helicopter, while the relative airflow on the retreating side is lower. This dissymmetry of lift increases as forward speed increases.

To generate the same amount of lift across the rotor disc, the advancing blade flaps up while the retreating blade flaps down. This causes the angle of attack to decrease on the advancing blade, which reduces lift, and increase on the retreating blade, which increases lift. As the forward speed increases, at some point the low blade speed on the retreating blade, together with its high angle of attack, causes a loss of lift (stall).

Retreating blade stall is a major factor in limiting a helicopter's top forward speed (V_{NE}) and can be felt developing by a low frequency vibration, pitching up of the nose, and a roll in the direction of the retreating blade. High weight, low rotor r.p.m., high density altitude, turbulence and/or steep, abrupt turns are all conducive to retreating blade stall at high forward airspeeds. As altitude is increased, higher blade angles are required to maintain lift at a given airspeed. Thus, retreating blade stall is encountered at a lower forward airspeed at altitude. Most manufacturers publish charts and graphs showing a V_{NE} decrease with altitude.

When recovering from a retreating blade stall condition, moving the cyclic aft only worsens the stall as aft cyclic produces a flare effect, thus increasing angles of attack. Pushing forward on the cyclic also deepens the stall as the angle of attack on the retreating blade is increased. Correct recovery from retreating blade stall requires the collective to be lowered first, which reduces blade angles and thus angle of attack. Aft cyclic can then be used to slow the helicopter.

GROUND RESONANCE

Ground resonance is an aerodynamic phenomenon associated with fully-articulated rotor systems. It develops when the rotor blades move out of phase with each other and cause the rotor disc to become unbalanced. This condition can cause a helicopter to self-destruct in a matter of seconds. However, for this condition to occur, the helicopter must be in contact with the ground.

If you allow your helicopter to touch down firmly on one corner (wheel type landing gear is most conducive for this) the shock is transmitted to the main rotor system. This may cause the blades to move out of their normal relationship with each other. This movement occurs along the drag hinge. [Figure 11-5]

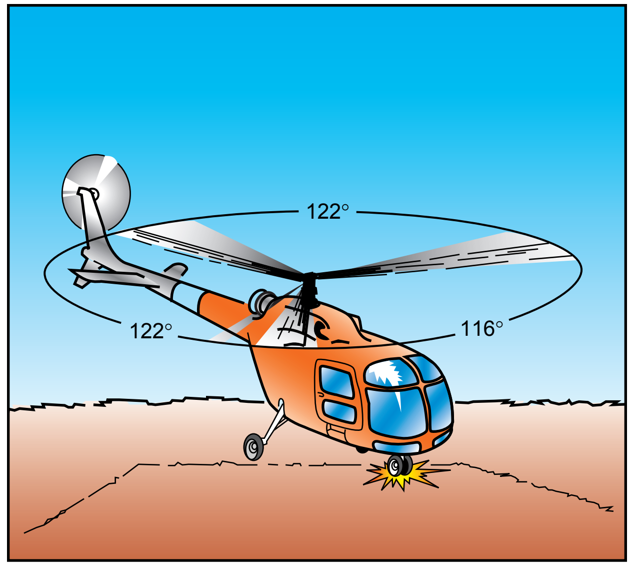

Figure 11-5. Hard contact with the ground can send a shock wave to the main rotor head, resulting in the blades of a three-bladed rotor system moving from their normal 120° relationship to each other. This could result in something like 122°, 122°, and 116° between blades. When one of the other landing gear strikes the surface, the unbalanced condition could be further aggravated.

If the r.p.m. is low, the corrective action to stop ground resonance is to close the throttle immediately and fully lower the collective to place the blades in low pitch. If the r.p.m. is in the normal operating range, you should fly the helicopter off the ground, and allow the blades to automatically realign themselves. You can then make a normal touchdown. If you lift off and allow the helicopter to firmly re-contact the surface before the blades are realigned, a second shock could move the blades again and aggravate the already unbalanced condition. This could lead to a violent, uncontrollable oscillation.

This situation does not occur in rigid or semirigid rotor systems, because there is no drag hinge. In addition, skid type landing gear are not as prone to ground resonance as wheel type gear.

DYNAMIC ROLLOVER

A helicopter is susceptible to a lateral rolling tendency, called dynamic rollover, when lifting off the surface. For dynamic rollover to occur, some factor has to first cause the helicopter to roll or pivot around a skid, or landing gear wheel, until its critical rollover angle is reached. Then, beyond this point, main rotor thrust continues the roll and recovery is impossible. If the critical rollover angle is exceeded, the helicopter rolls on its side regardless of the cyclic corrections made.

Dynamic rollover begins when the helicopter starts to pivot around its skid or wheel. This can occur for a variety of reasons, including the failure to remove a tiedown or skid securing device, or if the skid or wheel