Main Rotor Blade Analysis in Helicopter Accident Investigation

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Purposes and Goals

➔ Establish the last flight path, heading, and attitude and of the helicopter
➔ Establish the RPM of the main rotor and engine power levels
➔ Establish drive train continuity
➔ Establish sequence of events of the accident
Investigator must have a limited knowledge of the design of the rotor system and blade.
Design of Main Rotor Blades

- Wooden symmetrical airfoil
- Nickel leading edge, wooden filler, steel spar
Design of Main Rotor Blades

→ Aluminium spar and skin, honeycomb core
Design of Main Rotor Blades

➔ Composite asymmetrical airfoil
➔ Uni-directional S-2 glass/ epoxy fabric & E glass/ epoxy tape, fibreglass spar
➔ Superior fatigue tolerance, notch and corrosion resistance
Main Rotor Design Differences

- Normally wider cord / longer length blades
- Higher main rotor RPM/ higher blade inertia

Two Bladed Systems, (teetering, semi-rigid)
Main Rotor Design Differences

- Blades usually lighter construction, less cord, less length
- Main rotor RPM values marginally lower to compensate for cord area differences

Fully articulated, multi-blade systems
Main Rotor Design Differences

- Blades same construction as multi-bladed system
- Main rotor RPM values same as multi-bladed system

Coaxial- counter rotating, multi-blade systems
Main Rotor Damage Differences

- Blade bending, not shattering
- Blades generally intact
- Blade bending inboard and downward
- High angle of attack = blade tearing aft of spar

Low Main Rotor RPM
Main Rotor Damage Differences

→ Blade tip weights intact

Low Main Rotor RPM
Main Rotor Damage Differences

- Spar fractures, trailing edge separation
- Honeycomb fractured and separated
- Damage mainly to outboard sections of blade

High Main Rotor RPM
Main Rotor Damage Differences

➔ Tip weights “ejected”
➔ May travels for kilometres from the impact site (farther distances for multi-bladed systems)

High Main Rotor RPM
Main Rotor Damage Differences

➔ First blade to impact surface most damaged
➔ Following blades exhibit lesser damage due to main rotor inertia bleed off

High Main Rotor RPM
Main Rotor Damage Differences

Damage is in plane

High Main Rotor RPM
Main Rotor Damage Differences

→ Massive blade distortion on multi-bladed systems
→ Blades sustain more damage due to lighter construction
→ Articulated systems, dynamic stops fail

High Main Rotor RPM
Main Rotor Damage Differences

- Blade spindling/distortion
- Spar fractures depending on main rotor RPM
- Bending of spar depending on angle of attack

Damage From Water Impact
Factors Effecting Main Rotor RPM

➔ Inertia of the blade- with high inertia will lose RPM slowly with increased angles of attack
➔ Higher the helicopter gross weight and/or density altitude= more the blade wants to overspeed
➔ Manoeuvring- tends to increase RPM due to energy enhancement of the rotor system
Supporting Evidence

- Will collaborate other evidence
- Distorted or broken
- Direction of force will collaborate power on or off and autorotation

Main Rotor Controls
Damage to pitch horn, blade grip, mast assembly on semi-rigid and rigid systems = indication of high RPM

Main Rotor System
Supporting Evidence

→ Torque-tension strap damage

Main Rotor System
MR Spindle shear damage

Main Rotor System

Spindle sheared
Supporting Evidence

→ Swashplate duplex bearing damage = indication of high RPM

Main Rotor Swashplate
Supporting Evidence

- Pitch change rod end attachment damage
- Static overload indications = high RPM
- "Necking" indications = low RPM

Main Rotor Controls
Summary

Sometimes you just have a bad day!
Sometimes you never understand!?!?!?!?!
Thank you for your attention!