

**Helicopter Control:**

# What is Ground Resonance?



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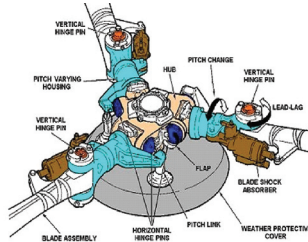
Before getting into the finer details of ground resonance, we should first have a basic understanding of the different rotor systems found on helicopters.

As explained in a prior article on the issue of retreating blade stall, dissymmetry of lift is compensated for by blade flapping. The advancing blade of the helicopter will flap upward, thereby reducing its angle of attack and thus the amount of lift created. Simultaneously the retreating blade will flap down, leading to an increase in lift, to compensate for the reduced relative airflow being experienced.

In a two-bladed rotor system, such as the Bell UH-1 or Jet Ranger 206, a semirigid rotor system is utilised whereby one of the blades may flap upwards with a corresponding downward movement of the second blade, much like a seesaw type of action. Two bladed helicopters can not experience ground resonance as the blades remain balanced through all flight conditions and no drag hinges are utilised, but more about that later.

Correspondingly, in machines such as the BO 105 & 117, a rigid rotor system is utilised whereby the hub and blades are rigidly connected without utilising any hinges. In order to negate dissymmetry of lift, the actual blade can flex much like the wings of a bird in flight. Two advantages of this system are that these helicopters are capable of aerobatic flight and mast bumping becomes a thing of the past. Once again, owing to the lack of drag hinges, ground resonance can not be experienced by a helicopter with a rigid rotor system.

The majority of three and four



bladed helicopters utilise a full articulated rotor system whereby the blade may still flap upwards or downwards, but totally independent of each other. Horizontal hinges allow for this flapping movement. In addition to this, the blade can still “feather” or rotate about its span or the distance from end-end, to allow for changes in pitch (or angle of attack).

The main difference with a fully articulated system is the incorporation of drag hinges or vertical hinge pins. This allows the blades to swing forwards and backwards in relation to each other in order to reduce stresses during flight and is commonly known as “leading and lagging” or “hunting”. During normal flight, all of the blades are normal spaced at equal distances (or angles) from each other. Should one of the blades go too far or too close

to another blade, the helicopter’s rotor system goes out of balance.

During a hard landing, violent shocks to the landing gear can pass through the helicopter’s fuselage and be transmitted to the rotor disk. This in turn, causes an imbalance in the normal relationship (or angle) between the different blades in a fully articulated rotor system, owing to the movement of the drag hinges. In a three-bladed rotor system, the blades are approximately 120° from each other, plus or minus a small amount and in a four-bladed system, the blades are approximately 90° apart. When the blades become imbalanced, the moving weight of the entire rotor disk is thus unequally distributed.

The corresponding imbalance can be so severe that the violent oscillations that follow can destroy an entire airframe within seconds. In other words, the lead-lag frequency of the rotor system is amplified by the natural frequencies of the airframe which then can lead to catastrophic damage.

Helicopters which utilise skid landing gear are less prone to ground resonance than those with

air-filled wheels (with the associated air-oil landing gear struts!), as the tyres tend to “bounce” during a hard landing. This amplifies the oscillation experienced by the helicopter and the resultant ground resonance effect. Some helicopters come equipped with damping isolating vibrators to absorb the energy of a potential ground resonance frequencies.

**When ground resonance strikes ...**

There are two possible corrective actions to be taken when ground resonance is experienced in a helicopter. If the main rotor RPM is relatively low, lowering the collective and shutting down the engines may be the only course of action. Shutting down the engines lowers the rotor RPM and by lowering the collective the pitch on the individual blades are reduced and thus the corresponding lift as well. This in turn will ensure that the tendency for the blades to move or “hunt”, (through movement of the drag hinges) is reduced. This reduction may allow for the blades to return to their normal in-phase position if the action is taken timeously and stop the ground resonance from destroying the helicopter.

However, if the Rotor RPM is in the normal range, the only corrective action is to take-off immediately without hesitation. This breaks contact with the ground and allows the blades to realign themselves back to their normal relationship or position. •

For a truly dramatic demonstration of ground resonance, have a look at:  
[http://www.heli-chair.com/videos\\_public/full\\_scale\\_heli\\_videos/ground\\_resonance/](http://www.heli-chair.com/videos_public/full_scale_heli_videos/ground_resonance/)



Safe Flying!