Multiturf Design Tool
Prediction of sports surface characteristics

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

With this design tool it is possible to predict:
- Rate of Reduction
- Energy restitution
- Deformation
- Fall protection
- HIC (Head Injury Criteria) (NEU-EN 1177)
- An indication of the risk on injuries

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.
THO cannot be kept responsible for decisions based on the predictions.
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\textsuperscript{st} and 2\textsuperscript{nd} + 3\textsuperscript{rd} 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
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)
<table>
<thead>
<tr>
<th>Simulation Set-ups</th>
<th>180 deg turn</th>
<th>Tackle</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-4.5 m/s impact speed</td>
<td>3-9 m/s contact speed</td>
<td></td>
</tr>
<tr>
<td>45° direction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn</td>
<td>2 Phi turn velocity</td>
<td>Landing</td>
</tr>
<tr>
<td>2 Phi turn velocity</td>
<td>0.5 m jumping height</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 m/s impact speed</td>
<td></td>
</tr>
</tbody>
</table>
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:

<table>
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<tr>
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<th>Tackle</th>
<th>180° Turn</th>
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<td></td>
<td></td>
</tr>
<tr>
<td>Stress in shinbone based on tibia index:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Multiturf Design Tool
## 1. Selection and input of data

### 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 [m²]**: 9450
- **Pile height [mm]**: 60
- **Free pile height [mm]**: 25

### RUBBER INFILL
- **Type of material**: Recycled car tyres (SBR)
- **Amount of rubber [kg/m²]**: 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
Multiturf Design tool

2. Calculated results

![Results Table]

FIFA requirements

<table>
<thead>
<tr>
<th>Artificial Athlete / Triple A</th>
<th>FIFA 2 star</th>
<th>FIFA 1 star</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock absorption</td>
<td>60 - 70%</td>
<td>55 - 70%</td>
<td>= average second-third impact</td>
</tr>
<tr>
<td>Vertical deformation</td>
<td>4 - 8 mm</td>
<td>4 - 9 mm</td>
<td>= average second-third impact</td>
</tr>
<tr>
<td>Energy restitution</td>
<td>20 - 40%</td>
<td></td>
<td>Triple A, ISA Sport requirements</td>
</tr>
</tbody>
</table>

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

Vertical ball bounce

- **Artificial Athlete**: 60 - 85 cm
- **Triple A**: 60 - 100 cm
## Multiturf Design tool

### 3. Effect of compaction of rubber infill

#### 3.1. Maximum compaction

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

<table>
<thead>
<tr>
<th></th>
<th>Artificial athlete</th>
<th>Triple A</th>
<th>Ball bounce</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force reduction</td>
<td>52</td>
<td>53%</td>
<td></td>
</tr>
<tr>
<td>Energy restitution</td>
<td>61</td>
<td>41%</td>
<td>1.05 m</td>
</tr>
<tr>
<td>Deformation</td>
<td>8.2</td>
<td>5.5 mm</td>
<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>No. of cycles</th>
<th>Force reduction [%]</th>
<th>Energy restitution [%]</th>
<th>Ball Bounce [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>66.4</td>
<td>42.9</td>
<td>0.92</td>
</tr>
<tr>
<td>10</td>
<td>65.7</td>
<td>43.4</td>
<td>0.92</td>
</tr>
<tr>
<td>30</td>
<td>64.8</td>
<td>44.0</td>
<td>0.93</td>
</tr>
<tr>
<td>100</td>
<td>62.9</td>
<td>45.7</td>
<td>0.94</td>
</tr>
<tr>
<td>350</td>
<td>61.5</td>
<td>46.6</td>
<td>0.96</td>
</tr>
<tr>
<td>1000</td>
<td>59.0</td>
<td>51.1</td>
<td>0.98</td>
</tr>
<tr>
<td>3000</td>
<td>58.1</td>
<td>52.5</td>
<td>0.99</td>
</tr>
<tr>
<td>100000</td>
<td>43.2</td>
<td>58.3</td>
<td>1.01</td>
</tr>
</tbody>
</table>

Graphs showing the change in Force reduction, Energy restitution, and Ball Bounce over the number of cycles.
4.2. Effect of the e-layer thickness on the Force reduction

<table>
<thead>
<tr>
<th>Infill layer thickness [mm]</th>
<th>Force reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>66.4</td>
</tr>
<tr>
<td>5</td>
<td>61.4</td>
</tr>
<tr>
<td>10</td>
<td>65.2</td>
</tr>
<tr>
<td>15</td>
<td>68.1</td>
</tr>
<tr>
<td>20</td>
<td>70.5</td>
</tr>
<tr>
<td>25</td>
<td>72.5</td>
</tr>
<tr>
<td>30</td>
<td>74.1</td>
</tr>
<tr>
<td>35</td>
<td>75.6</td>
</tr>
<tr>
<td>40</td>
<td>76.7</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Children's Triple A</th>
<th>Normal Triple A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force Reduction [%]</td>
<td>79</td>
</tr>
<tr>
<td>Energy Restitution [%]</td>
<td>33</td>
</tr>
<tr>
<td>Vertical Deformation [mm]</td>
<td>5.0</td>
</tr>
</tbody>
</table>
5. Injury prediction

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**

<table>
<thead>
<tr>
<th>Type of shoe</th>
<th>Artificial turf shoe for hockey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running speed</td>
<td>Running</td>
</tr>
</tbody>
</table>

**Calculated indications of the risk on injuries**

- **Landing**
  - Ankle fracture due to dorsiflexion:
  - Ankle fracture due to inversion / eversion:
  - Ankle injury due to ligament failure:

- **Rotation**
  - 180° Turn

- **Tackle**

- **Injury based on tibia index**