Option 3: T- style
    - Option 4: thread less connection
    - Option 5: quick disconnect

Polyurethane tubing

Air supply fitting

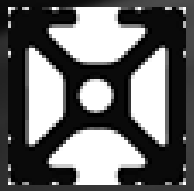
Base

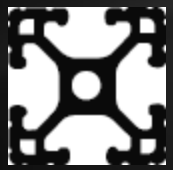


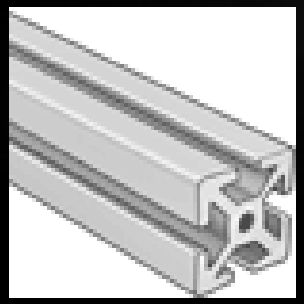


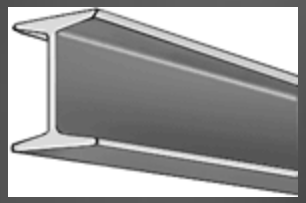
Requirements:

- Must support:
  - Bearing system
  - Specimen housing
- Must be able to maintain bearing alignment for high impact transmission
- Prototype must be:
  - Affordable
  - Scalable
  - Portable





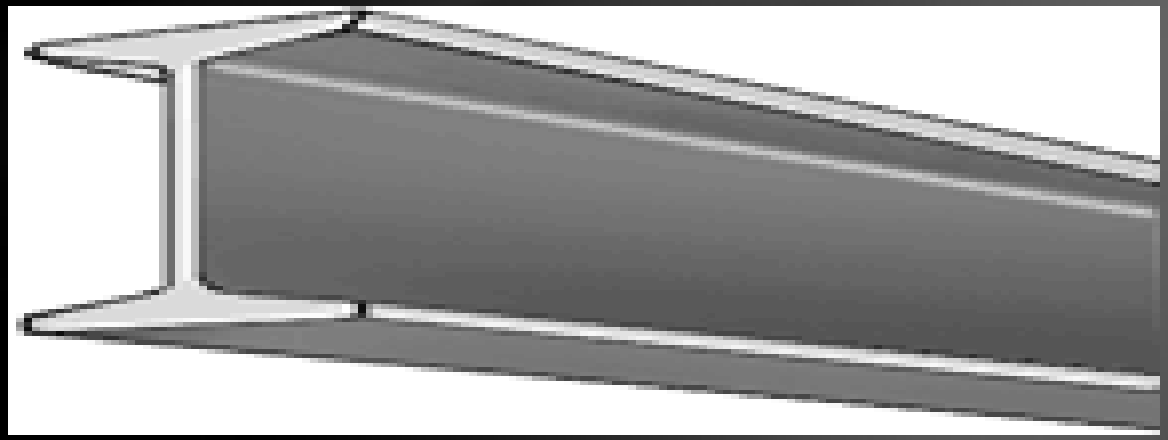




Base

Concept 1 I beam

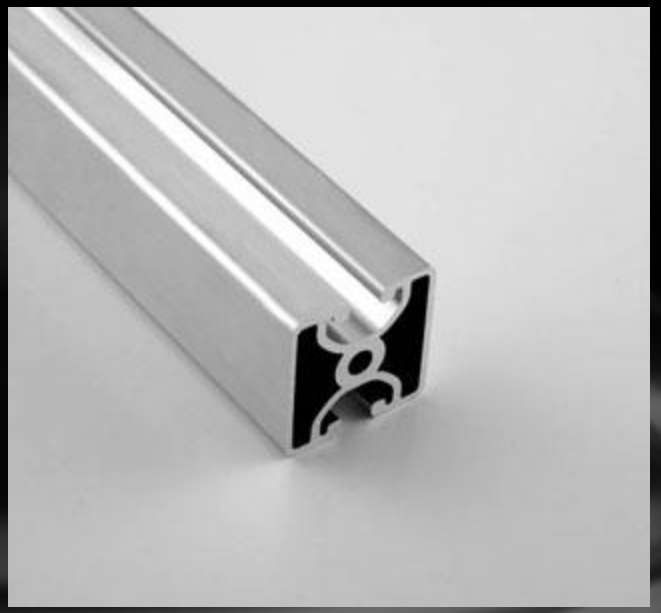
- As this is an upgrade to an existing system the existing I beam will be the most obvious choice
- I beams have been historically proven to be efficient load carrying structures
- I beams are readily available making them scalable and affordable
- I beams especially efficient against bending
- A single I beam could support all necessary systems for the SHPB experiment making the system portable.



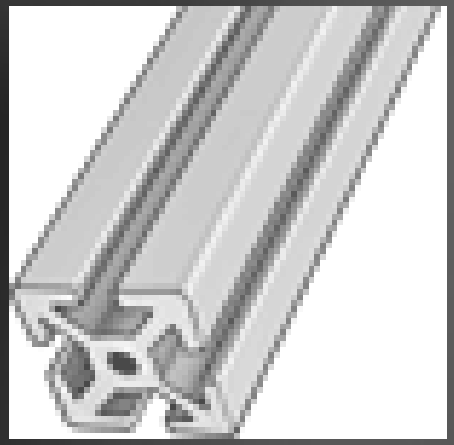
Base

Concept 2

T-Slotted Framing



- T-slotted framing is an extruded aluminum product
- It is lightweight and available in sufficient lengths making it portable
- It is also widely sold and is affordable
- However, even though it is sold in large quantities there is not a readily available large version meaning it is not scalable
- The best quality of T slotted framing is the ability of the slots to attach the framing to the grounded object and each part of the system
- It is inherently not as strong as an I beam as it is made of aluminum, and has a size limit of 1.5 inches

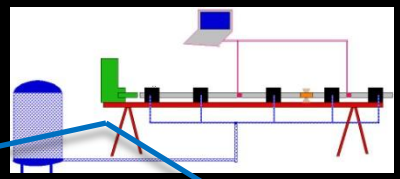


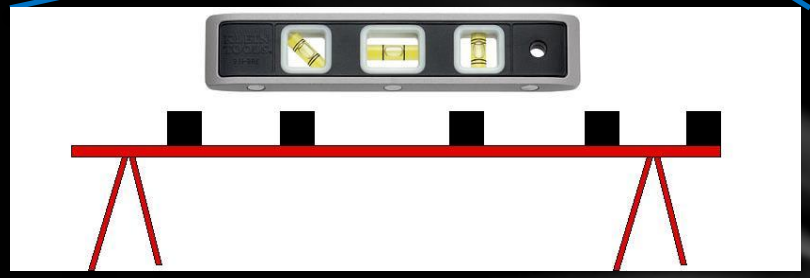
Base

Concept 3 Wood Frame

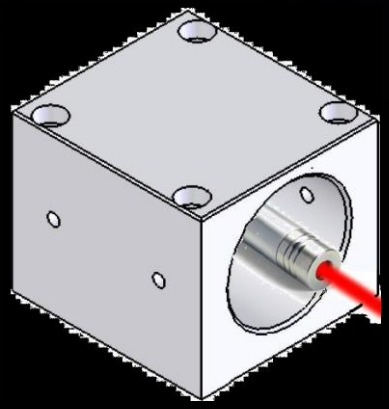
- Wood Framing is the most widely used engineering material
- The low cost of wood makes it very affordable
- Wood is also easily worked making it customizable
- Wood is light weight and cheaply bought in long sections, making it portable and scalable
- Wood is prone to warping making it very difficult to use as an alignment structure

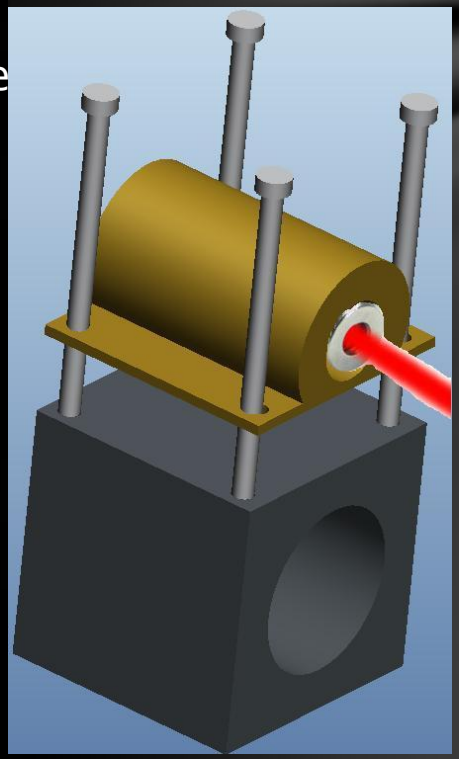
Bearing Alignment





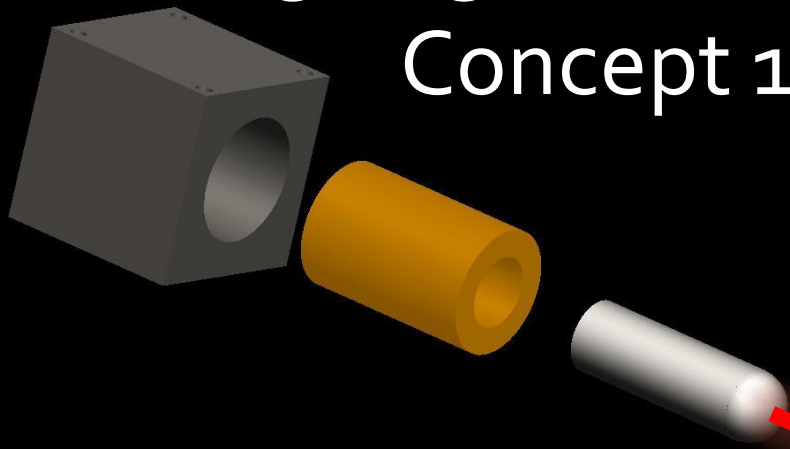
- Bearing alignment key to project success
- Proper bearing alignment is needed for any decrease in friction to be maintained
- Properly aligned bars will also extend the life of the bearings
- Misalignment will give false data due to friction





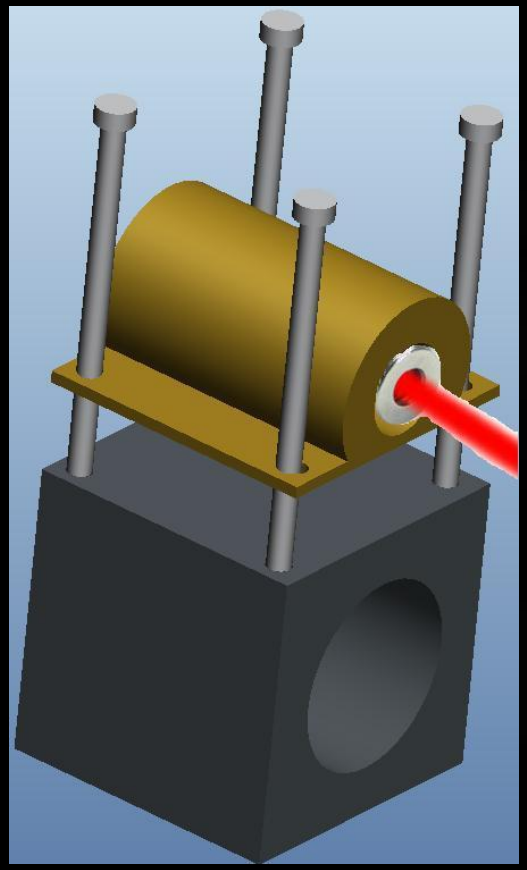
Bearing Alignment

Concept 1 Center Bore Alignment



- Precision machined insert
  - Allows for easy insertion
  - Tightly constrains the laser
  - Uses exact center of bore giving advantage over exterior mount
  - Could damage porous material
  - May become lodged inside of bearing
  - Insert thickness has a maximum ~ 0.13 in
- High precision laser bore alignment will be accurate to far beyond AFRL needs
- Quickly transferable from bearing to bearing

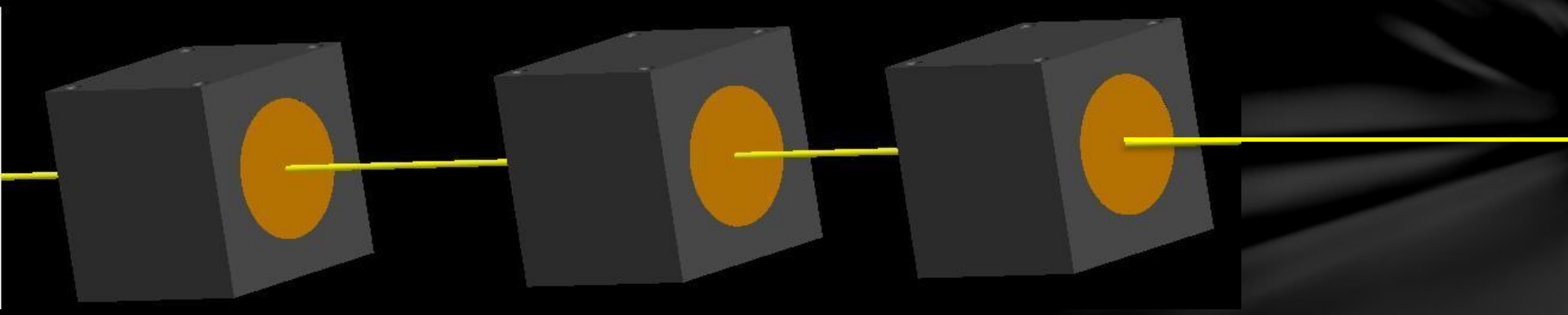
Bearing Alignment
Concept 2 Exterior Mount Alignment



- Precision machined attachment
  - Allows for exact alignment
  - Tightly constrains the laser
  - Easier to machine than the center bore alignment design
  - No potential for damage
- High precision laser bore alignment will be accurate to far beyond AFRL needs
- Easily transferable from bearing to bearing

Bearing Alignment

Concept 3 Tensioned Cable Alignment



- Precision inserts allow for
  - Automatically aligning bearings
  - One time alignment for all bearings
  - Could damage porous material
  - May become lodged in material
- Cable setup is more affordable than a laser system

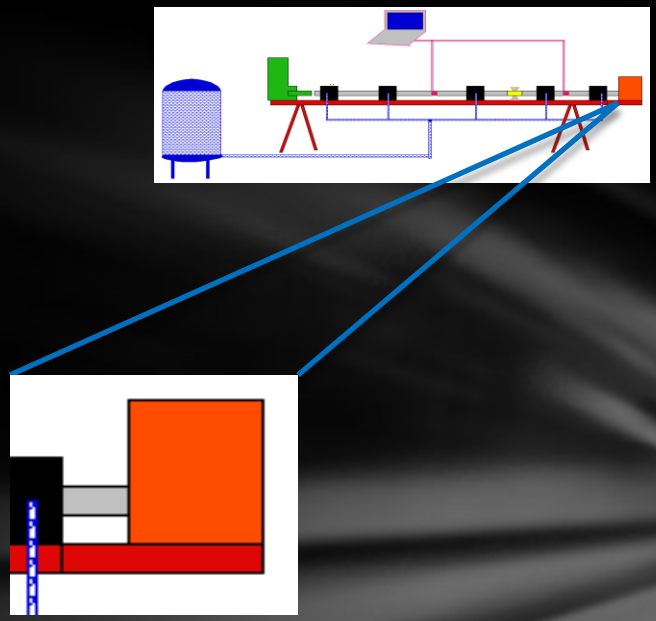
Momentum Trap

Absorbs transmitted wave

Reduces shock to system

Requirements

- Low cost
- Easily acquired materials



Momentum Trap

Concept 1: Shock Absorber

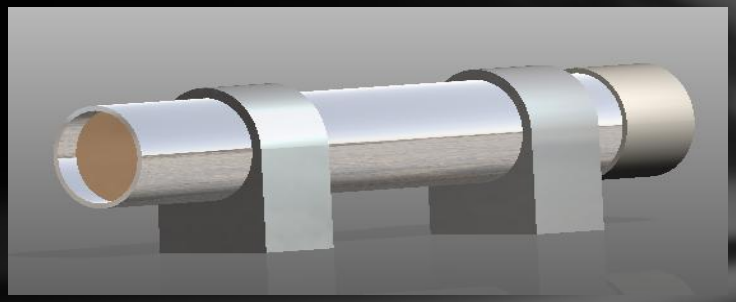
- Design
  - Piston and Spring as shown
- Available online
- Price
  - May be drawback
- Rebound
  - May not be applicable

Shock Absorber

Momentum Trap

Concept 2: Custom Impact Bumper

- Design
  - Tube and supports
- Fill with shock absorbing materials
  - Soft foam rubber
  - Polyurethane



Custom Impact Bumper

Concept 3: Manufactured Bumper

- Design
  - Pre-built impact absorber / bumper
- Many different styles
- Available online
- Relatively low cost

Pre-Manufactured Bumpers

Strain Gauges

Provide stress pulse detection

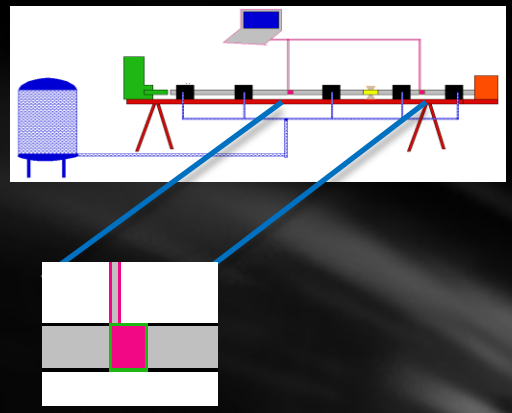
Convert ε into a readable measurement

SHPB experiment

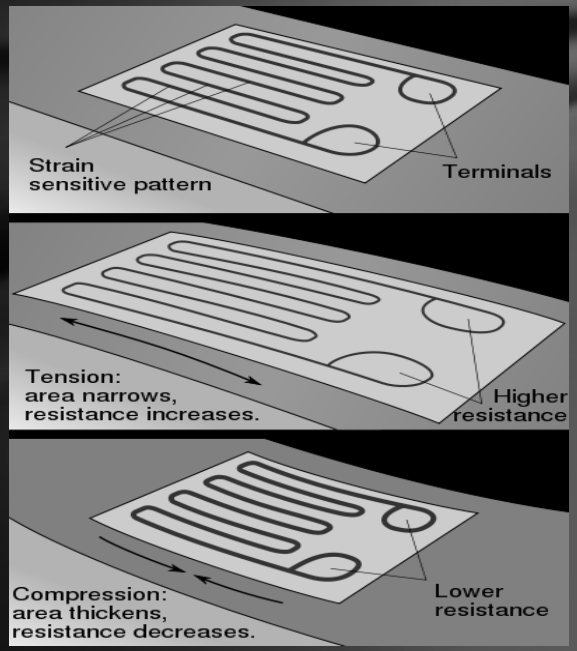
- High Strain Rates
- Approximately 1 millisecond test duration

Option 1: Resistance Based Strain Gauges

- Strain Sensitive Geometry
- Durable
- Relatively low cost



Strain Gauge

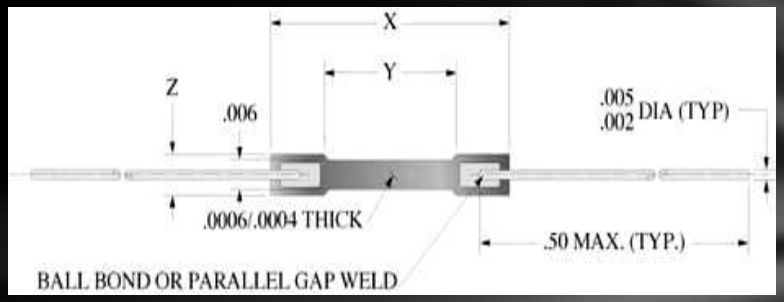


Foil Strain Gauge Mechanism

Strain Gauges

Option 2: Semiconductor Based

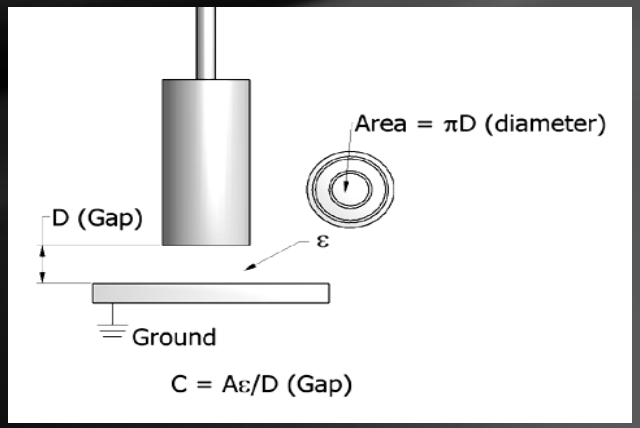
- Strain sensitive material
- Easily Damaged
- Higher cost



Semiconductor Strain Gauge

Option 3: Capacitance Based

- Strain sensitive Geometry
- Rugged
- Less common



Capacitance Strain Gauge

Final choice will depend on cost and shock durability.

Data Analysis

Software based

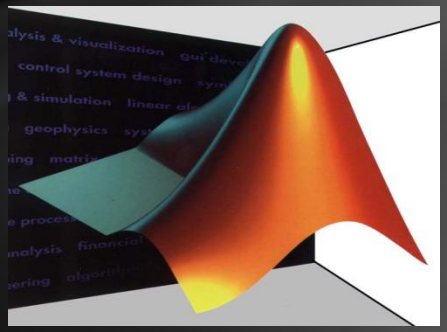
Required to record time related data

High data rates

- Waves last only milliseconds
- Requires sampling rates of 100 KHz

Option 1: LabVIEW

- User friendly interface
- Quick setup



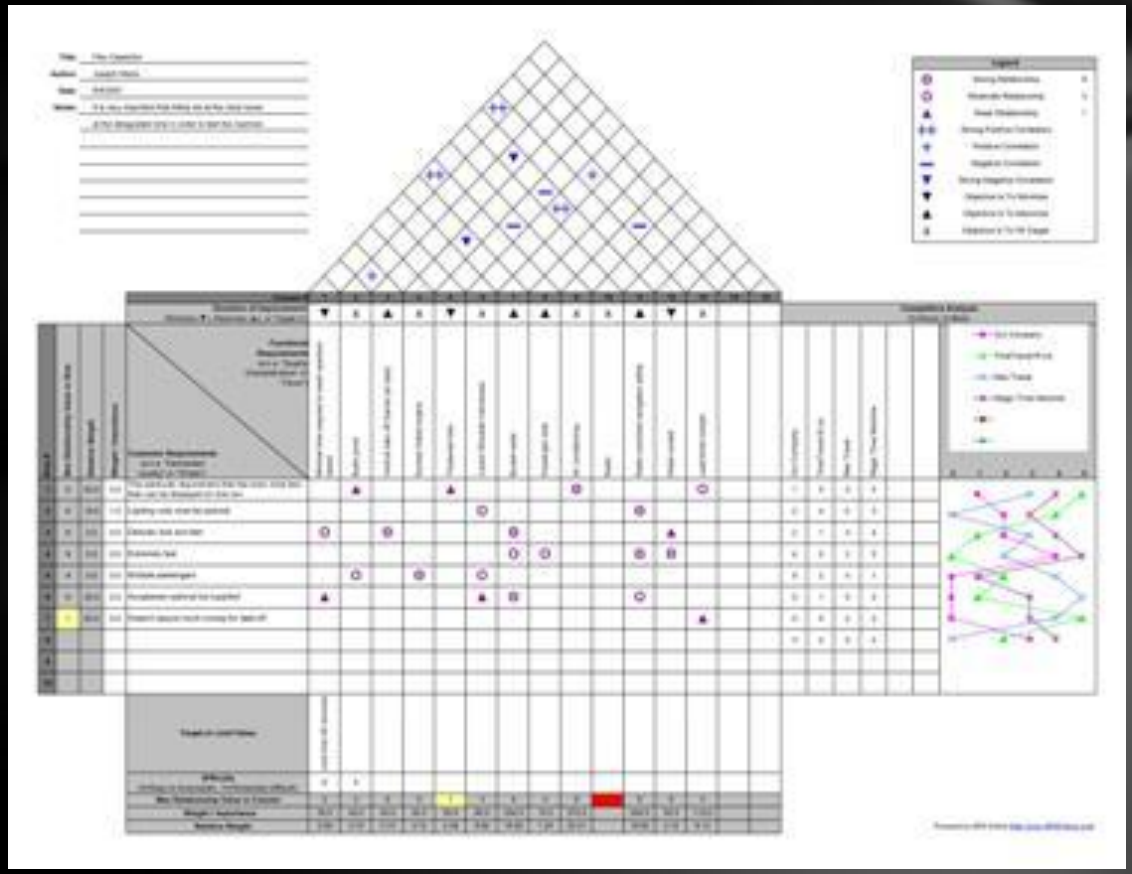
Option 2: MatLab Data Acquisition toolbox

- Powerful
- Instant Analysis

Decision Criterion

The following qualities will determine the final decision matrix. They are applied as relevant to each subsystem.

- Cost
- Weight
- Size
- Durability
- Portability
- Scalability
- Accuracy
- Data Quality
- User Interface



Questions?

Comments?

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