

RELIABLE OPTIMAL USE OF MATERIALS FOR WIND TURBINE ROTOR BLADES



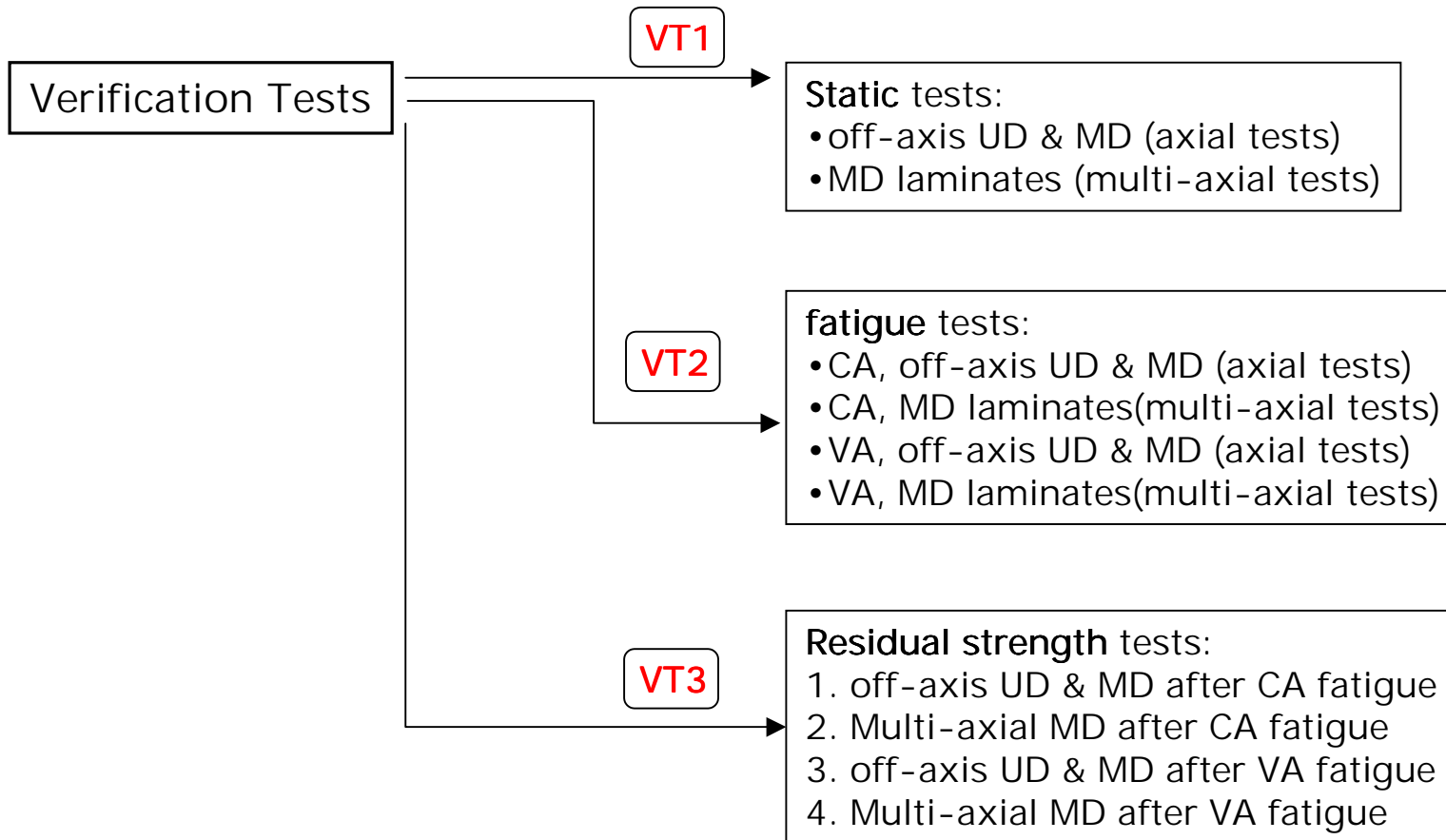
**OPTIMAT BLADES**

(ENK6-CT-2001-00552)

# Verification test program. UD off-axis and MD specimens

TASK GROUP 2: Investigation of blade material behavior  
under complex stress states

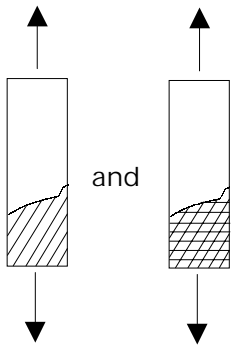
Theodore P. Philippidis, April 2002  
University of Patras, Dept. of Mechanical Engineering & Aeronautics





## VT1. Verification tests for static strength

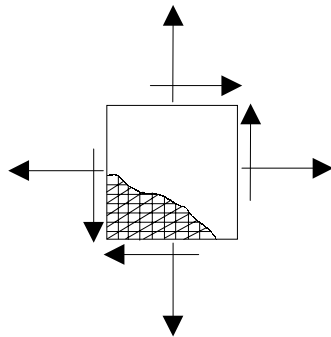
### VT1.1 off-axis UD & MD (axial tests)



At 2 different off-axis orientations, e.g.  $10^\circ$  and  $60^\circ$ , 6 coupons (3T+3C),  
2 different laminates (UD and MD) = **24 coupons**

**Time schedule: 1 week (24 coupons)**

### VT1.2 MD laminates (multi-axial tests)



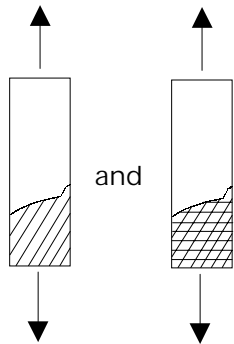
At 2 different complex stress states (pressure and suction representative)  
5 specimens from MD laminates = **10 specimens**

**Time schedule: 2 weeks (10 specimens)**



## VT2. Verification tests for fatigue strength

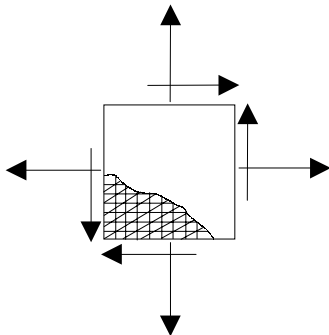
### VT2.1 CA off-axis UD & MD (axial tests)



At 2 different off-axis orientations, e.g.  $10^\circ$  and  $60^\circ$ , 5 coupons, 2 different Laminates, high ( $10^6$ ) and low ( $10^3$ ) cycle fatigue (different stress ratios can be used for UD and MD laminates) = **40 coupons**

**Time schedule: 3 months (40 coupons)**

### VT2.2 CA MD laminates (multi-axial tests)



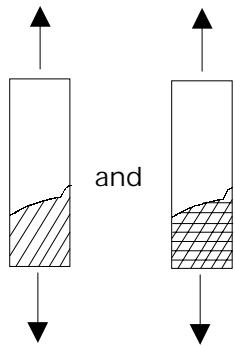
At 2 different complex stress states (pressure and suction representative) 5 specimens from MD laminates, high ( $10^6$ ) and low ( $10^3$ ) cycle fatigue = **20 specimens**

**Time schedule: 2 months (20 specimens)**



## VT2. Verification tests for fatigue strength

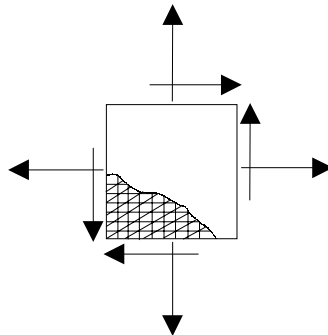
### VT2.3 VA off-axis UD & MD (axial tests)



At 2 different off-axis orientations, e.g.  $10^\circ$  and  $60^\circ$ , 5 coupons, 2 different laminates (UD and MD), under VA loading = **20 coupons**

**Time schedule: 2 months (20 coupons)**

### VT2.4 VA MD laminates (multi-axial tests)



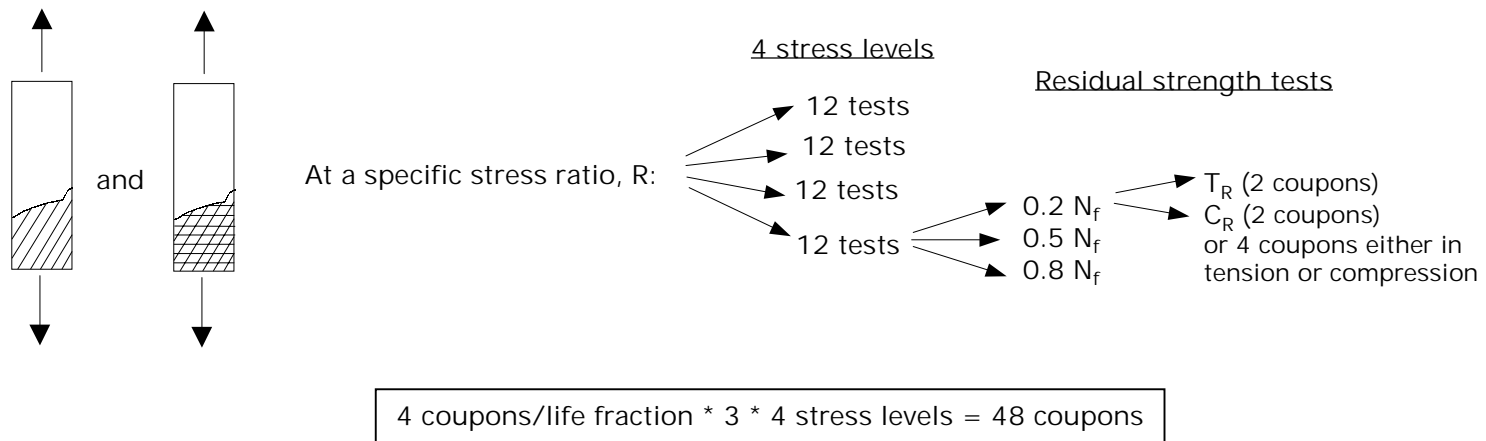
At 2 different complex stress states (pressure and suction representative) 5 specimens from MD laminates, VA loading = **10 specimens**

**Time schedule: 1 month (10 specimens)**



## VT3. Verification tests for residual strength

### VT3.1 off-axis UD & MD after CA fatigue

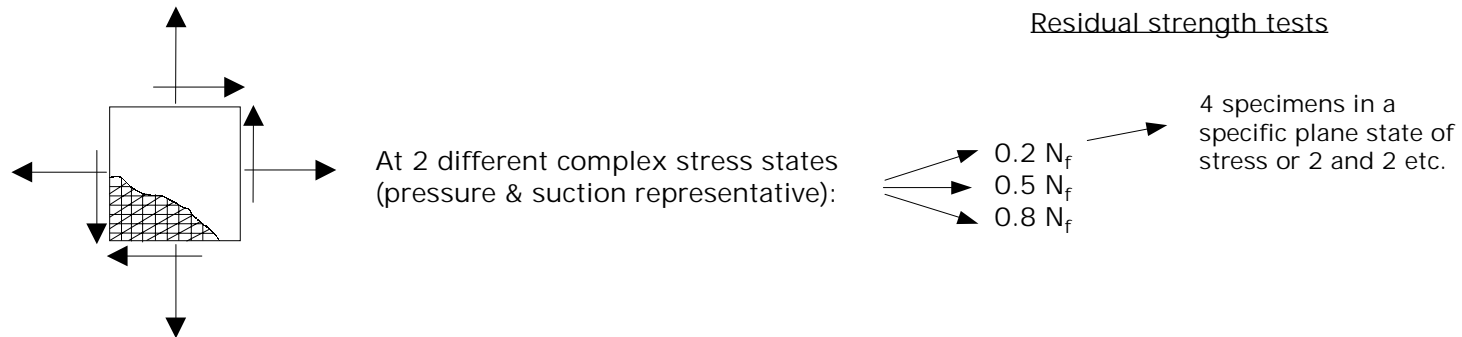


**Time schedule:** 1.2 months for 48 coupons. **Therefore, 1.2 months \* 2 (UD, MD) = 2.4 months (96 coupons)**



## VT3. Verification tests for residual strength

### VT3.2 multi-axial MD after CA fatigue



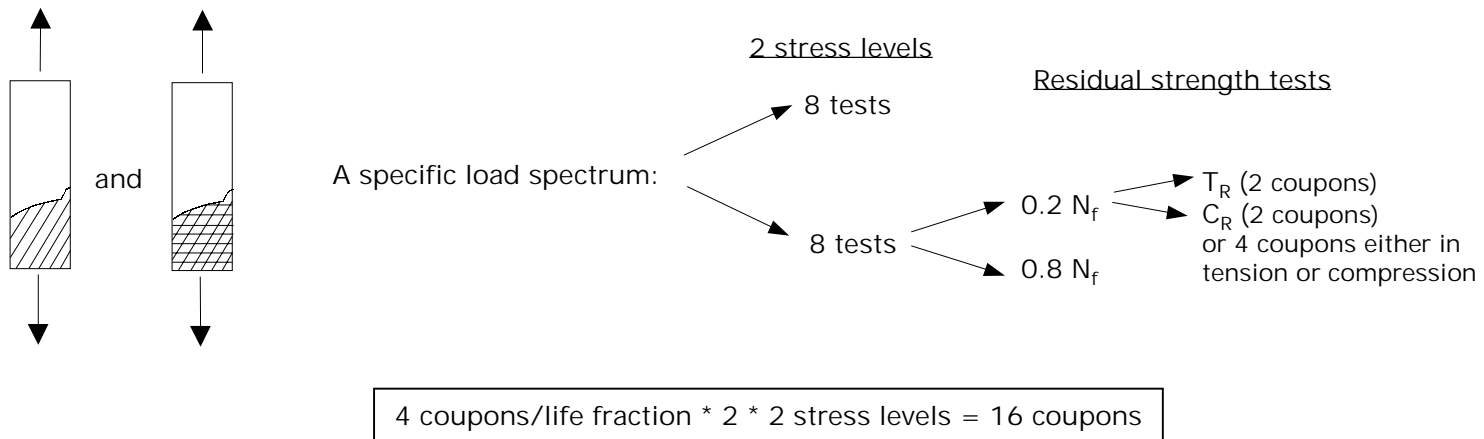
2 complex stress states \* 4 specimens/life fraction \* 3 = 24 specimens

**Time schedule: 2 months (24 specimens)**



## VT3. Verification tests for residual strength

### VT3.3 off-axis UD & MD after VA fatigue

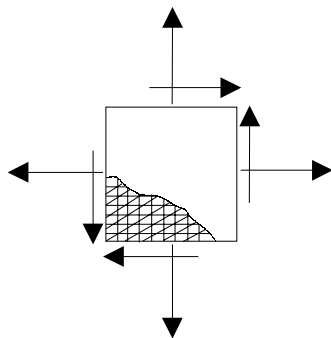


**Time schedule:** 0.4 months for 16 coupons. Therefore, 0.4 months \* 2 (UD, MD)  $\approx$  1.0 month (32 coupons)



## VT3. Verification tests for residual strength

### VT3.4 multi-axial MD after VA fatigue



At 2 different complex stress states (pressure & suction representative and where different loading axes could simulate different spectra):

#### Residual strength tests

0.2  $N_f$   
0.8  $N_f$

4 specimens in a specific plane state of stress or 2 and 2 etc.

2 complex stress states \* 4 specimens/life fraction \* 2 = 16 specimens

**Time schedule: 1 month (16 specimens)**