DIN 18032 Part II Basics: What are these Contraptions?

By

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- The following presentation was given at the 2004 MFMA Meeting in Phoenix Arizona
- Animations included in the original presentation have been deleted to reduce file size

Additional Information

- **Additional Information is available at www.asetservices.com**
  - **A supporting document DIN-001 is also available at www.asetservices.com/info_links.html**
  - **Video demonstrations are also available at www.asetservices.com/equipment.html**

Speaker Background

- **Graduated with PhD in Engineering from Purdue in 1997**
- **Worked for Robbins Sports Surfaces as research engineer until 2001**
- **Became licensed engineer in Ohio in 2002**
- **Founded ASET Services in March of 2002**

Topics

- Ball Rebound Overview and Video
- Force Reduction Overview and Video
- Vertical Deflection Overview and Video
- Area Indentation Overview and Video
- Purpose and Use In Specifications

Topics

- **Performance requirements**
- **Limitations and Alternatives**
- **If time permits**
  - **Rolling Load Overview**
  - **Surface Friction Overview**
  - **A few more video clips**

Disclaimers

- This presentation is based on the best information available at the time of development
- It represents the opinion of the author, but other interpretations may be equally valid
- Not intended as a complete review of all of the topics included in this presentation

Presentation Limits

- **Focus on Area Elastic Sports Surfaces**
  - **Point Elastic, and Combination systems have slightly different requirements**
- **Referenced foreign standards include some translations, and have been verified to the extent possible**

The MFMA and DIN

- **The MFMA's DIN Position**
  - **Accepts all parameters as desirable**
  - **Not a blanket endorsement of DIN**
    - **Some situations may be better served by floor systems that fail to meet some or even all of the parameters of the DIN standard**

Overview of DIN 18032 Part II

- **1965**
  - **First edition of 18032**
  - **No floor testing section**
- **1975**
  - **First requirements were set**
    - **But equipment was quite different than today**
- **1978**
  - **Force reduction was standardized**

Overview of DIN 18032 Part II

- **1986**
  - **DIN complete 18032-2 issued**
- **Since 1986**
  - **Changes and clarifications have been made**
  - **But test methods have remained similar throughout the revisions**

Overview of DIN 18032 Part II

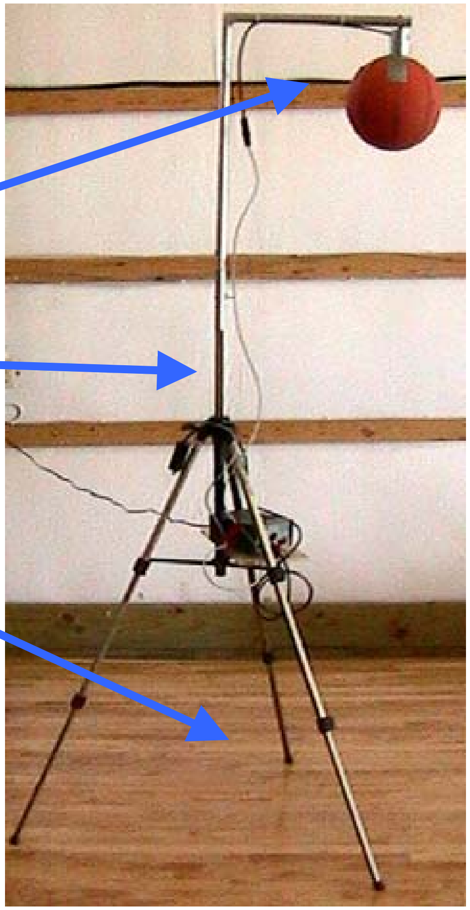
- **Provides a method of quantitatively comparing sports surfaces**
- **Establishes performance requirements to ensure that each community is getting a sports surface of similar quality**

Ball Rebound – DIN

- **Provides an indication of the ‘playability’ of the sports surface**
- **Measures how well the ball rebounds off of the sports surface compared to a rebound on a concrete**

Ball Rebound – DIN

- **What does it look like?**
  - **Typical features**
    - **Mechanical Release**
    - **Adjustable height**
    - **Stable Base**



Ball Rebound – DIN

- **Mechanical Release**
  - **Drops without spin**
  - **Improves repeatability**
  - **Magnetic, Mechanical (hook), or Vacuum**

Ball Rebound – DIN

- How is the height measured?
  - Most common method is acoustical determination of impact times
    - Find the time between the 1st and the 2nd impacts (Δt)
    - Using physics and the time between impact the height can be calculated

$$H(m) = \frac{9.81}{8}(\Delta t)^2 + .245$$

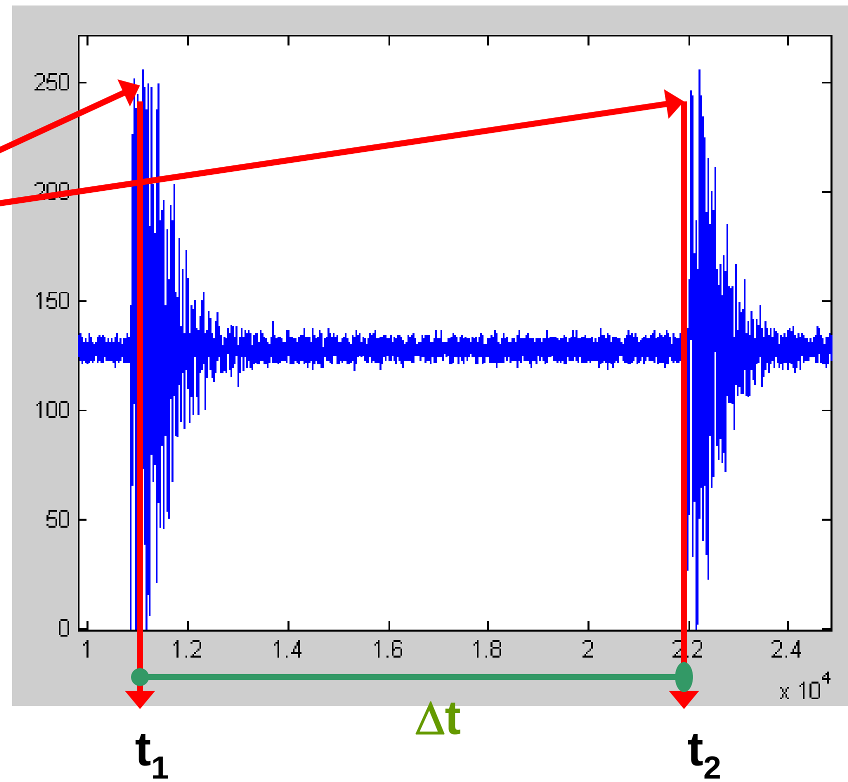
Ball Rebound – DIN

- **Sound Graphs**
  - **Raw Sound**

Looking for maximum points

The time when the maximum sound values occur yields Δt

$$H(m) = \frac{9.81}{8}(\Delta t)^2 + .245$$



Ball Rebound – DIN

- **Equation Used To Calculate**

$$BR = \left(\frac{H_{floor}}{H_{con}} \right) 100$$

Example

$$BR = \frac{1.35m}{1.48m} 100 = \frac{4.45\,ft}{4.88\,ft} 100 = 91\%$$

Force Reduction – DIN

- **Provides an indication of the ‘resilience’ or ‘cushioning’ of the sports surface**
- **Impact duration is approximately 20 ms (0.02 sec)**
  - **Compares to the ‘passive’ peak during landing where peak force occurs approximately ~ 10 ms after contact**
    - **Called passive because the body can not actively respond to the input in this time**

Force Reduction– DIN

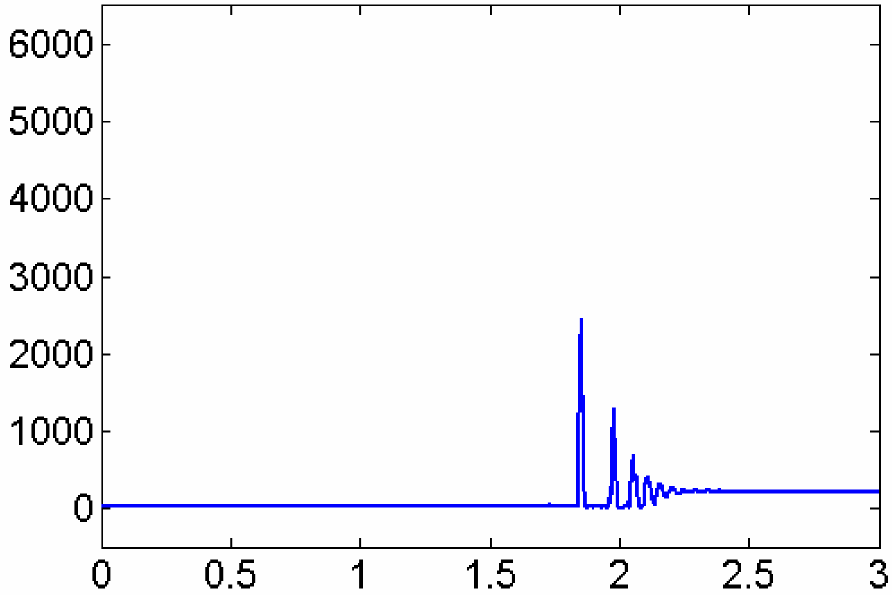
- Force reduction is represents the degree to which the sports surface reduces impact forces produced on a ‘rigid surface’
  - A rigid surface is defined in the standard as a 10 mm (~7/16 in) thick steel plate attached to a 200 mm (~8 in) thick concrete slab
    - Because of this definition, the baseline cannot be determined onsite
    - Concrete often has a force reduction of 1 to 2%

Force Reduction– DIN

- **Test Overview**
  - **A 20 kg (44 lbs) drop mass is dropped from a height of 55 mm (~2-1/8 in)**
  - **Weight impacts a 2000 N/mm (11,420 lb/in) spring**
  - **Impact force is measured directly using a load cell**

Force Reduction– DIN

- Sports surface
  - Weight "impacts" surface ~3 times



Force Reduction – DIN

- **Equation Used To Calculate**

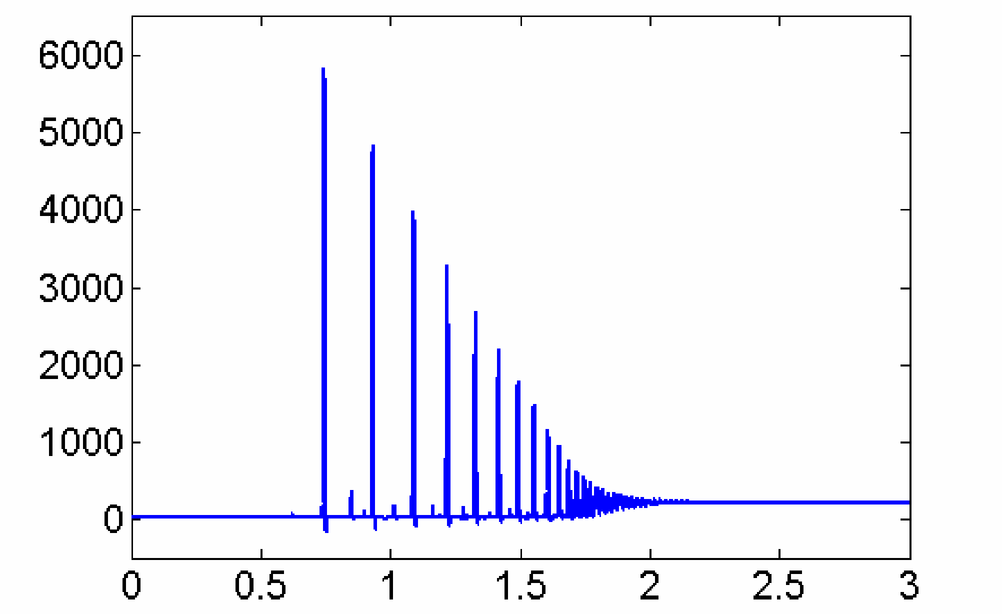
$$FR(\%) = \left(1 - \left(\frac{F_{floor}}{F_{rigid}}\right)\right)100$$

Example

$$FR = \left(1 - \left(\frac{500lbs}{1500lbs}\right)\right)100 = 66\%$$

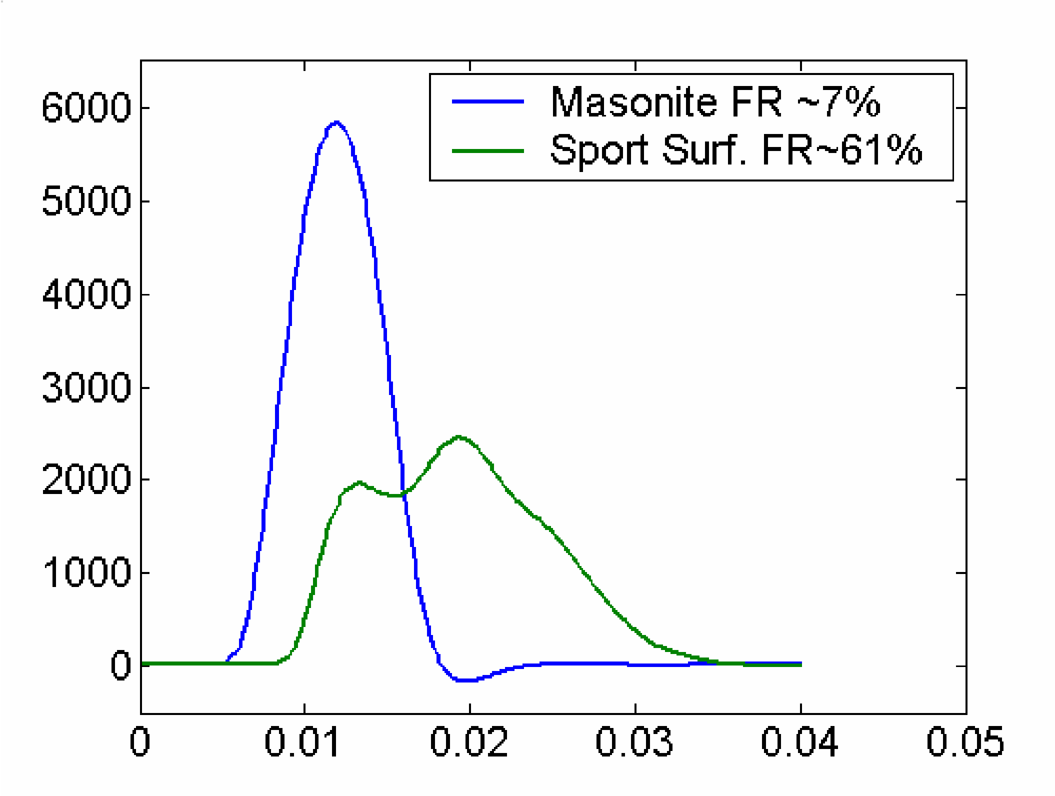
Force Reduction– DIN

- **Masonite**
  - **Weight "impacts" ~ 10 times**



Force Reduction– DIN

- **Impact Force Curves**



Vertical Deflection – DIN

- Provides an indication of how much the floor can move
- The impact simulates a running stride, or the active phase of a landing
- The result indicates how much the floor would be expected to deflect under a 1500 N (336 lbs) load

Vertical Deflection– DIN

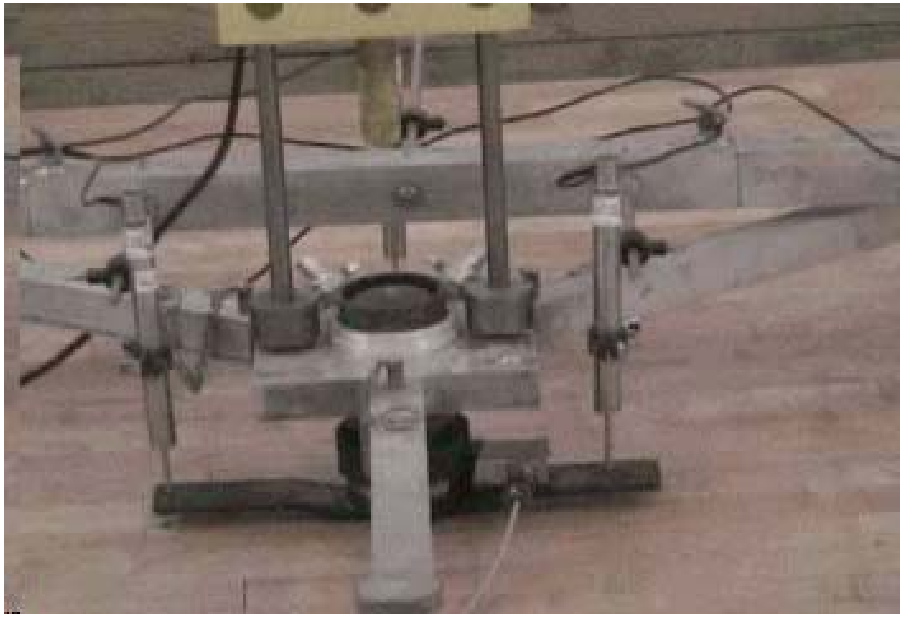
- Requires the measurement of the force generated during impact (F_{def})
- Requires the measurement of the deflection at the point of impact (d_0)

Vertical Deflection– DIN

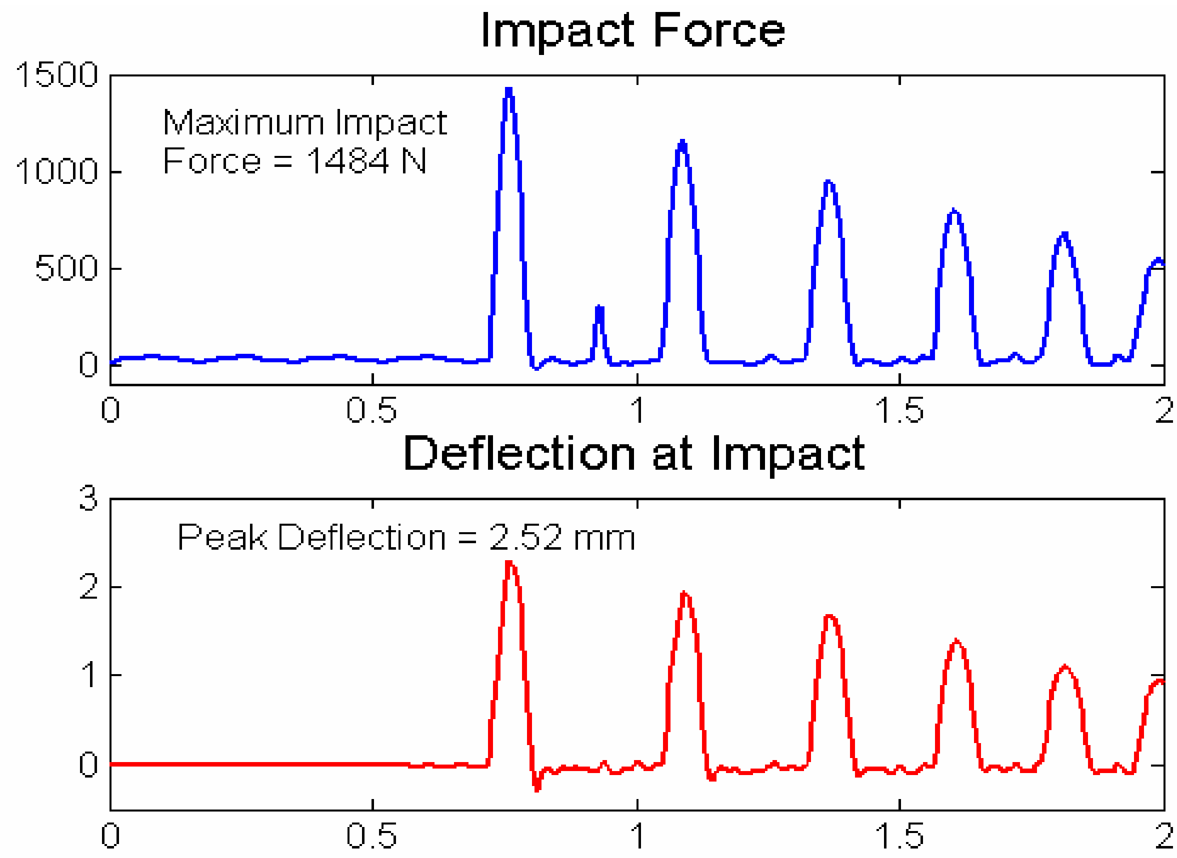
- **Test Overview**
  - **A 20 kg (44 lbs) drop mass is dropped from a height of 120 mm (~4-3/4 in)**
  - **Weight impacts a 40 N/mm (230 lb/in) spring**
  - **Impact force is measured directly using a load-load cell**
  - **The Deflection at impact is measured using LVDT’s (Linear Velocity-Displacement Transducers)**

Vertical Deflection– DIN

- **In action**



Vertical Deflection– DIN



Vertical Deflection– DIN

- **Equation used to calculate**

$$StVv(mm) = \left(\frac{d_{\max}}{F_{def}}\right)1500 = \left(\frac{1}{k}\right)1500$$

Example

$$StVv = \left(\frac{2.52mm}{1484}\right)1500 = 2.55mm$$

Area Indentation – DIN

- Provides an Indication of what?
  - How much mass is put in motion?
    - Somewhat, but not universal
  - How well vibrations are transmitted through the floor
    - Very much related to ‘damping’ properties of the system
- Uses the same test setup as Vertical Deflection

Area Indentation– DIN

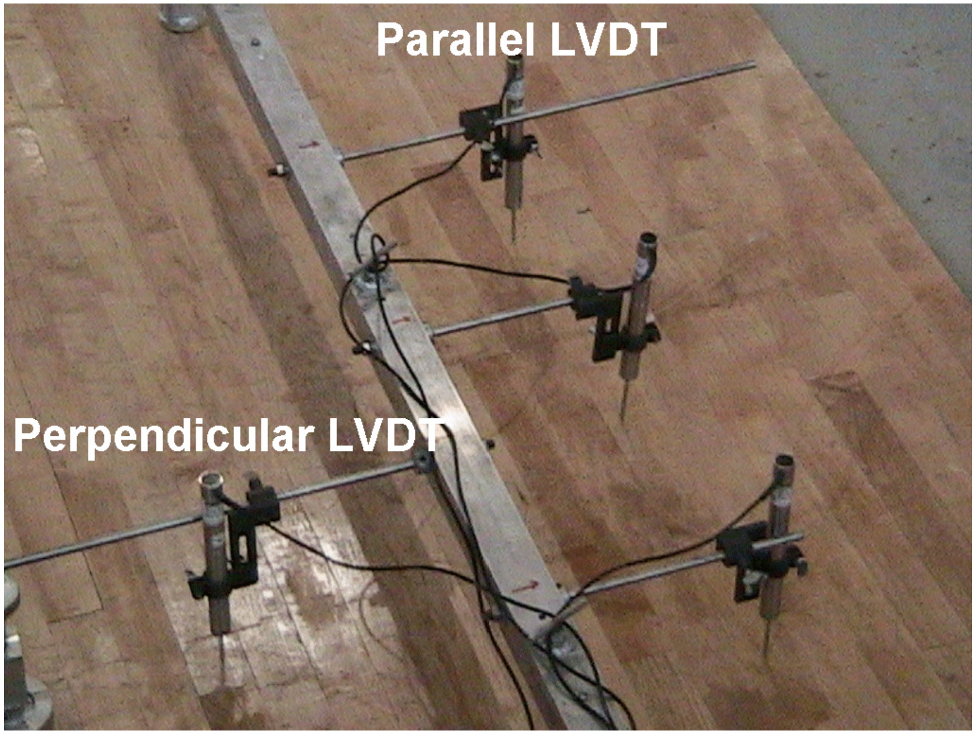
- **Reports the amount of deflection that occurs 500 mm (~20 inches) from the point of impact as a % of the vertical deflection**
  - **Requires vertical deflection (*StVv*)**
  - **Requires deflection Parallel to the maple 500 mm from the impact point (f_{para})**
  - **Requires deflection Perpendicular to the maple 500 mm from the impact point (f_{perp})**

Area Indentation– DIN

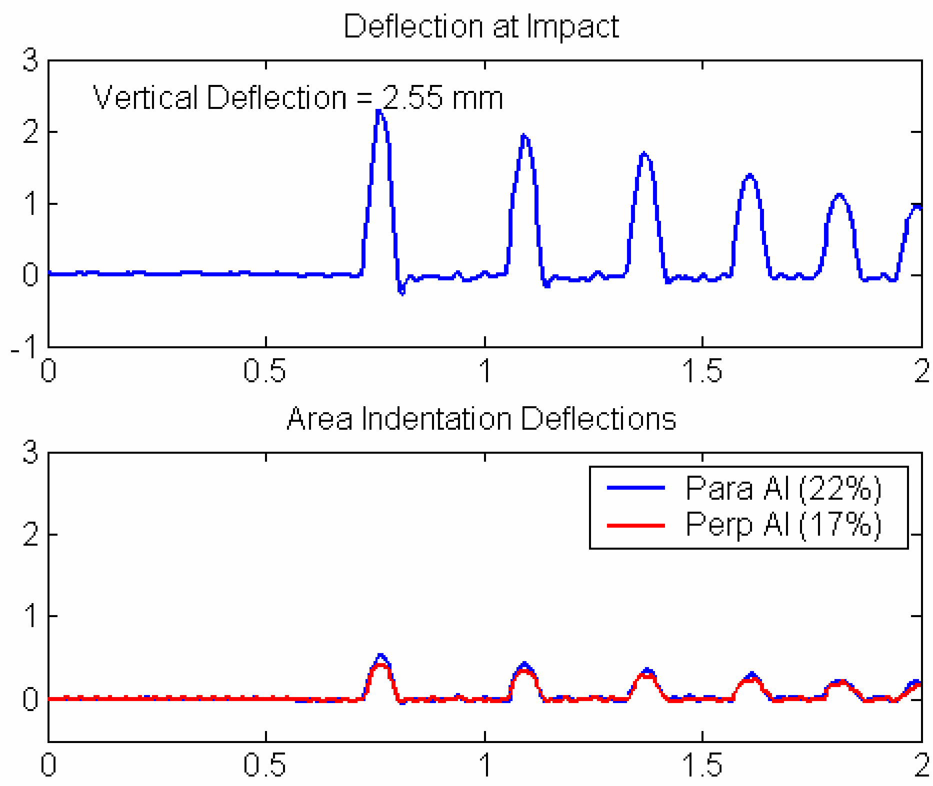
- **Test Overview**
  - **The vertical deflection for the point or drop is calculated**
  - **The maximum deflections 500 mm from the impact parallel and perpendicular to the maple are measured using an LVDT**
  - **These values are then used to compute the Area Indentation**

Area Indentation– DIN

- **Components**



Area Indentation– DIN



Area Indentation– DIN

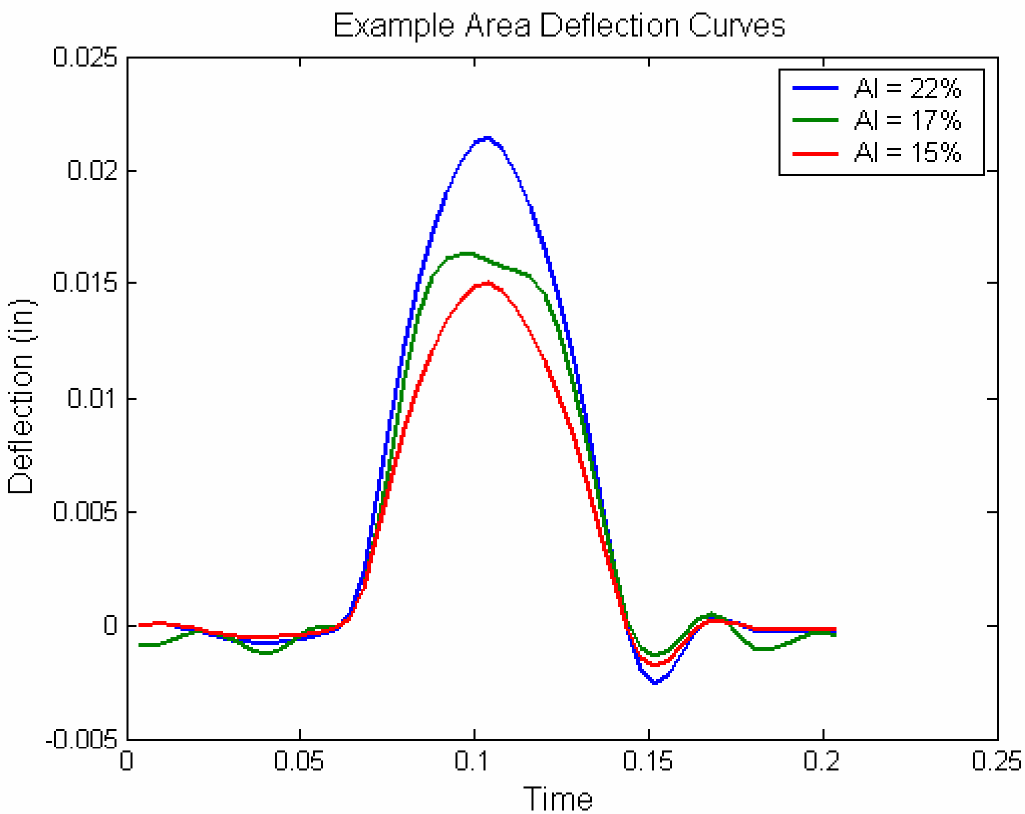
- **Equation used to calculate**

$$\overline{AI}(\%) = \left(\frac{f_{perp} + f_{para}}{2 * StVv} \right) 100$$

Example

$$\overline{AI}(\%) = \left(\frac{0.256mm + 0.456mm}{2 * 2.54mm} \right) 100 = \left(\frac{0.356mm}{2.54mm} \right) 100 = 14\%$$

Area Indentation– DIN



Requirements

- **Ball Rebound**
  - **Greater than 90%**
- **Force Reduction**
  - **Greater than 53%**
- **Vertical Deflection**
  - **Greater than 2.3 mm (0.09 inches)**
- **Area Indentation**
  - **Less than 15%**

Purpose and Use

- **Ensure that all facilities in Germany have sports halls that meet minimum requirements**
  - **Suitability testing is mandatory**
  - **Field test certification more common than not**

Purpose and Use

- North America Is Not Germany
  - North American DIN Realities
    - Suitability Testing is Voluntary
    - Field certification is rare
    - Results are primarily a marketing tool
      - DIN Certified
      - DIN Rated
      - DIN Tested
    - The MFMA could serve a valuable roll by developing definitions

Purpose and Use

- **Are all DIN floors equivalent?**
  - **Section 4.1.3 “A careful consideration of the priorities of the hall is necessary to decide which construction will meet best the requirements in individual use”**
    - **Within Germany all DIN floors are not considered equal in all facilities**

Purpose and Use

- **Using results in job specifications**
  - **Specifying more stringent performance levels in key areas ok**
    - **Examples:**
      - **Greater than 95% ball rebound**
      - **Greater than 60% force reduction**

Purpose and Use

- Over specification may be problematic
  - Example:
    - 95% ball rebound
    - 61% force reduction
    - 2.6 mm vertical deflection
    - 12% Area Indentation
- Possible problems
  - Setting the owners expectations too high
  - Limiting the field-tested performance that would be accepted

Limitations and Alternatives

- **There are some significant limitations in the standards discussed so far**
- **Often there are alternative tests or views that might be of interest**

Limitation

- DIN Ball Rebound field testing for dead-spots
  - Have to test concrete on-site
    - Not always possible
  - Can only reference concrete

Alternative

- ASTM F-2117 Ball Rebound test
  - Allows any reference surface
    - Can use owner selected reference points to as baseline
      - Measure problem points and random points
      - Look for deviations in results

Alternative

- ASTM F-2117 – Continued
  - Advantages
    - Allows comparison to the rest of the floor not to concrete
  - Disadvantage
    - Not as widely known in the industry

Limitation

- **Area Indentation Examples**

Example 1

$$\overline{AI}(\%) = \left(\frac{0.256mm + 0.456mm}{2 * 2.54mm} \right) 100 = \left(\frac{0.356mm}{2.54mm} \right) 100 = 14\%$$

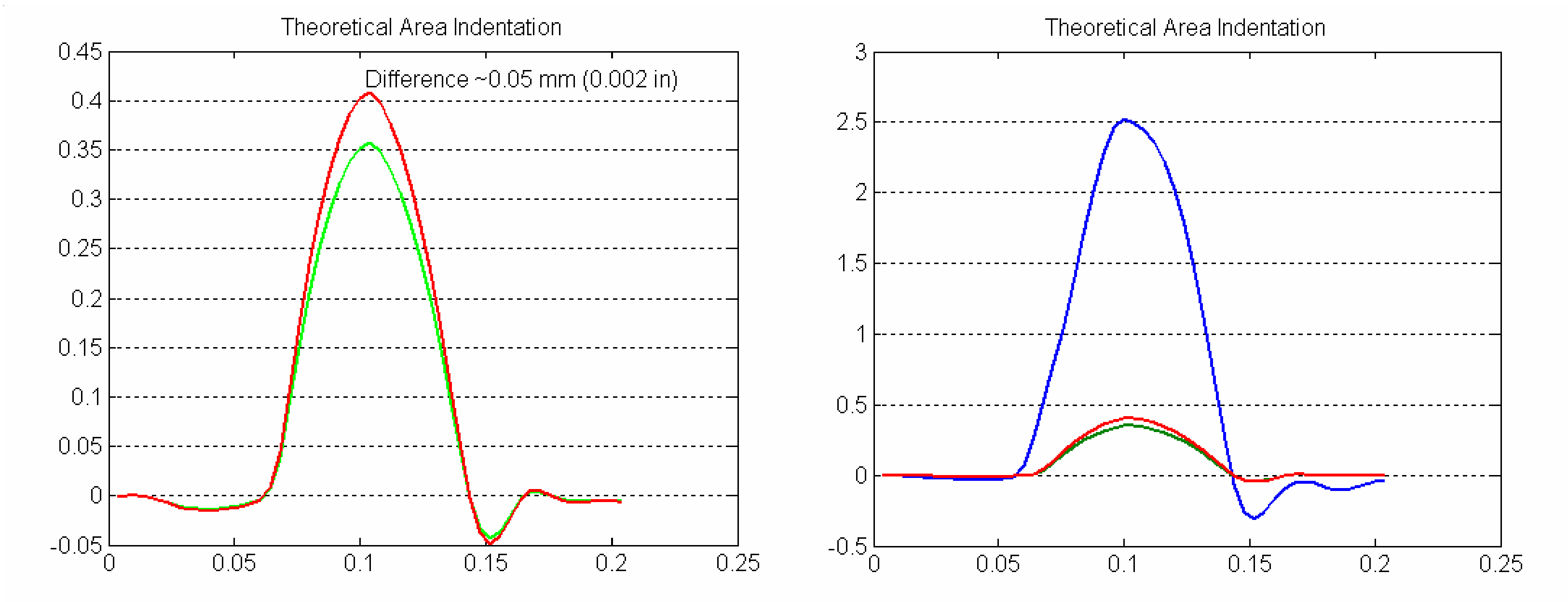
Example 2

$$\overline{AI}(\%) = \left(\frac{0.356mm + 0.456mm}{2 * 2.54mm} \right) 100 = \left(\frac{0.406mm}{2.54mm} \right) 100 = 16\%$$

Limitation

- Area Indentation
  - How much difference between pass and fail in the previous slide
    - 0.05 mm (0.002 inches)
    - Difference between passing and failing can be as small as 0.025 mm or 0.001 inches

Limitation



Theoretical Area Indentation
Difference ~0.05 mm (0.002 in)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0
0.05
0.1
0.15
0.2
0.25
Theoretical Area Indentation
3
2.5
2
1.5
1
0.5
0
-0.5
0
0.05
0.1
0.15
0.2
0.25

Alternatives

- **Allow Area Indentations up to 20%**
  - **Norway, Austria**
- **Do not measure Area Indentation**
  - **Czech Republic, Great Britain, France**
    - **GB & France adopted standards very different from DIN-18032 Part II**

Questions

- **If you're looking for more information on this topic, visit**

www.asetservices.com

Thanks

- Dan Heney for technical information
- Hans Knauf for some historic information on the development of the standard
- To the MFMA for inviting me
- To you for your attention