



Instituut voor Sportaccommodaties



# Multiturf Design Tool

## Prediction of sports surface characteristics

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ISA Sport

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Multiturf Design tool


**Introduction**

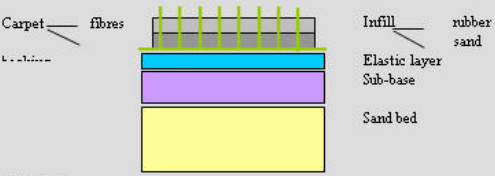
[Info AA test](#) [Info HIC test](#) [To Step 1](#)

Within the European project Multiturf a design tool has been developed for the prediction of some important properties of 3rd generation artificial turf fields based on standard test methods.










With this design tool it is possible to predict :

- force reduction
- energy restitution
- deformation
- ball bounce
- HIC (Head Injury Criterion) (NEN-EN 1177)
- an indication of the risk on injuries

Carpet fibres



*Note: The predictions made with this tool are model calculations. Therefore predictions will not exactly correspond to measurements and can thus not be used in stead of measurements.  
TNO cannot be kept responsible for decisions based on the predictions.*

The Multiturf project (contract COOP-CT-2005-016456) is sponsored by the 6th framework program of the European Commission.





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# Multiturf

## Purpose:

- Improvement of artificial turf fields / materials
- Based on biomechanics
- Prediction tool

## Partners:

- Research: TNO, IBV, ISA-Sport
- Industry: Saltex Oy, Arcadis, Edel Grass, Poligras, Ten Cate, Recipneu

## Results:

- Multi-sports, multi-purpose systems
- Design tool

# Multiturf Design Tool

To develop a design tool which can predict:

- sport technical properties of an artificial turf field
- the effect of a field on the human body concerning injuries

The resulting tool can be used to

- predict whether a field will fulfil certain standards
- design a field
- calculate indications of the risk on injuries,
- without the need of doing a lot of tests.
- calculation of costs



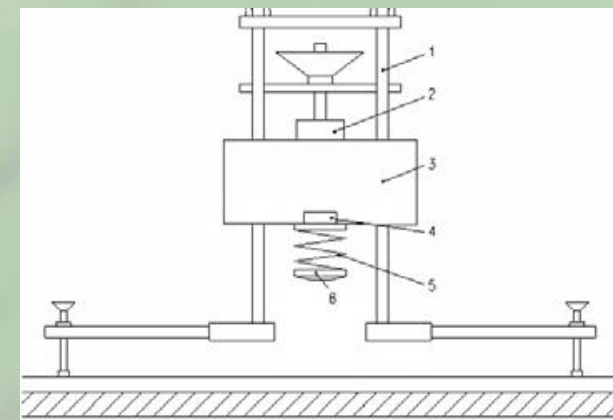
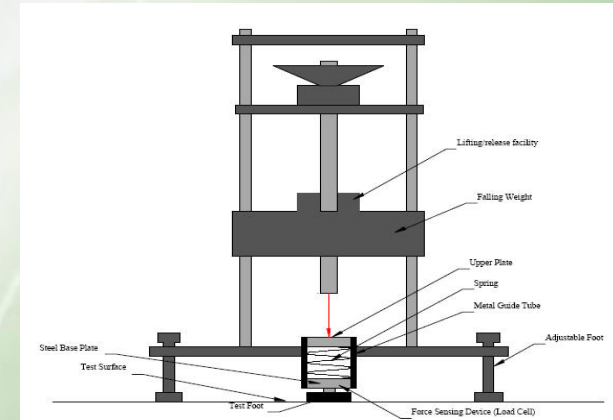
# Mechanical part

Prediction of sport technical performance:

- Artificial athlete and Triple A, 1<sup>st</sup> and 2<sup>nd</sup> + 3<sup>rd</sup> impact, also children
  - Force reduction
  - Energy restitution
  - Vertical deformation
- HIC value
- Ball bounce

In addition to this:

- Compaction of rubber
- Friction for human modelling
- Cost calculation

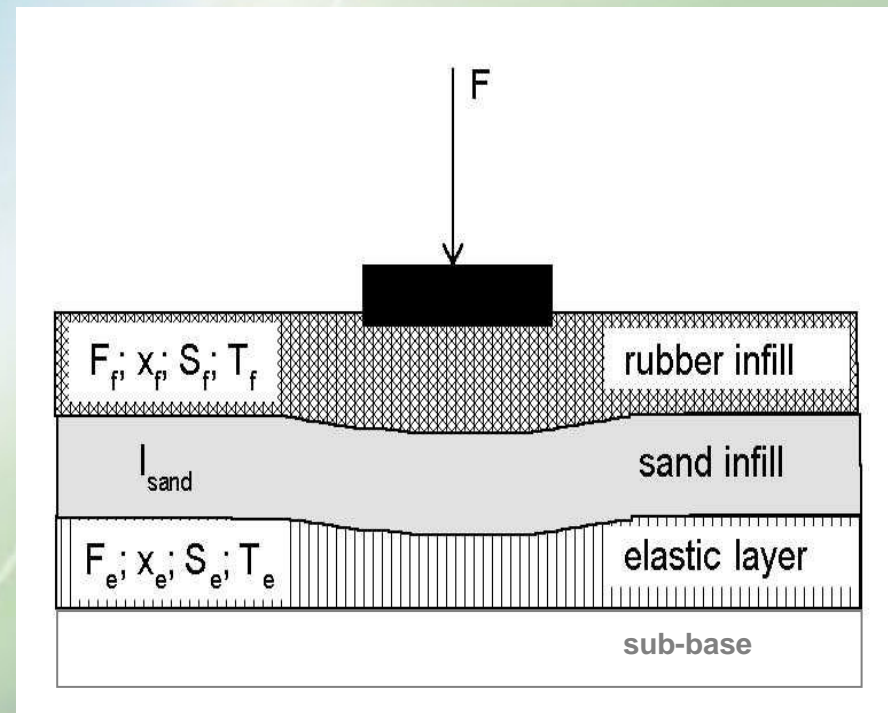


# Modelling of properties

- Modeling all layers of the field
- Including the fibers
- Rigid sand (only passes stress)

But:

- Tests vary due to circumstances
- Tool based on a model of reality



# Physical properties

Force and displacement depending of:

- Damping, viscosity, Elasticity, Density, Stiffness
- Mass / Spring / Height
- Shape of head (HIC / Athlete)
- Multilayer

Childrens AA (IBV):

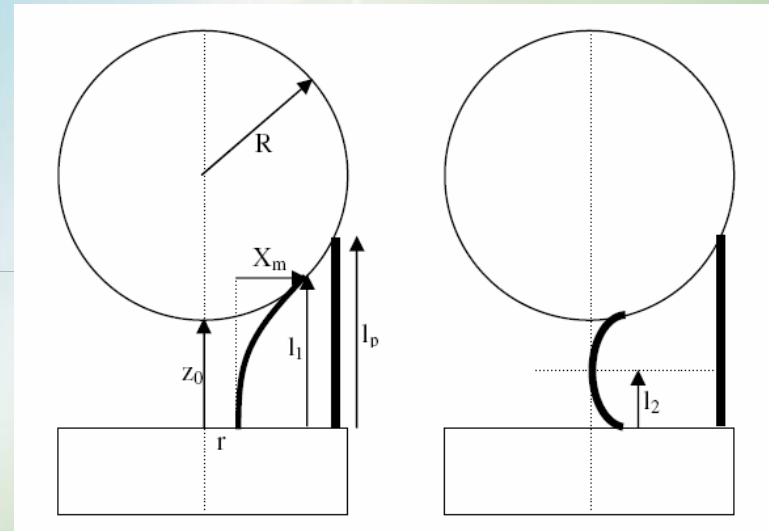
- Drop height 15 mm i.t.o. 55mm
- Weight 10 kg i.t.o. 20 kg.



# Physical properties

## Ball Bounce:

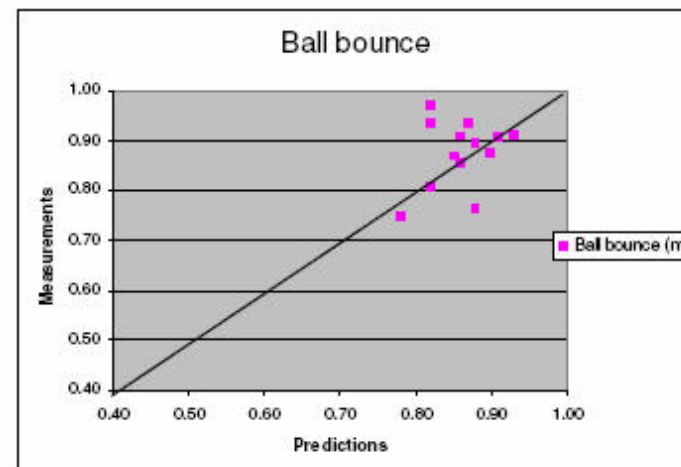
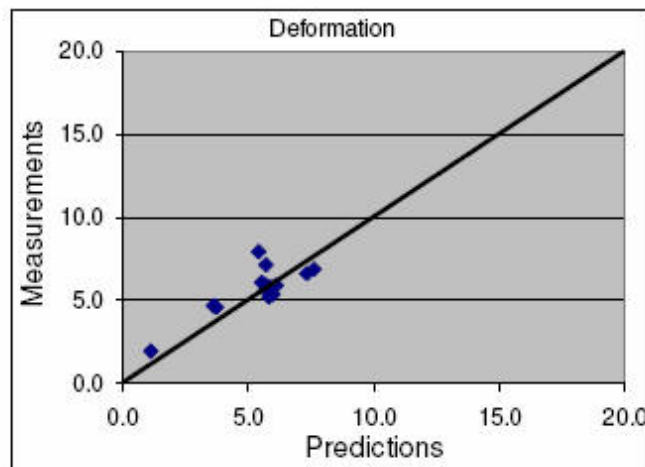
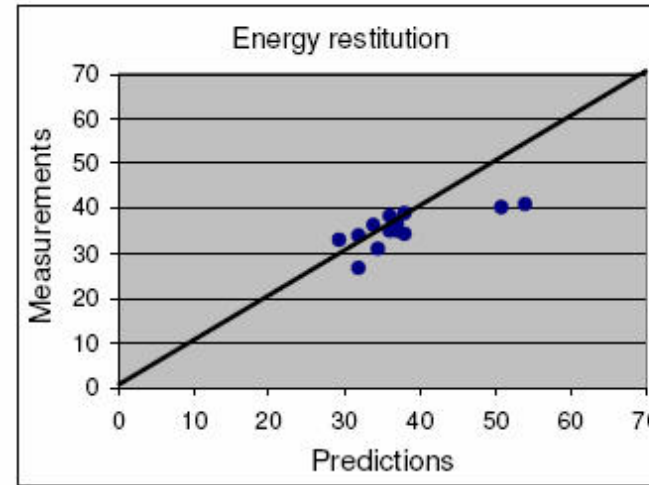
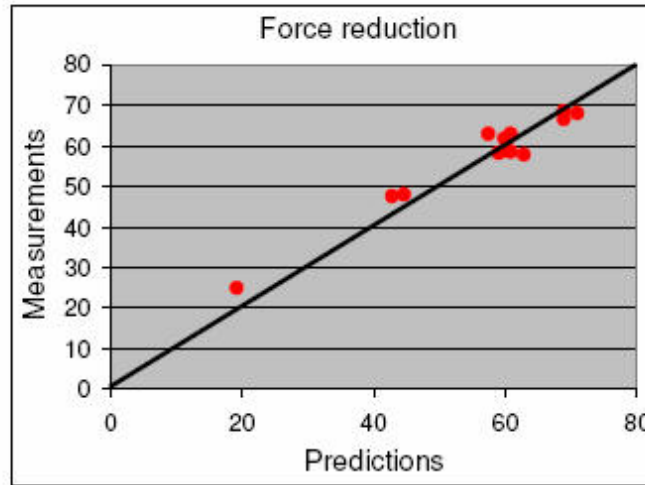
- Ball Properties
- Field Properties
- Pile bending in slip mode
- Pile bending in stick mode.



## Traction:

- Height of stud
- Diameter of stud
- Density and volume fraction of the rubber
- Compression stress applied
- Friction coefficient (also shape and size of particles)

# Verification (IBV and ISA)



# Add new materials

Insert new material and properties  
to the material database in the  
tool

Pile yarn: to be added by Thiolon /  
TNO

Rubber infill:

- E-modulus of solid rubber
- $\tan \delta$  of solid rubber
- density of solid rubber

E-layer or shock pad:

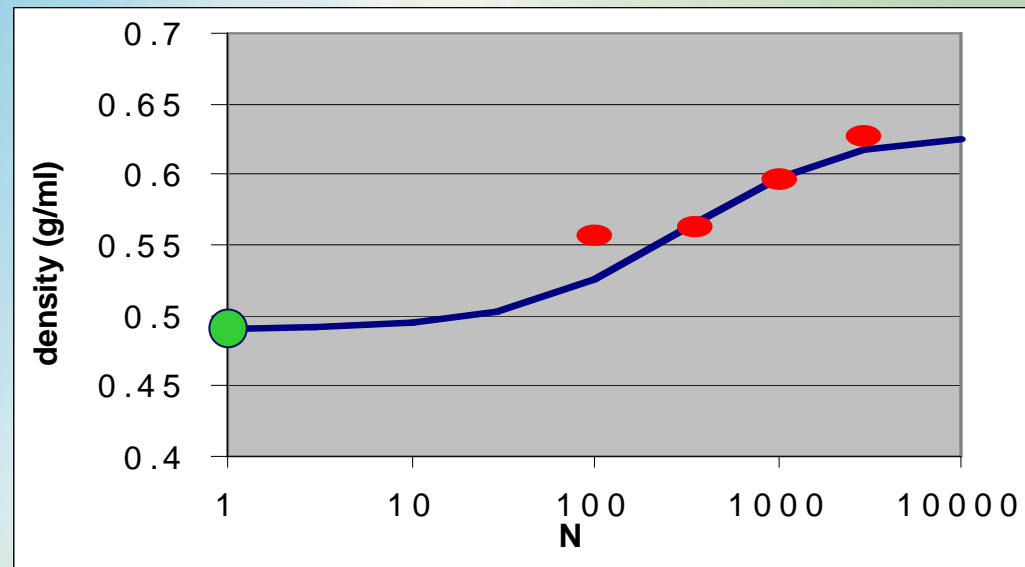
- E-modulus of e-layer or  
shock pad
- $\tan \delta$  of e-layer or shock pad

# Sensitivity analysis

- Type of yarn: small influence
- Pile height: influence on ball bounce
- Stitch rate: influence on FR and ball bounce
- Sand infill: some influence on ball bounce
- Rubber infill: large influence on all properties
- Children: experience higher SA and lower ER
- Avoid extreme systems !

# Compaction of rubber

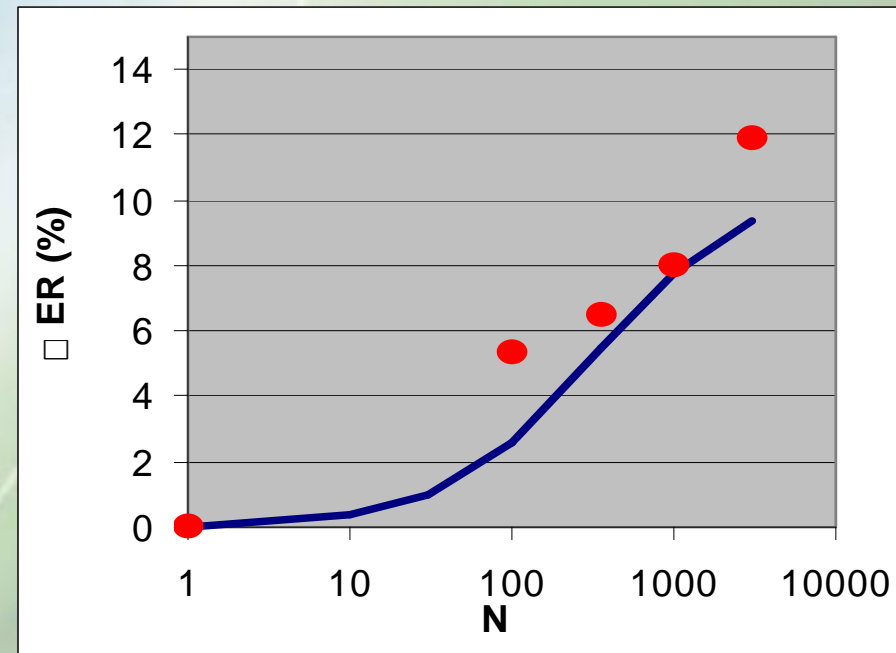
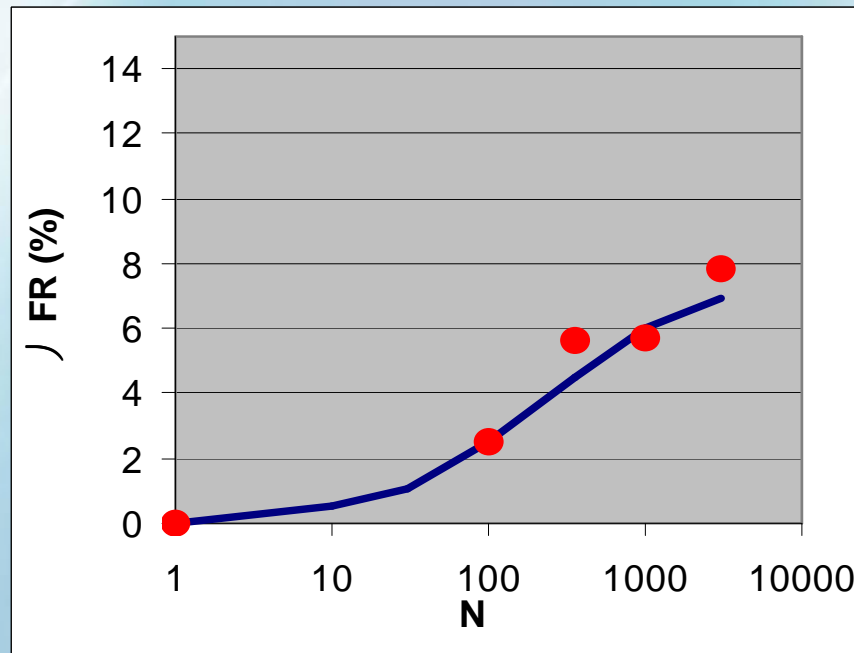
Density of infill increases upon repeated loading



Verified with Lisport and destructor  
Degradation not taken into account

# Compaction of rubber: FR & ER

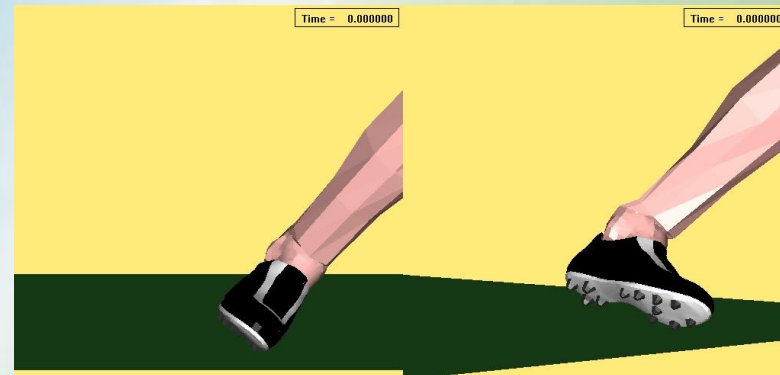
- Change in FR & ER during compaction are well predicted using Design Tool



# Prediction on movements

Depending of:

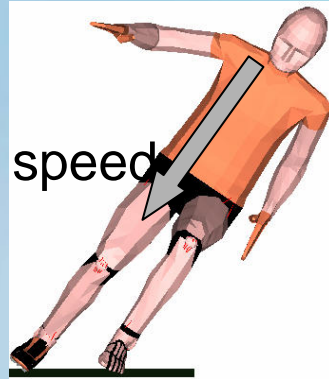
- Artificial turf:
  - Friction
  - Compression stiffness
- Shoe:
  - Varying stud length
  - Number of studs
- Relations between fields / shoes / movement and rotation of ankle / forces in ligaments / tibia and injury risks are calculated separately
- Just an indication! (individuals are individuals)



# Simulation Set-ups

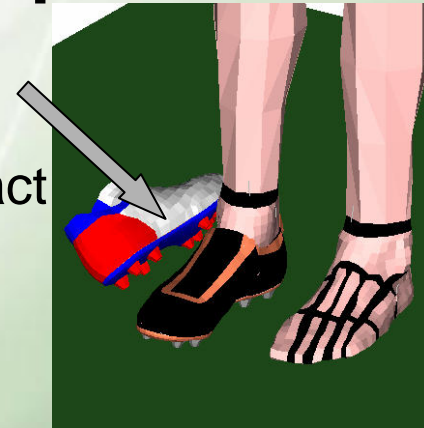
180 deg turn

3-4.5 m/s impact speed  
45° direction



Tackle

3-9 m/s contact speed



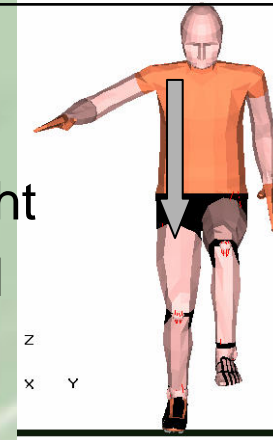
Turn

2 Phi turn velocity

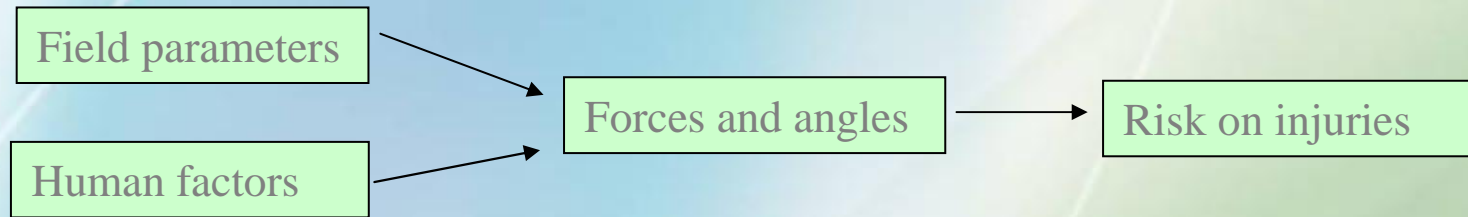


Landing

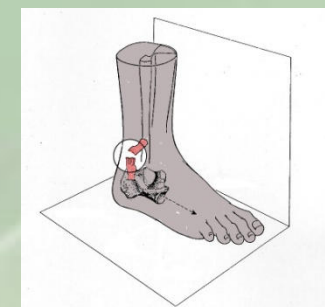
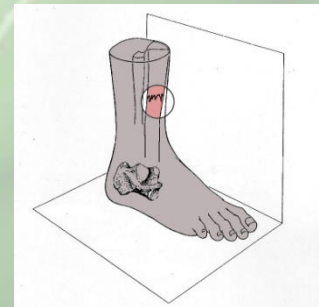
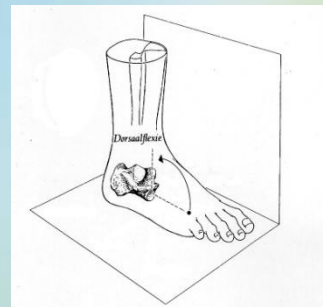
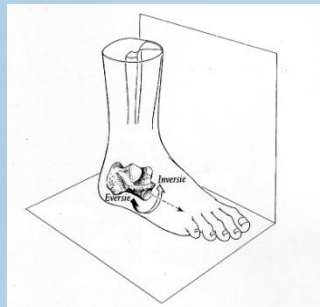
0.5 m jumping height  
3 m/s impact speed



# Injury Prediction



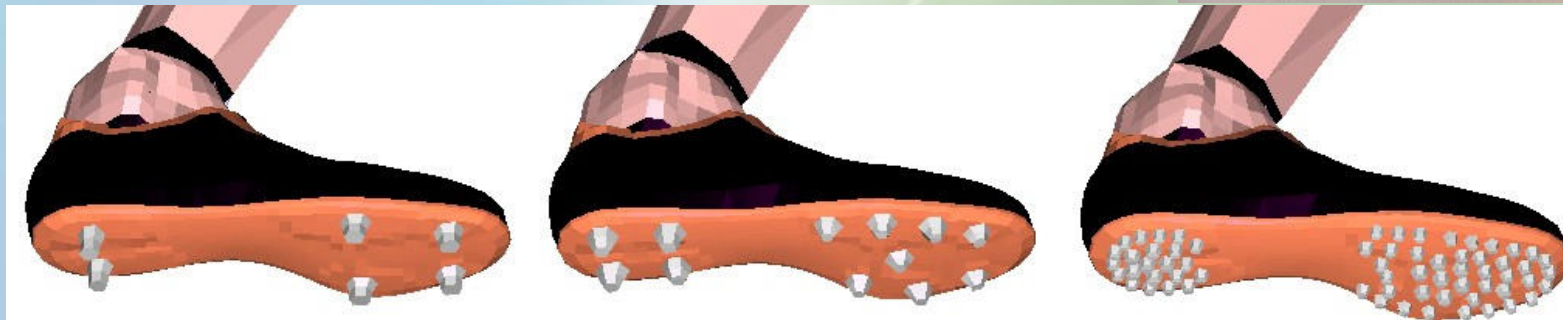
⇒ Calculation of forces on bones, muscles and ligaments and angles of the ankle



# Shoes

3 different soccer shoes:

Different number and size of studs



# Results Injury Prediction

## Calculated indications of the stress levels

Stress in ankle due to dorsiflexion:



Stress in ankle due to inversion / eversion:

Stress in ankle ligaments:



Stress in shinbone based on tibia index:

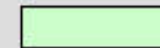
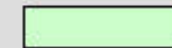
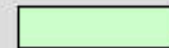
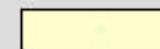
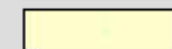
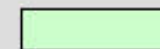
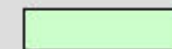
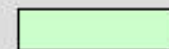
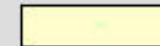
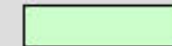
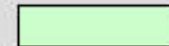
Landing



Tackle



180° Turn





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# The Multiturf Design Tool





# Multiturf Design tool



## 1. Selection and input of data

[To Step 2: Calculation](#)

### PILE YARN

Type of material	<input type="text" value="LSR 11000"/>
Pile thickness [micron]	<input type="text" value="100"/>
Pile width [mm]	<input type="text" value="12"/>

### CARPET

No of stitches per 10 cm	<input type="text" value="18"/>
No of rows per 10 cm	<input type="text" value="5.25"/>
Tuft density [ $/m^2$ ]	<input type="text" value="9450"/>
Pile height [mm]	<input type="text" value="60"/>
Free pile height [mm]	<input type="text" value="25"/>

### RUBBER INFILL

Type of material	<input type="text" value="Recycled car tyres (SBR)"/>
Amount of rubber [ $kg/m^2$ ]	<input type="text" value="9.81"/>
Layer thickness [mm]	<input type="text" value="20"/>

### SAND INFILL

Layer thickness [mm]	<input type="text" value="15"/>
----------------------	---------------------------------

### ELASTIC LAYER

Type of material	<input type="text" value="Prefab recSBR 10 mm"/>
Thickness of layer [mm]	<input type="text" value="0"/>

### SUB-BASE

Type of material	<input type="text" value="Concrete"/>
------------------	---------------------------------------



## Multiturf Design tool



### 2. Calculated results

[Back to Step 1: Data](#) [To Step 3: Compaction](#)

	Artificial Athlete	Triple A	
Force reduction	55	56	%
Energy restitution	61	43	%
Deformation	7.6	5.3	mm
<input type="button" value="First Impact"/>		<a href="#">To: Graphs</a>	
<input type="button" value="Second+third Impact"/>			

Ball bounce
Rebounce height
0.92 m

HIC test	
Critical fall height	
0.83 m	
<input type="button" value="Run calculation"/>	
<a href="#">To: Graphs</a>	

### FIFA requirements

Artificial Athlete / Triple A	FIFA 2-star	FIFA 1-star	Remarks
Shock absorption	60 - 70%	55 - 70%	= average second+third impact
Vertical deformation	4 - 8 mm	4 - 9 mm	= average second+third impact
Energy restitution	20 - 40%		Triple A; ISA Sport requirements
<i>The players experience coincides with the first impact of the test.</i>			
<b>Vertical ball bounce</b>	60 - 85 cm	60 - 100 cm	



## Multiturf Design tool



### 3. Effect of compaction of rubber infill

[Back to Step 1: Data](#)

[To Step 4: Trendlines](#)

Run compaction calculation

#### 3.1. Maximum compaction

Prediction of the effect of maximum compaction of the rubber infill on the Force reduction and Energy restitution.

	Artificial athlete	Triple A	
Force reduction	52	53	%
Energy restitution	61	41	%
Deformation	8.2	5.5	mm

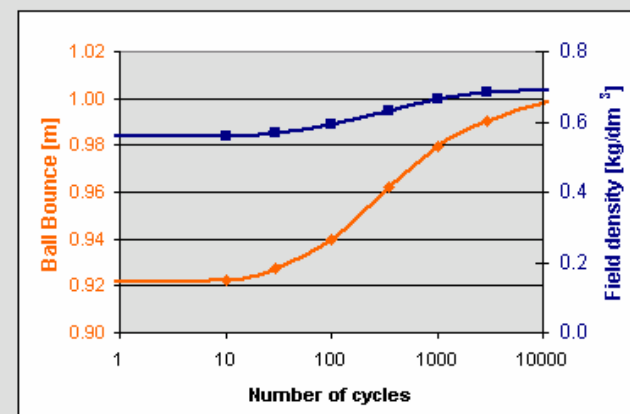
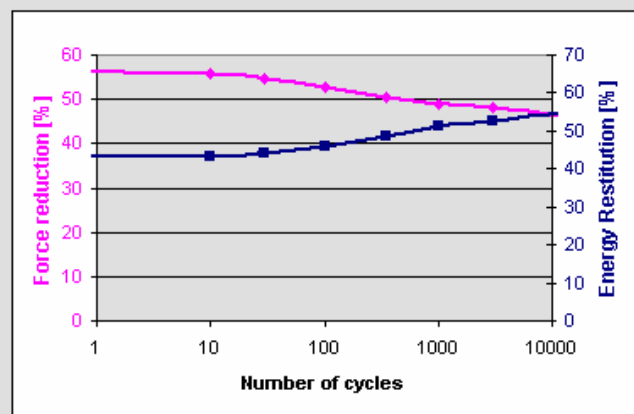
  

Ball bounce
1.05 m

### 3.2. Effect of compaction of rubber infill in time

In this calculation the density of the rubber infill is increasing in time and at the same time the infill layer thickness decreases. Both have effect on the FR and ER in time.

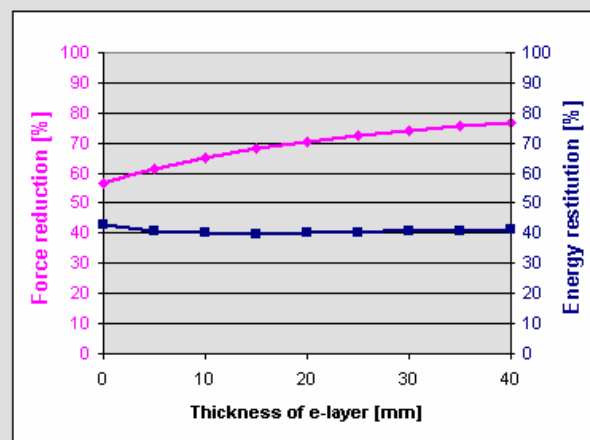
No. of cycles	Force reduction [%]	Energy restitution [%]	Ball Bounce [m]
0	56.4	42.9	0.92
10	55.7	43.4	0.92
30	54.8	44.0	0.93
100	52.9	45.7	0.94
350	50.5	48.6	0.96
1000	49.0	51.1	0.98
3000	48.1	52.5	0.99
100000	43.2	58.3	1.01



#### 4.2. Effect of the e-layer thickness on the Force reduction

Run calculation  
Elayer

Infill layer thickness [mm]	Force reduction [%]
0	56.4
5	61.4
10	65.2
15	68.1
20	70.5
25	72.5
30	74.1
35	75.5
40	76.7



#### 4.3. Calculation based on the Triple A adjusted for children.

Simulation of the impact as experienced by children  
For comparison also the normal triple A results have been added in the table underneath.

	Children's Triple A	Normal Triple A
Force Reduction [%]	79	56
Energy Restitution [%]	33	43
Vertical Deformation [mm]	3.0	5.3

## 5. Injury prediction

[Back to Step 1: Data](#)   [To Step 6: Cost calculation](#)

In this sheet an indication is calculated for the risk on different types of injuries. The calculations are based on your choices from sheet '1 Data selection and input'. Furthermore you have to make some extra choice for the human factors.

### HUMAN FACTORS





**Type of shoe**

**Running speed**

Risk indications:

- low risk
- medium risk
- high risk

### Calculated indications of the risk on injuries

	Landing	Rotation	Tackle	180° Turn
 Ankle fracture due to dorsiflexion:	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #FFFF00; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #FFFF00; border: 1px solid black;"></span>
 Ankle fracture due to inversion / eversion:	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>
 Ankle injury due to ligament failure:	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #FF0000; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #FF0000; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #FFFF00; border: 1px solid black;"></span>
 Shinbone injury based on tibia index:	<span style="display: inline-block; width: 20px; height: 20px; background-color: #FFFF00; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>	<span style="display: inline-block; width: 20px; height: 20px; background-color: #90EE90; border: 1px solid black;"></span>