Polyvinyl Alcohol (PVA) fiber
For Concrete & Mortar

Quality and performance of PVA fibers for durable constructions

September 28th 2023
BIBM Congress Amsterdam

Tomoka Yoshida
KURARAY CO., LTD.
KURALON™ and KURALON K-II™

KURALON™ and KURALON K-II™ is synthetic fiber which is made from PVA resin. In 1950, Kuraray started its commercial production and especially it has long history in cement composite market as substitute of asbestos.

SPECIAL FEATURES

- High Strength
- High Modulus
- Low Elongation
- Good adhesion to Cement Matrix
- Alkaline Resistance
- Weathering Resistance
- Light Weight
- No Corrosion

kuraray
Fiber Properties

KURALON™ and KURALON K-II™ has unique properties in comparison with other fiber material such as Steel, AR-Glass, Polypropylene.

<table>
<thead>
<tr>
<th>Property</th>
<th>KURALON™</th>
<th>Steel fiber</th>
<th>AR-Glass fiber</th>
<th>Polypropylene fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>MPa</td>
<td>850-1790</td>
<td>490-980</td>
<td>2500</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td>GPa</td>
<td>23-45</td>
<td>200</td>
<td>74</td>
</tr>
<tr>
<td>Density</td>
<td>g/cm³</td>
<td>1.30</td>
<td>7.85</td>
<td>2.78</td>
</tr>
</tbody>
</table>

In comparison with
- Steel fiber: lightweight, no corrosion
- AR-Glass fiber: higher alkaline resistance, higher elongation
- Polypropylene fiber: higher tensile strength and modulus, better adhesion to cement matrix

KURALON™, KURALON K-II™; Kuraray’s technical brochure
Other fibers; Kikuta and Minashi, Concrete Journal, pp.414-417, Vol.50, No.5, 2012, 5
Alkaline Resistance

KURALON™ and KURALON K-II™ has good chemical resistance and especially shows great alkaline resistance. Below data shows strength retention of each fiber material after soaking into extraction of cement slurry at 80 degrees C.
Flexural Behavior of KURALON™ reinforced concrete

KURALON™ and KURALON K-II™ have good adhesion to cement, which prevents them from falling out and provides high fiber reinforcement effect.

Test method: ASTM C1399-02 Geometry of specimen (mm): 100/100/350 Fiber dosage: 20kg/m³

KURALON™ and KURALON K-II™ form chemical bonds with the cement matrix. Ca ion in cement slurry is attracted by PVA and makes calcium compounds layers. It seems reasonable to think that calcium compound layer plays an important role for adhesion.
Cracking Control

Evaluation for dry shrinkage cracking control by ASTM C1581:

![Graph showing change in crack mouth opening over time for Plain mortar, PP fiber, and Kuralon K-II.](image1)

Shrinkage cracking test specimen

**Change in crack mouth opening**
- Mix: W/C=0.55, S/C=4.0, Vf=0.3 vol%, horizontal twin axis mixer
- Mould-off, Top surface sealing: 24 hrs after molding
- Aging: 20°C/40%RH

Effect of fiber reinforcement is the bridging effect of cracks. By using KURALON™, Crack Mouth Opening can be reduced to 1/3 of Plain mortar.
Applications

Shotcrete for slope reinforcement
Architectural use
Decorative architectural structure
Building wall/Façade
Bridge deck slab
OA panel for floor
Wind proof panel for railways
Retrofit
Tunnel lining
Overlay for road pavement
Concrete slab on grade
KURALON™ and KURALON K-II™ - for concrete infrastructure

KURALON™ is a synthetic fiber, made from polyvinyl alcohol (PVA), suitable fiber material for “Durable and less maintenance concrete infrastructures” suggesting Carbon footprint and Life Cycle Cost efficiency, thanks to its good affinity to cement which leads to better crack control under severe conditions, such as cold weather, heavy loading traffic.

APPLICATIONS
• PVA fiber reinforced concrete slab deck of bridges
• Concrete pavement for heavy loading traffics (scrap yards/airports)
• Permanent concrete formworks reducing rehabilitation

BENEFITS
• No/less metal elements (No/less corrosion)
  → Less maintenance
• Benefits of end customers-Less consumption of cement
  → Reduce CO₂ emission

kuraray
KURALON™ and KURALON K-II™ suppresses fine cracks caused by repeated freezing and thawing, resulting in very little scaling, which is expected to improve freezing damage resistance.
Durability under repeated dynamic load

An authority in Japan reported on the application of PVA fiber reinforced concrete roadbeds with KURALON™ RF 4000/30 mm - 2.0 vol % has a capability of withstanding more than 100,000 cycles of dynamic load with 13 times of a designated load value.

KURALON™ has been used on some Japanese railway tracks. Compared to ballast, KURALON™ is more durable and requires less exchange and maintenance.
Case study – Focus on the life time benefits

Basis of calculation
This study is based on the guideline for LCC of constructions published in 2004 by Japanese Civil Engineering Consultants Association.

In this study, we assumed partial repair every 25 years without any renewal construction for 100 years, assuming a PVC-FRC slab deck.

Result of study
The initial cost of the PVA-FRC slab deck is a little higher than the commodity RC deck slab, but the total cost over 50 years is lower than using the commodity method.
Life cycle assessment of the PVA-SHCC(ECC) joint slab deck for bridges

Advantages of PVA-SHCC(ECC) over conventional systems*

*Keoleian et al. estimated that the ECC link slab system consumes 40% less total primary energy and produces 39% less carbon dioxide in comparison with the traditional steel joint system. Keoleian et al. estimated that the ECC bridge deck system has significant advantages in environmental performance: 40% less life cycle energy consumption, 50% less solid waste generation, in comparison with the traditional steel joint system.

KURALON K-II™ for UHPC—Design oriented building application

KURALON K-II™ high-tenacity type is produced by Kuraray’s special spinning process. In addition to its high mechanical properties, it has high adhesiveness to cement materials and alkali resistance, which makes it an ideal fiber for UHPC, standing for Ultra High-Performance Concrete in the construction industry.

APPLICATIONS
- Iconic PVA fiber-UHPC façade, solar shading, ceiling
- PVA fiber UHPC furniture

BENEFITS
- Design oriented building material
- Thin and lightweight
- Durable building materials with good affinity to cement
- Design flexibility with less chipping & less crack building materials
- No rust stains

Tram Station Canopy by UHPC
KURALON K-II™ – Technical data to create UHPC for façade

New fiber: RF400H/12mm

In 2022, we launched RF400H, a higher strength fiber for UHPC. We conducted bending tests with RF400, conventional fiber and RF400H for general UHPC mix design.

<table>
<thead>
<tr>
<th>Tensile Strength (MPa)</th>
<th>RF400 (current fiber)</th>
<th>RF400H (new fiber)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,100</td>
<td>1,400</td>
</tr>
</tbody>
</table>

Mix Proportion

<table>
<thead>
<tr>
<th></th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water/Binder</td>
<td>0.18</td>
</tr>
<tr>
<td>Water/Cement</td>
<td>0.21</td>
</tr>
<tr>
<td>Sand/Binder*</td>
<td>0.92</td>
</tr>
<tr>
<td>Silica Fume/Binder</td>
<td>0.14</td>
</tr>
</tbody>
</table>

* Binder: OPC + Silica Fume

Flexural test method

Compressive strength: 110–120 N/mm²

Test condition:
Specimen size: W x D x L = 40 x 40 x 160 (mm)
Load speed: 0.2 mm/min
General map of fiber dosage vs. items for each application or mix

KURALON™ and KURALON K-II™ product range meet your demands

- **Dosage**
  - 3.0vol% (39kg/m³)
  - 2.0vol% (26kg/m³)
  - 1.0vol% (13kg/m³)
  - 0.5vol% (6.5kg/m³)
  - 0.1vol% (1.3kg/m³)

- **Diameter**
  - 27μm
  - 45μm
  - 100μm
  - 200μm
  - 660μm

- **ECC**
  - 3D concrete printing, etc.

- **Durable concrete & mortar with ductility**
  - Concrete slab
  - Concrete pavement
  - Retaining wall
  - Curtain wall
  - Airport Apron & Taxiway
  - Permanent framework
  - Steps
  - Floor panel

- **Improvement of lightweight concrete**
  - Offshore structures etc.

- **Cracking control**
  - High performance repair mortar (Polymer modified mortar)

- **UHPC, UHPFRC, UFC**
  - Facade, Sun shading, Ceiling etc.

<table>
<thead>
<tr>
<th>Fiber Diameter</th>
<th>Fiber Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>27μm</td>
<td>RMS702/6mm</td>
</tr>
<tr>
<td>45μm</td>
<td>RSC15/6mm</td>
</tr>
<tr>
<td>100μm</td>
<td>REC515/6mm</td>
</tr>
<tr>
<td>200μm</td>
<td>RECS100L/12mm</td>
</tr>
<tr>
<td>660μm</td>
<td>RF400/12mm</td>
</tr>
<tr>
<td></td>
<td>RF400/6mm, 12mm</td>
</tr>
<tr>
<td></td>
<td>RF400/12mm, 13mm</td>
</tr>
</tbody>
</table>
Your Contacts

Booth No. 50

KURARAY CO., LTD.
Tokiwabashi Tower, 2-6-4, Otemachi, Chiyoda-ku, Tokyo 100-0004/Japan
+81 3 6701 1358

KURARAY EUROPE GMBH
Philipp-Reis-Straße 4 D-65795 Hattersheim am Main/Germany
+49 69 305 85377

KURARAY AMERICA INC.
460 Greenway Industrial Drive, Suite E, Ft. Mill SC 29708/USA
+1 803 396 7359

October 31, 2023