Guadua Angustifolia Kunth as an alternative to metals and synthetic fibers

In order to build comfortable urban furniture including Hi-Tech wind turbine for powering ultimate technology L.E.D. street lamp.

Iker Gómez Iborra, BAMBHAUS COMPOSITES, S.L.
Iván Villalva, ALBAERO, S.L.
Mónica Rios Arroyo, BAMBHAUS COMPOSITES, S.L.
Jaime Espinosa, Polytechnic University of Madrid (UPM)
IX W.B.C. 2012 G.A.K. as an alternative to metal and synthetic fibers

BAMBAUS MAIN LINES

ENGINEERED BAMBOO FOR SUSTAINABLE DEVELOPMENT

• Importing and distribution
• Housing + Urban development
  – Flexible, evolving BIOhousing
• RD+i
  – Industrialized Building systems
  – Joints and conexions of poles
  – Biohousing
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

DIFFICULTIES FOR INTRODUCING BAMBOO IN BUILDING SECTOR

- Unknown material
- Variable properties
- Non isotropic properties
- Quality acceptance
- Fatigue and wear resistance
- Fire behaviour
- Price
- Profitability
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

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security factors

take advantage of them

proper selection

treatments

treatments

Unknown material
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

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security factors
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treatments

Unknown material

show the material in extrem conditions
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers in extrem conditions.

Iker gómez iborra; ivan villalba; monica ríos arroyo; jaime espinosa;
• IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

EXTREM CONDITIONS:

URBAN FURNITURE + WIND TURBINE
• IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

EXTREM CONDITIONS:

URBAN FURNITURE

+ WIND TURBINE

• Wear resistance
• Atmospheric conditions
• Safety standards
• Citizen behaviour
• Mechanical fatigue
• Vandalism
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

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EXTREM CONDITIONS:

URBAN FURNITURE

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So we have designed:

LED-Lamp, wind turbine, bench, trashbin, and parking for 6 bikes
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

**REQUIREMENTS FOR URBAN FURNITURE DESIGN**

- Built and repaired “priceless” (In behalf of tax payers)
- Citizens need a place to
  - REST
  - RELAX
  - SOCIALIZE
  - CONNECT THE CITY
  - FEEL PROTECTED

LED-Lamp, wind turbine, bench, trashbin, and parking for 6 bikes
• IX W.B.C. 2.012 G.A.K. as an alternative

BIKE PARKING
LOT
8 BIKES

LIGHT LAMP
G.A.K. CANE

PLAY SURFACE
G.A.K. STICKS 50x15mm.

FLOOR PLAN

Iker gómez iborra; ivan villalba; monica rios arroyo; jaime espinosa;
IX W.B.C. 2.012 G.A.K. as an alternative

Many other designs

MAIN SECTION
• IX W.B.C. 2.012 G.A.K. as an alternative

Many other designs

MAIN SECTION
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

WIND RESOURCE IN THE CITIES AND ELECTRICITY PRODUCTION

Classical models are not appropriate:
Solari, Von Karman

2 Main types of wind:
• Turbulent wind (non directional)
• Street canyon (directional)

CFD Modelling is needed in order to avoid unnecessary spent of resources.
• Wind characteristics
• Trees growth
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

WIND TURBINE CHOICE AND ENERGY PRODUCTION

3 different types of wind turbine:

- **vertical axis**
- **horizontal axis**
- **turbulent wind**
- **directional wind**

![Diagram of wind turbines]

Cp ≈ 0.20  
0.35-0.59*  
0.31-0.52

Iker gómez iborra; ivan villaiba; monica ríos arroyo; jaime espinosa;
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers
WIND TURBINE CHOICE AND ENERGY PRODUCTION

3 different types of wind turbine:

- **vertical axis**
- **Horizontal axis**

**TURBULENT WIND**

**DIRECTIONAL WIND**

Savonius VAWT: 0.20

Modern HAWT: 0.35-0.59*

Giromill/Darrieus VAWT: 0.31-0.52

[Images of wind turbines]
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POWER NEEDED AND SURFACE

HI TECH LED LAMP: 2x150W (2x90W)
365 days x 8 hours a day = 876 KW·h (525 KW·h)
P= ½ x ρ x S x v³ x Cp
Savonius: S=4.3 m²  
Darrieus optimized: S=1.9 m²
• IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

POWER NEEDED AND SURFACE

2 types of vertical axis windturbines

COMPARISON OF SURFACE
SAVONIOUS vs DARRIEUS
4.3 m² vs 1.9 m²

Ø 92
Ø 45
• IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers
STREET DISPOSAL FOR AVOIDING SELF DISTURBANCE

STREET DISPOSAL:
Different heights or positions helps to minimize turbulence and breaking effect on consecutive air turbines.
• IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

GUADUA ANGSTIPHOLIA KUNTH AS MAIN MATERIAL

• LOW DENSITY
• HIGHT DIRECTIONAL STRENGTH (TRACTION)
• ELASTIC PROPIERTIES
• NATURAL BEHAVIOUR AGAINST STRONG WINDS
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers
GUADUA ANGUSTIPHOLIA KUNTH AS MAIN MATERIAL

<table>
<thead>
<tr>
<th>TYPICAL VALUES</th>
<th>Flexural Bending*</th>
<th>Parallel compression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Density</td>
<td>Strength</td>
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<tr>
<td></td>
<td>Kg/m³</td>
<td>MPA</td>
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<tr>
<td>GAK AXIAL TRACTION</td>
<td>800</td>
<td>100</td>
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<tr>
<td>GAK CANE</td>
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<td>45</td>
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<td>2024 ALUMINUM</td>
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<td>290</td>
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<td>4130 STEEL</td>
<td>7850</td>
<td>841</td>
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<tr>
<td>GAK STICK</td>
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<td>45</td>
</tr>
<tr>
<td>GAK STICK+CORTEX</td>
<td>800</td>
<td>80</td>
</tr>
<tr>
<td>GAK FIBERS*</td>
<td>1200</td>
<td>800</td>
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<tr>
<td>GAK COMPOSITES*</td>
<td>1200</td>
<td>150</td>
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<td>GLASS FIBER AXIAL</td>
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<td>3445</td>
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</table>
• IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers
GUADUA ANGUSTIPHOLIA KUNTH AS MAIN MATERIAL

• LOW DENSITY
  HIGHER INERTIA MODULUS

• DIRECTIONAL STRENGTH (TRACTION)
  FIBRE REINFORCEMENT

• ELASTIC PROPERTIES
  CHANGING WIND AND ACCELERATION STRESS ABSORPTION

• NATURAL BEHAVIOUR AGAINST STRONG WINDS
  IDEAL FOR MAST BUILDING
• IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

**EMBODIED CO₂ APPROACH**

<table>
<thead>
<tr>
<th>Description</th>
<th>Weight</th>
<th>Embodied CO₂</th>
<th>Embodied Energy</th>
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<tbody>
<tr>
<td></td>
<td>kg</td>
<td>kg CO₂/kg</td>
<td>total MJ/kg</td>
</tr>
<tr>
<td>GAK. Cane</td>
<td>150</td>
<td>-0.55</td>
<td>-82.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
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</tr>
<tr>
<td>GAK. Stick</td>
<td>500</td>
<td>-0.4</td>
<td>-200</td>
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<tr>
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<td></td>
<td></td>
<td>10</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>5000</td>
</tr>
<tr>
<td>Concrete base:</td>
<td>500</td>
<td>0.13</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>650</td>
</tr>
<tr>
<td>Corrugated Steel</td>
<td>20</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>47.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>948</td>
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<tr>
<td>Steel and metals:</td>
<td>15</td>
<td>2</td>
<td>30</td>
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<td></td>
<td></td>
<td></td>
<td>48.4</td>
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<td></td>
<td>726</td>
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<td>Electrics and Optics:</td>
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<td>4</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1350</td>
</tr>
<tr>
<td>windturbine G.A.K. based:</td>
<td>50</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>12.5 kg CO₂</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11,024 MJ</td>
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</table>
### IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

**EMBODIED CO2 APPROACH**

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (kg)</th>
<th>Embodied CO2 (kg CO2/kg)</th>
<th>Total CO2 (kg)</th>
<th>Embodied Energy (MJ/kg)</th>
<th>Total Energy (MJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Cane</td>
<td>300</td>
<td>2</td>
<td>600</td>
<td>50</td>
<td>15000</td>
</tr>
<tr>
<td>GAK. Stick</td>
<td>500</td>
<td>-0.4</td>
<td>-200</td>
<td>10</td>
<td>5000</td>
</tr>
<tr>
<td>Concrete base</td>
<td>1500</td>
<td>0.13</td>
<td>195</td>
<td>1.3</td>
<td>1950</td>
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<tr>
<td>Corrugated Steel</td>
<td>80</td>
<td>2</td>
<td>160</td>
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<td>3792</td>
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<td>Steel and metals:</td>
<td>0</td>
<td>2</td>
<td>30</td>
<td>48.4</td>
<td>726</td>
</tr>
<tr>
<td>Electrics and Optics:</td>
<td>15</td>
<td>4</td>
<td>60</td>
<td>90</td>
<td>1350</td>
</tr>
<tr>
<td>Windturbine polymer composite:</td>
<td>40</td>
<td>8</td>
<td>320</td>
<td>50</td>
<td>2000</td>
</tr>
</tbody>
</table>

**Total**

- 1.160 kg CO2
- 47.818 MJ
• IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

EMBODIED CO₂ APPROACH

• G.A.K. BASED URBAN FURNITURE + G.A.K. BASED WIND TURBINE
  \[ \text{CO}_2 \approx 12 \]

• G.A.K. BASED URBAN FURNITURE + TRADITIONAL COMPOSITE & STEEL WIND TURBINE
  \[ \text{CO}_2 \approx 1.160 \text{kg} \]

• EMBODIED ENERGY RELATION
  1 TO 4
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

CONCLUSIONS

• G.A.K. CAN BE COMBINED WITH HI TECH EQUIPMENT

• DUE TO MECHANICAL PROPERTIES G.A.K. IS A GREAT ALTERNATIVE TO STEEL, ALUMINUM AND OTHER SYNTHETIC MATERIALS; BUT SHOULD STUDIED IN ADVANCE.

• CO2 EMISSIONS AND ENERGY EMBODIED MUST TAKE AS AN APPROACH

•ALTHOUGHLY USE OF G.A.K. OR OTHER BAMBOO OR WOODS BALANCING CO2 EMISSIONS IS A DIFFICULT TASK.
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

APPENDIX: COST OF PROJECT

ESTIMATED COST FOR INDUSTRIAL / SERIES PRODUCTION;

PRODUCED & INSTALLED IN VITORIA-GASTEIZ
 европей green capital 2012
• IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

APPENDIX: COST OF PROJECT

INDUSTRIAL PRODUCTION, (VITORIA-GASTEIZ AS SITE)

- 8 BIKE PARKING LOT
  G.A.K. STICKS 50x15mm.
  2,000€

- FLOOR PLAN
  BENCH
  G.A.K. STICKS 50x15mm.
  800€

- PLAY SURFACE A
  G.A.K. STICKS 50x15mm.
  1,000€

- PLAY SURFACE B
  G.A.K. STICKS 50x15mm.
  1,500€

- EASY PRIVAT ACCES TO ELECTRICAL MAINTENANCE
  800 €
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

APPENDIX: COST OF PROJECT; SEEKING INVESTORS

R.D.I. PROJECT FOR VITORIA-GASTEIZ EUROPEAN GREEN CAPITAL 2012:

RESEARCH DEVELOPED, PRODUCED, INSTALLED & MAINTAINED

**300-600W WINDTURBINE**

- 5 UNITS: 60.000€
- 2 YEAR MAINTENANCE: 10.000€

**3.000-5.000W WINDTURBINE**

- 5 UNITS: 125.000€
- 2 YEAR MAINTENANCE: 24.000€

**G.A.K. COMPOSITES WIND BLADES R.D.I.**

- 1.5-2 YEARS: 150.000€

**WIND MAP**

- EACH SECTOR: 20.000€
- MEDIUM CITY: 60.000-100.000€
IX W.B.C. 2.012 G.A.K. as an alternative to metal and synthetic fibers

THANK YOU VERY MUCH FOR YOUR INTEREST AND DISPLAYED KNOWLEDGE

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Engineered Bamboo for Sustainable Development