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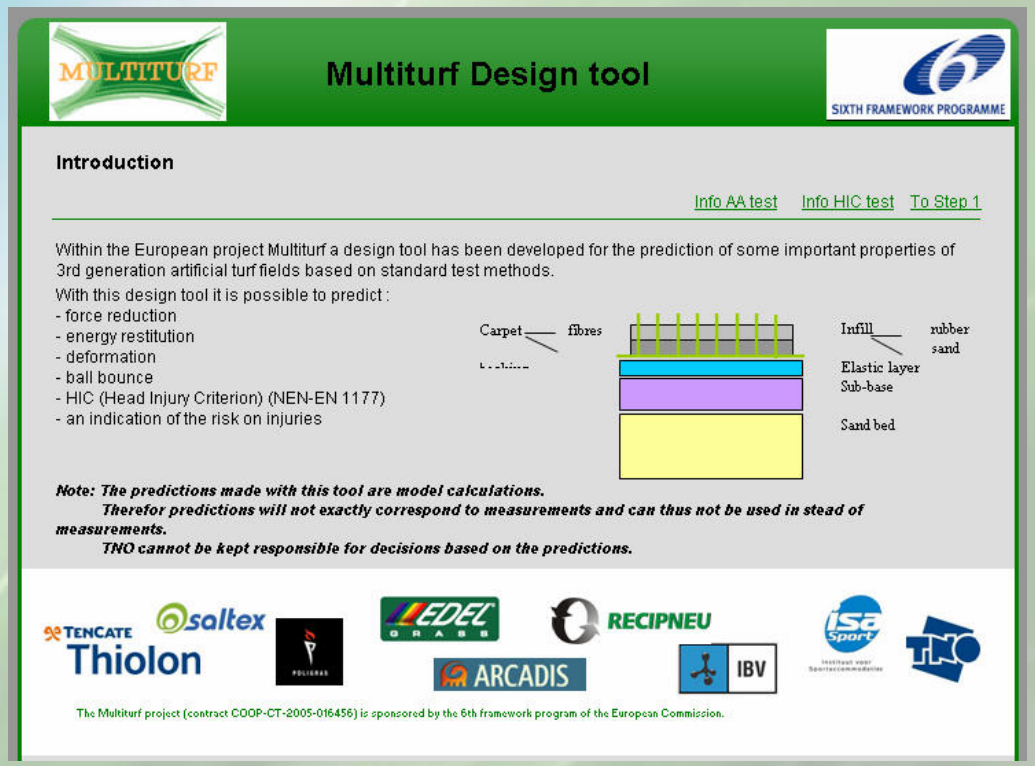
Multiturf Design Tool

Prediction of sports surface characteristics



G.J Kieft

ISA Sport

April 24th 2008

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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

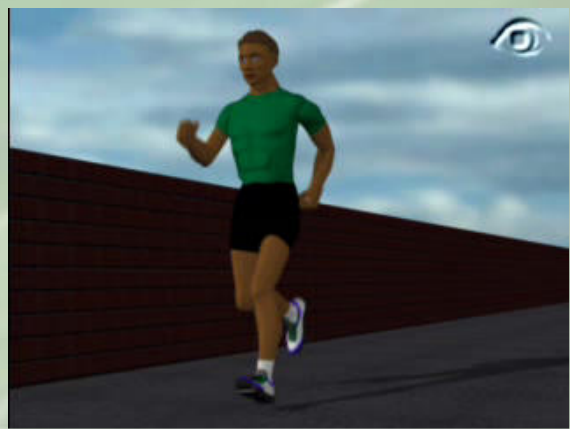
Multiturf Design Tool

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

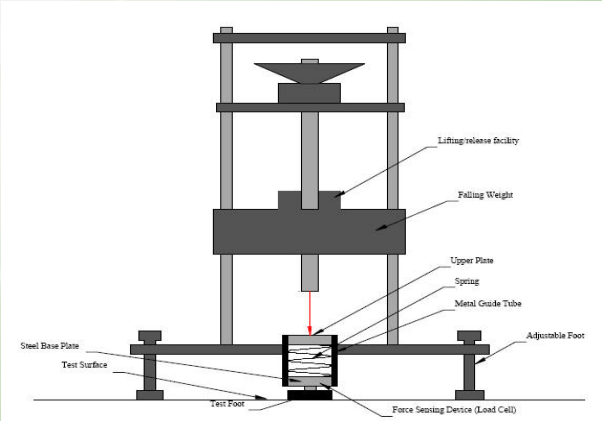
- predict whether a field will fulfil certain standards
- design a field
- calculate indications of the risk on injuries,
- without the need of doing a lot of tests.
- calculation of costs

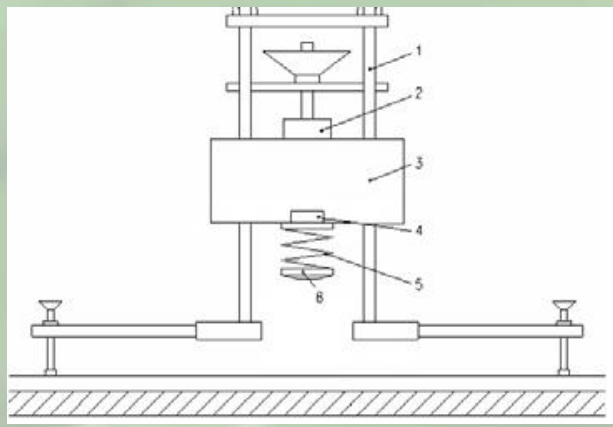


Mechanical part

Prediction of sport technical performance:

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





In addition to this:

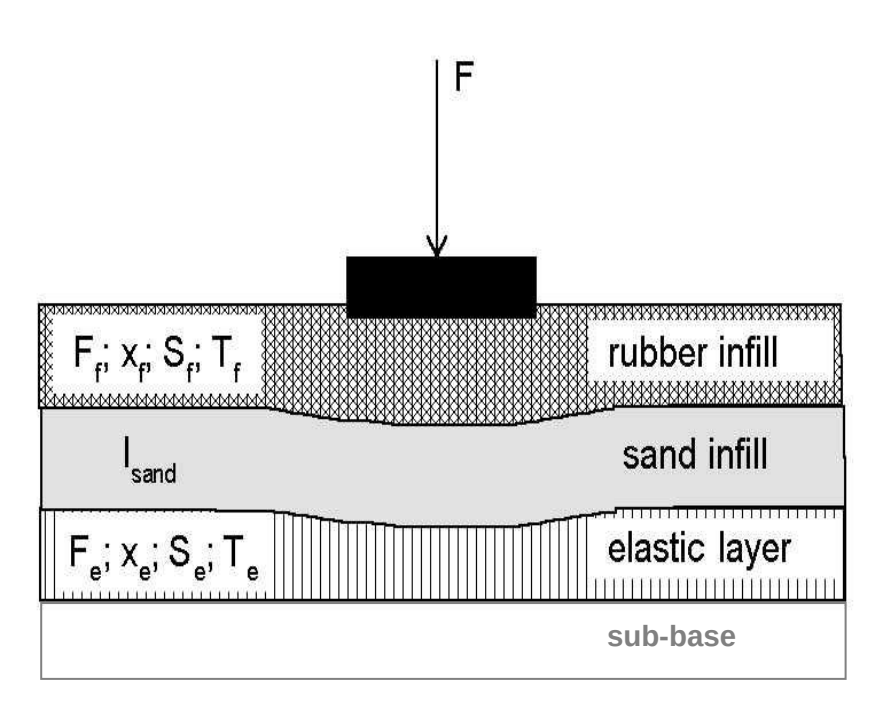
- Compaction of rubber
- Friction for human modelling
- Cost calculation

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

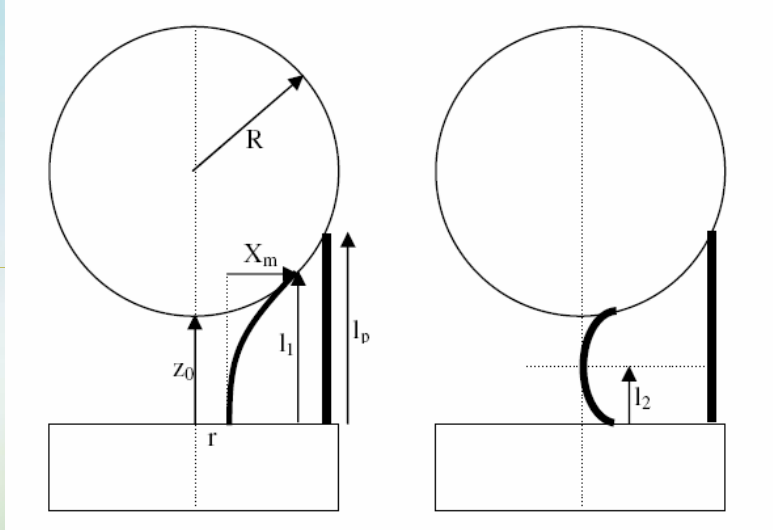
Childrens AA (IBV):

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

Physical properties

Ball Bounce:

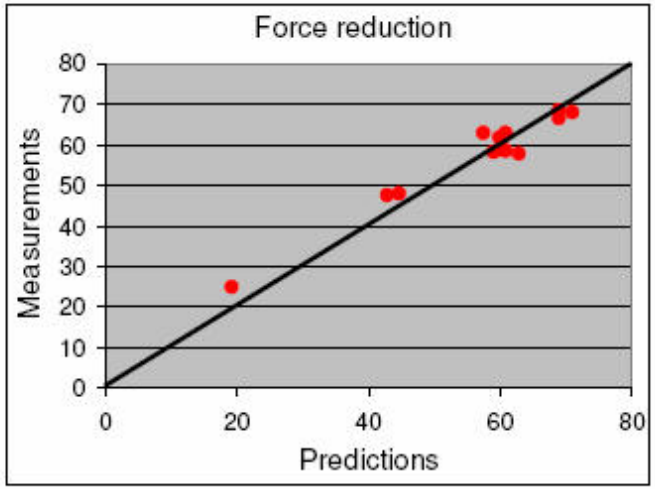
- Ball Properties
- Field Properties
- Pile bending in slip mode
- Pile bending in stick mode.

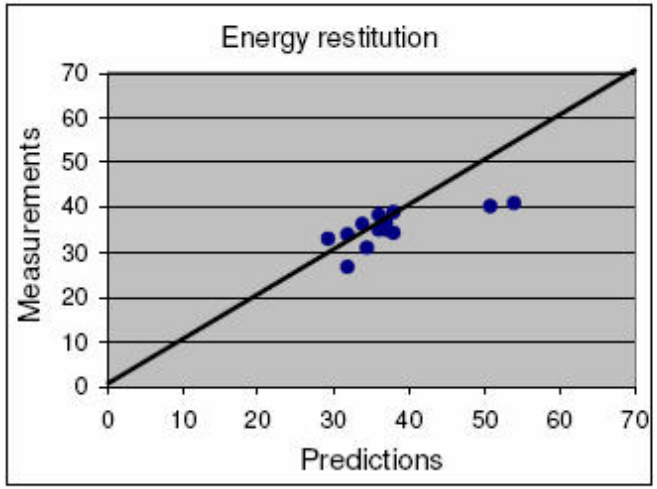


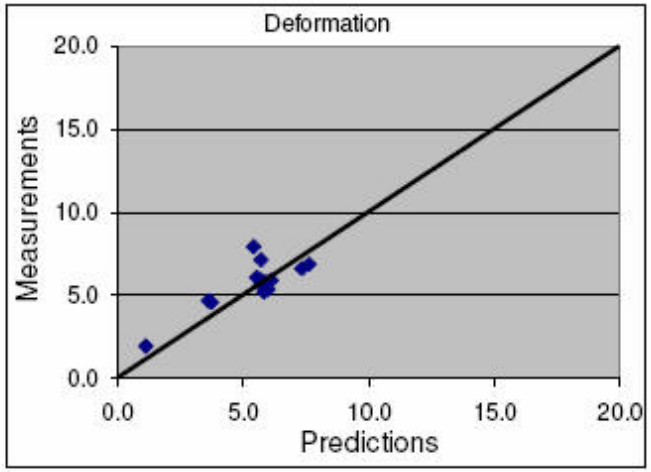
Traction:

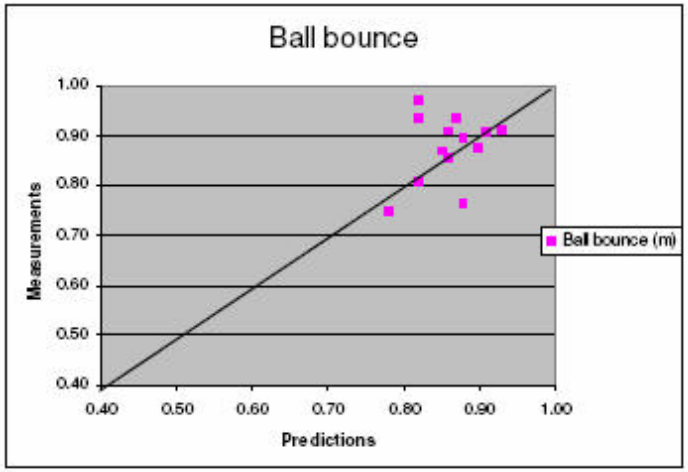
- Height of stud
- Diameter of stud
- Density and volume fraction of the rubber
- Compression stress applied
- Friction coefficient (also shape and size of particles)

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 δ of solid rubber
- density of solid rubber

E-layer or shock pad:

- E-modulus of e-layer or shock pad
- tan δ of e-layer or shock pad

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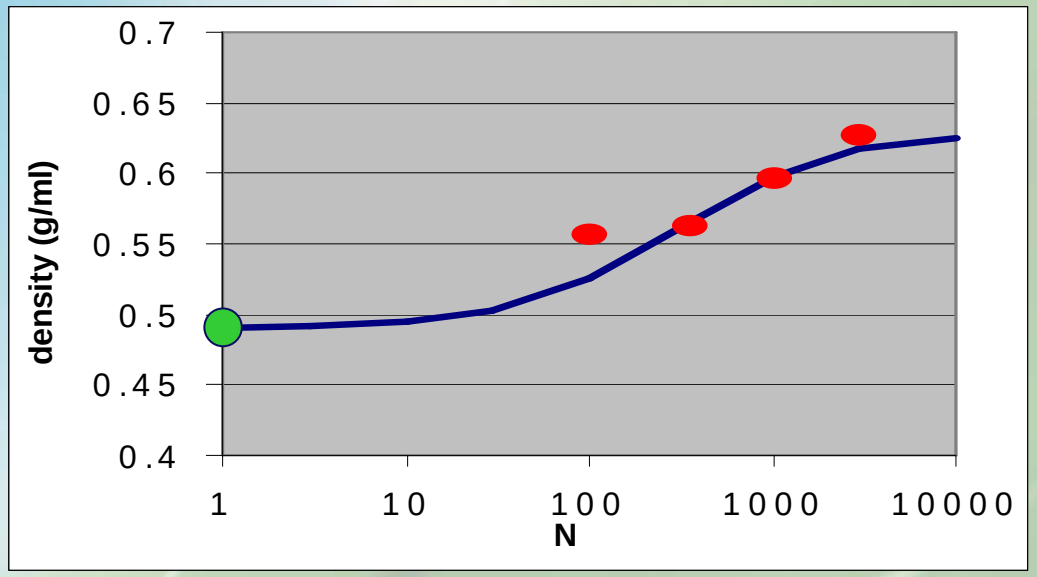
Sensitivity analysis

- 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

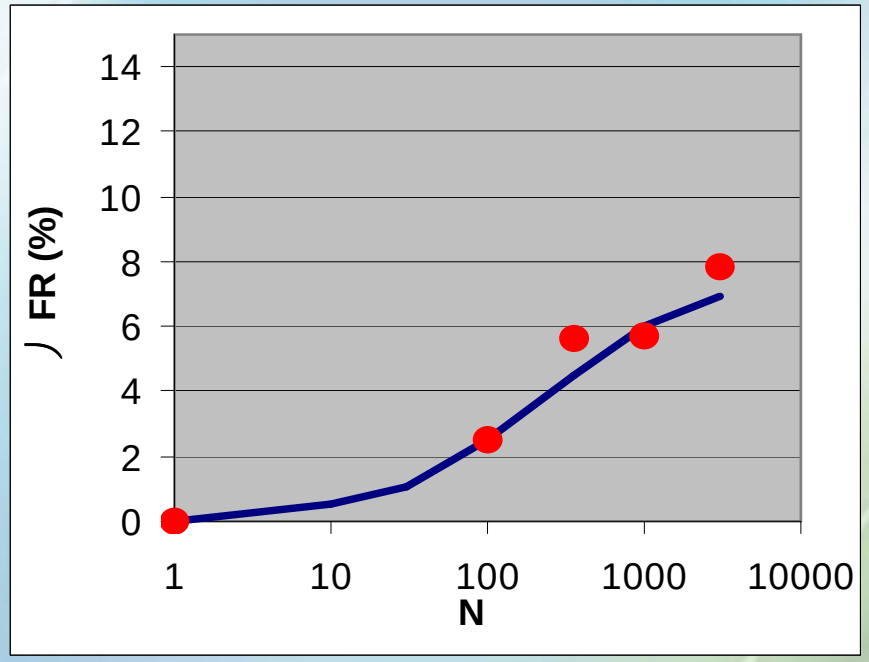


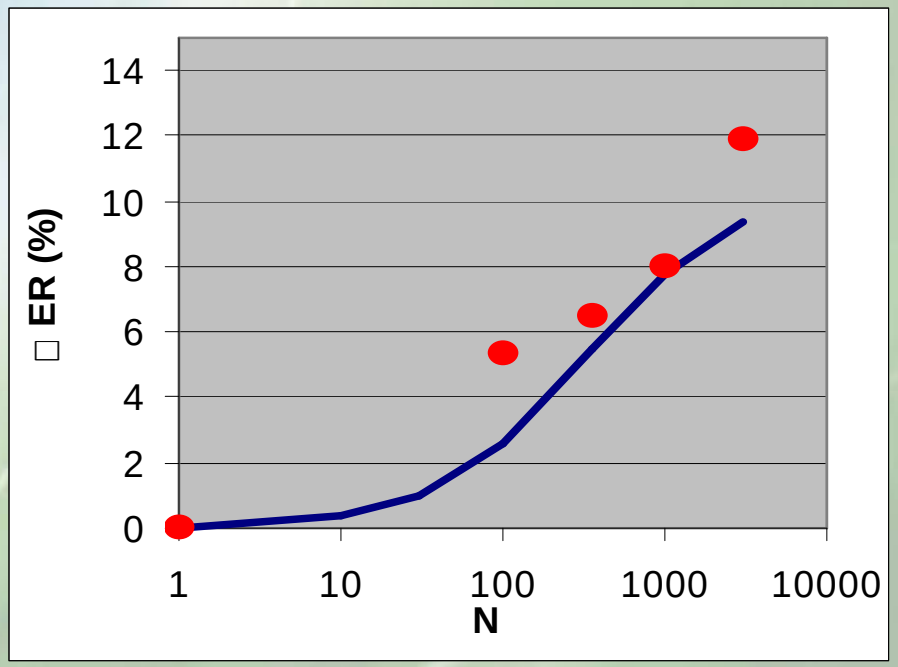
Verified with Lisport and destructor

Degradation not taken into account

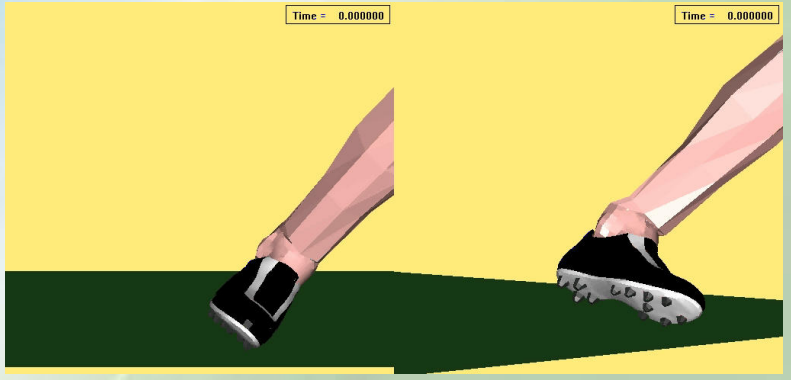
Compaction of rubber: FR & ER

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





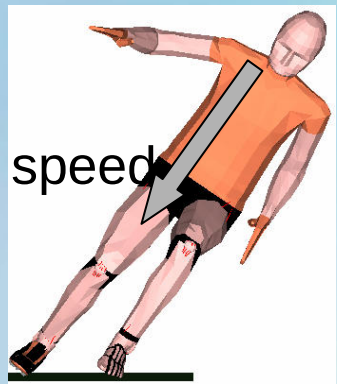
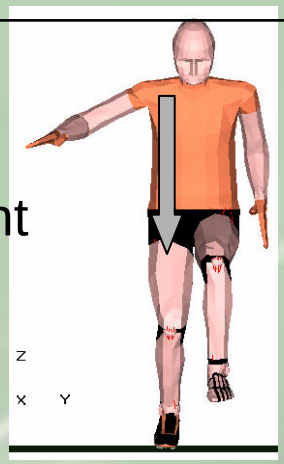
Prediction on movements



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)

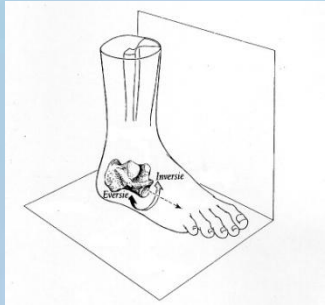
Simulation Set-ups

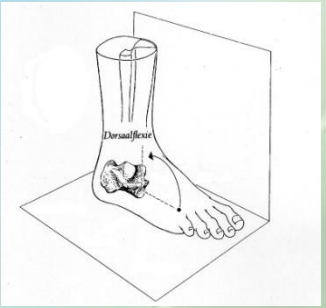
180 deg turn 3-4.5 m/s impact speed 45° direction 	Tackle 3-9 m/s contact speed 
Turn 2 Phi turn velocity 	Landing 0.5 m jumping height 3 m/s impact speed 

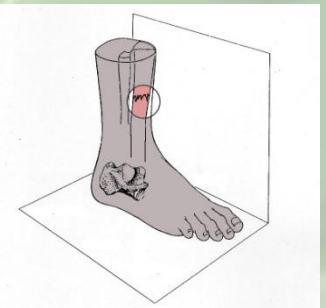
Injury Prediction

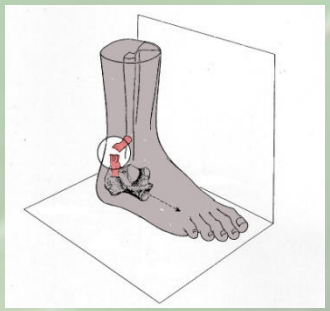
Field parameters → Forces and angles
Human factors → Forces and angles
Forces and angles → Risk on injuries

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





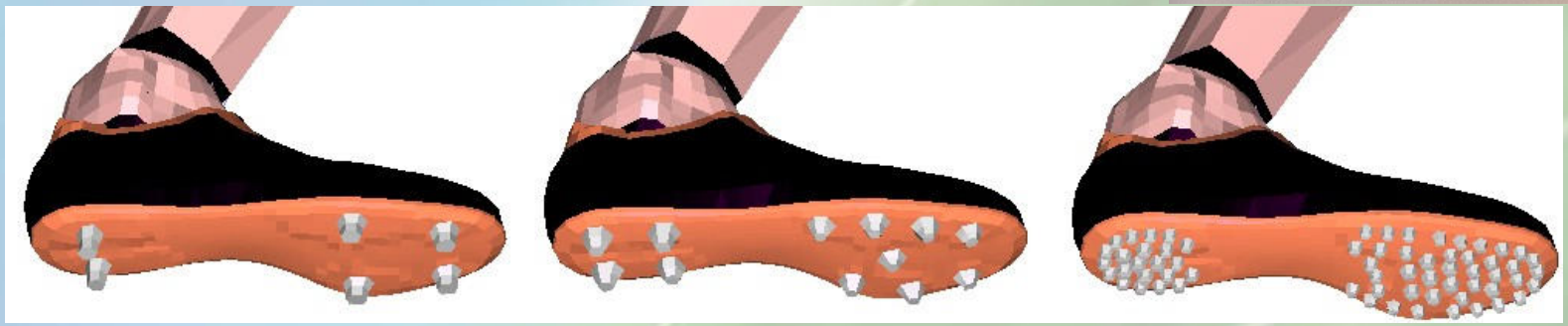




Shoes

3 different soccer shoes:

Different number and size of studs



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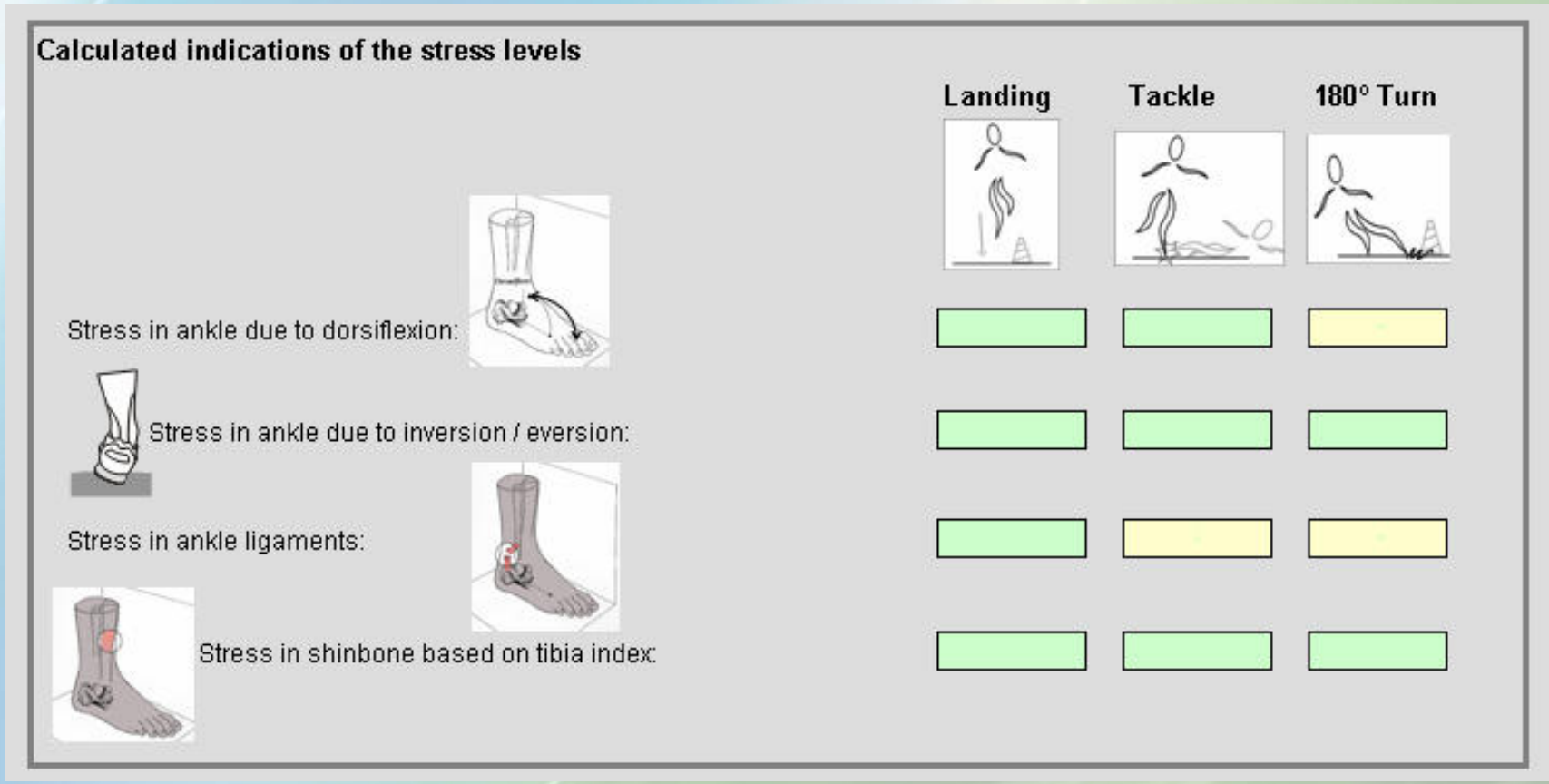
Results Injury Prediction



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The Multiturf Design Tool

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Multiturf Design tool

SIXTH FRAMEWORK PROGRAMME

1. Selection and input of data

To Step 2: Calculation

PILE YARN

Type of material	LSR 11000
Pile thickness [micron]	100
Pile width [mm]	12

CARPET

No of stitches per 10 cm	18
No of rows per 10 cm	5.25
Tuft density [/m^2]	9450
Pile height [mm]	60
Free pile height [mm]	25

RUBBER INFILL

Type of material	Recycled car tyres (SBR)
Amount of rubber [kg/m^2]	9.81
Layer thickness [mm]	20

SAND INFILL

Layer thickness [mm]	15

ELASTIC LAYER

Type of material	Prefab recSBR 10 mm
Thickness of layer [mm]	0

SUB-BASE

Type of material	Concrete

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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

First Impact

Second+third Impact

To: Graphs

Ball bounce

Rebounce height

0.92 m

HIC test

Critical fall height

0.83 m

Run calculation

To: Graphs

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

The players experience coincides with the first impact of the test.

Vertical ball bounce	60 - 85 cm	60 - 100 cm

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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

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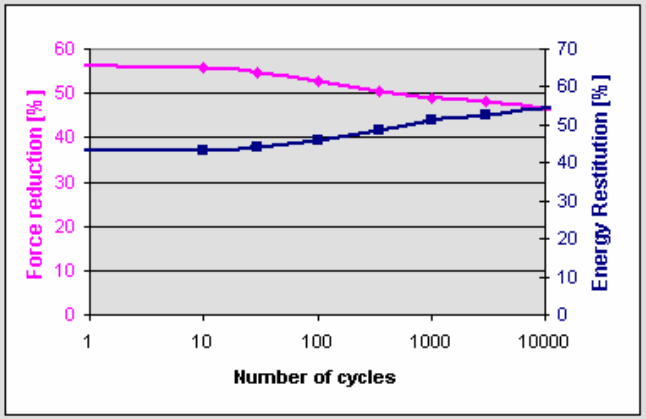
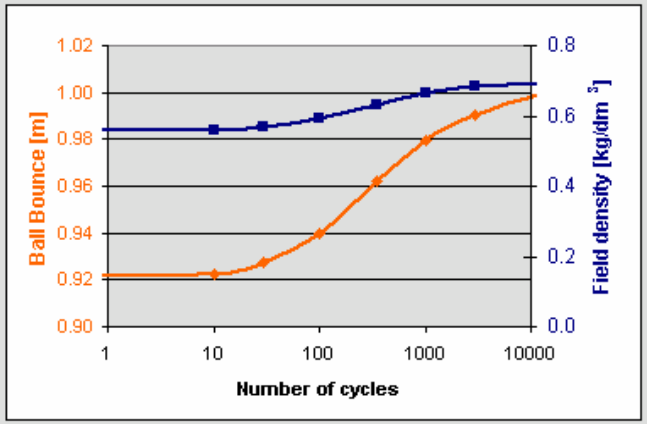
3.2. Effect of compaction of rubber infill in time

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





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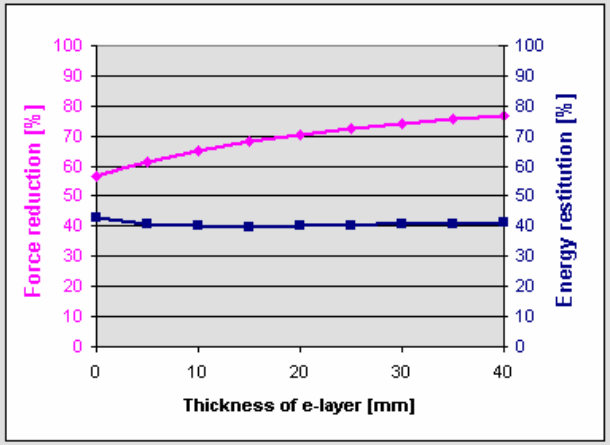
4.2. Effect of the e-layer thickness on the Force reduction

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 Restititution [%]	33	43
Vertical Deformation [mm]	3.0	5.3

Multiturf Design tool

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'.
Furhermore you have to make some extra choice for the human factors.

Risk indications:
- low risk
- medium risk
- high risk

HUMAN FACTORS

Type of shoe Artificial turf shoes for hockey

Running speed Running

Calculated indications of the risk on injuries

	Landing	Rotation	Tackle	180° Turn
Ankle fracture due to dorsiflexion:				
Ankle fracture due to inversion / eversion:				
Ankle injury due to ligament failure:				
hinbone injury based on tibia index:				