GROUND RESONANCE

From my understanding the back ground of today’s audience, I believe we should all know what ground resonance is all about. However, there are some recovery or normal procedures often over looked that can induce ground resonance if it has not happened yet.

Due to the considerable weight and high RPM the rotor is spinning at, there is tremendous momentum (energy) stored in the rotor disc. The disc must be rotating at the aerodynamic center at high RPM and at a physically balanced center at low RPM, if the rotor disc C.G. shifts slightly outside of the center of the mast, throwing the rotor system out of alignment against the airframe. On the ground without an oleo damper system for the landing gear, the helicopter goes into ground resonance.

The destruction is brought on by the considerable stored energy (momentum) in each of the rotor blades in the rotor system taking the mast with it outside of the geometric center of the mast. The shaking rapidly grows in violence, exceeding the structure strength of the mast, transmission mounts, and the oleo dampers. The cyclic in the cockpit may emulate the rotor disc movement (rotor feedback) so violently that the pilot sometimes cannot hold it, the rotor blades may strike the tail boom and or the cockpit, promptly the helicopter disassemble itself, moments later the helicopter is a pile of junk.

From most helicopter flying handbook we will find this familiar language,

if the helicopter develops ground resonance while there is flying RPM, the pilot should come to hover right away to stop the resonance. If the helicopter does not have flyable RPM while on the ground, the ground resonance develops, the pilot should promptly roll off the throttle and shut down the engine.

Watch this video: AS350 Ground Resonance Brazil 10252016.mp4
There are some very important awareness for the pilots who fly fully articulated rotor system not mentioned in any books or in their training. The first one that comes into my mind is when EVER any pilot sits in any type of helicopter, during the ground run up or shutting down process, the pilot should be keenly aware of the shaking that is present or progressing in the airframe. The shaking or vibration in the frame or in the flight control should be immediately resolved by moving the cyclic in a small circle. Somewhere in that small circular movement there will be a quiet spot, that’s the spot the pilot should position the cyclic at. That position is not always the same position. Depends on the slope, wind velocity and direction the position of cyclic changes accordingly.

For a fully articulated rotor system this procedure should minimize the possibility of potential ground resonance and wear and tear of the droop stop. For a semi-rigid rotor system this should minimize the wear and tear of mast pumping or the transmission mount. For a composite or a rigid rotor system this will minimize the mast bolts limitation excursion and transmission mount wear and tear.

Usually ground resonance does not just explodes into action in the fully articulated rotor helicopter. It always starts in a small wobble and if the pilot ignores it or not aware of what can happen quickly, not taking action immediately to minimize the wobble, ground resonance will take charge of the helicopter. When the wobble starts, the pilot should immediately move the cyclic in a small circle to quiet down the oscillation. This is the first step. If this is not enough, then the pilot needs to get light on the skids with collective. Getting light on the skids does two things to the rotor system.

1. It reduces the up and down action of airframe bouncing off the ground due to wobble.
2. It will put the blades into the aerodynamic balance state so the airframe would not wobble which excites the airframe into ground resonance

If the above actions is not satisfactory, then the pilot needs to rise into a hover to calm down the airframe and try to land on a different surface that’s softer, like on the grass pad or a dirt field. Keep in mind these reaction from pilot should be intuitive and quickly.

This video is for after landing, helicopter has flying RPM, if ground resonance occurs the pilot should raise the collective to get airborne. A scene from TV series in the 80's, a Gazelle recovered from Ground Resonance: Gazelle lift off GR 10252016.mp4

The second point most pilots aren’t aware of is, according to the check list and teaching, the first thing pilot should do after landing is to reduce engine RPM to a cool down RPM, starts the clock for engine cool down count down, friction down the flight controls and then onto other items on the check list. Do we see any problem here?
Keep in mind there are some very big and strong pilots around. After they friction down the flight control, if ground resonance occurs, the pilot pulls the collective to raise the helicopter into the air, while the helicopter is in the air, the cyclic being fractioned down so tight, it flies like there is a hydraulic failure. Many pilot have no experience to hover a hydraulic failed helicopter, their immediate thoughts are the helicopter is not controllable and give up, the crash happens. Therefore, the application of friction device on the flight controls after landing should have this consideration in mind.

According to the pilot handbook, the pilot should cut the throttle if ground resonance occurs while the rotor does not have flyable RPM. This is too general a statement to make for an emergency situation, if the pilot follow this advice generally, the outcome will be a self-destructed helicopter.

The pilot should remember only during start up rotor engagement if the oscillation starts, the pilot should immediately shut the engine down and disengage the rotor. This is very rare situation now with new rotor head design. The next situation would be while the pilot is cooling down the engine and the oscillation starts. Again very rare situation to have a ground resonance. But if one should starts to develop while at intermediate cool down stage, move the cyclic and raise the collective to get light on the skids should minimize the opportunity of getting into a ground resonance.

“Ground resonance has not been "solved", and is still a big concern for anyone who flies a helicopter with a fully-articulated rotor system. It basically is an out-of-balance condition in the rotor system of a helicopter on the ground that rapidly increases in frequency until the helicopter shakes itself apart. It is usually caused by a hard ground contact, and is much more likely in aircraft with improperly maintained landing gear (deflated oleo struts, for example).”

The above statement was an excerpt from someone in the internet not sure who and where from. I agree with all of it except the part “Ground resonance has not been "solved". We have as helicopter designers for approved production helicopter. It’s the people not knowledgeable enough to handle the helicopter that caused many incidents or accidents. Sometimes maybe it’s a part or a component of the helicopter that is not quite up to par that starts the oscillation.

Here is a video of a H300B helicopter that went into ground resonance. It was acquired by AMI for teaching the maintenance technicians in the class. Usually the maintenance schools acquire barely flyable aircrafts, engines, and airframes for the purpose of using them as teaching tools for their classes. AMI Ground Resonance 10272016.mp4
Remember this happened in 2008. Only 8 years ago here in the US and in a maintenance technical school! Attached pictures should tell you why.

Oleo Strut