- The airplane will experience a reduction in static source pressure as it leaves the ground effect area and a corresponding increase in indicated airspeed.

Due to the reduced drag in ground effect, the airplane may seem to be able to take off below the recommended airspeed. However, as the airplane rises out of ground effect with an insufficient airspeed, initial climb performance may prove to be marginal because of the increased drag. Under conditions of high-density altitude, high temperature, and/or maximum gross weight, the airplane may be able to become airborne at an insufficient airspeed, but unable to climb out of ground effect. Consequently, the airplane may not be able to clear obstructions, or may settle back on the runway. The point to remember is that additional power is required to compensate for increases in drag that occur as an airplane leaves ground effect. But during an initial climb, the engine is already developing maximum power. The only alternative is to lower pitch attitude to gain additional airspeed, which will result in inevitable altitude loss. Therefore, under marginal conditions, it is important that the airplane takes off at the recommended speed that will provide adequate initial climb performance.

Ground effect is important to normal flight operations. If the runway is long enough, or if no obstacles exist, ground effect can be used to an advantage by using the reduced drag to improve initial acceleration. Additionally, the procedure for takeoff from unsatisfactory surfaces is to take as much weight on the wings as possible during the ground run, and to lift off with the aid of ground effect before true flying speed is attained. It is then necessary to reduce the angle of attack to attain normal airspeed before attempting to fly away from the ground effect area.

SHORT-FIELD TAKEOFF AND MAXIMUM PERFORMANCE CLIMB

Takeoffs and climbs from fields where the takeoff area is short or the available takeoff area is restricted by obstructions require that the pilot operate the airplane at the limit of its takeoff performance capabilities. To depart from such an area safely, the pilot must exercise positive and precise control of airplane attitude and airspeed so that takeoff and climb performance results in the shortest ground roll and the steepest angle of climb. [Figure 5-7]

The achieved result should be consistent with the performance section of the FAA-approved Airplane Flight Manual and/or Pilot's Operating Handbook (AFM/POH). In all cases, the power setting, flap setting, airspeed, and procedures prescribed by the airplane's manufacturer should be followed.

In order to accomplish a maximum performance takeoff safely, the pilot must have adequate knowledge in the use and effectiveness of the best angle-of-climb speed (V_X) and the best rate-of-climb speed (V_Y) for the specific make and model of airplane being flown.

The speed for V_X is that which will result in the greatest gain in altitude for a given distance over the ground. It is usually slightly less than V_Y which provides the greatest gain in altitude per unit of time. The specific speeds to be used for a given airplane are stated in the FAA-approved AFM/POH. It should be emphasized that in some airplanes, a deviation of 5 knots from the recommended speed will result in a significant reduction in climb performance. Therefore, precise control of airspeed has an important bearing on the successful execution as well as the safety of the maneuver.

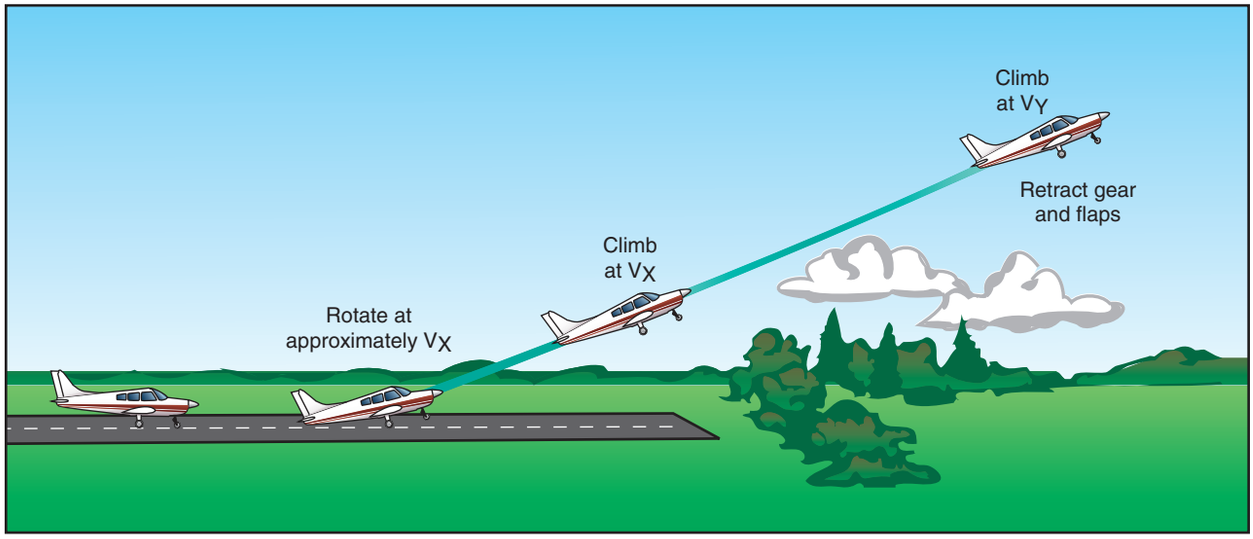

Figure 5-7. Short-field takeoff.

TAKEOFF ROLL

Taking off from a short field requires the takeoff to be started from the very beginning of the takeoff area. At this point, the airplane is aligned with the intended takeoff path. If the airplane manufacturer recommends the use of flaps, they should be extended the proper amount before starting the takeoff roll. This permits the pilot to give full attention to the proper technique and the airplane's performance throughout the takeoff.

Some authorities prefer to hold the brakes until the maximum obtainable engine r.p.m. is achieved before allowing the airplane to begin its takeoff run. However, it has not been established that this procedure will result in a shorter takeoff run in all light single-engine airplanes. Takeoff power should be applied smoothly and continuously—without hesitation—to accelerate the airplane as rapidly as possible. The airplane should be allowed to roll with its full weight on the main wheels and accelerated to the lift-off speed. As the takeoff roll progresses, the airplane's pitch attitude and angle of attack should be adjusted to that which results in the minimum amount of drag and the quickest acceleration. In nosewheel-type airplanes, this will involve little use of the elevator control, since the airplane is already in a low drag attitude.

LIFT-OFF

Approaching best angle-of-climb speed (V_X), the airplane should be smoothly and firmly lifted off, or rotated, by applying back-elevator pressure to an attitude that will result in the best angle-of-climb airspeed (V_X). Since the airplane will accelerate more rapidly after lift-off, additional back-elevator pressure becomes necessary to hold a constant airspeed. After becoming airborne, a wings level climb should be maintained at V_X until obstacles have been cleared or, if no obstacles are involved, until an altitude of at least 50 feet above the takeoff surface is attained. Thereafter, the pitch attitude may be lowered slightly, and the climb continued at best rate-of-climb speed (V_Y) until reaching a safe maneuvering altitude. Remember that an attempt to pull the airplane off the ground prematurely, or to climb too steeply, may cause the airplane to settle back to the runway or into the obstacles. Even if the airplane remains airborne, the initial climb will remain flat and climb performance/obstacle clearance ability seriously degraded until best angle-of-climb airspeed (V_X) is achieved. [Figure 5-8]

The objective is to rotate to the appropriate pitch attitude at (or near) best angle-of-climb airspeed. It should be remembered, however, that some airplanes will have a natural tendency to lift off well before reaching V_X. In these airplanes, it may be necessary to allow the airplane to lift off in ground effect and then reduce pitch attitude to level until the airplane accelerates to best angle-of-climb airspeed with the wheels just clear of the runway surface. This method is preferable to forcing the airplane to remain on the ground with forward-elevator pressure until best angle-of-climb speed is attained. Holding the airplane on the ground unnecessarily puts excessive pressure on the nosewheel, may result in "**wheelbarrowing**," and will hinder both acceleration and overall airplane performance.

INITIAL CLIMB

On short-field takeoffs, the landing gear and flaps should remain in takeoff position until clear of obstacles (or as recommended by the manufacturer) and V_Y has been established. It is generally unwise for the pilot to be looking in the cockpit or reaching for landing gear and flap controls until obstacle clearance is assured. When the airplane is stabilized at V_Y, the gear (if equipped) and then the flaps should be retracted. It is usually advisable to raise the flaps in increments to avoid sudden loss of lift and settling of the airplane. Next, reduce the power to the normal climb setting or as recommended by the airplane manufacturer.

Common errors in the performance of short-field takeoffs and maximum performance climbs are:

- Failure to adequately clear the area.
- Failure to utilize all available runway/takeoff area.
- Failure to have the airplane properly trimmed prior to takeoff.
- Premature lift-off resulting in high drag.
- Holding the airplane on the ground unnecessarily with excessive forward-elevator pressure.
- Inadequate rotation resulting in excessive speed after lift-off.
- Inability to attain/maintain best angle-of-climb airspeed.

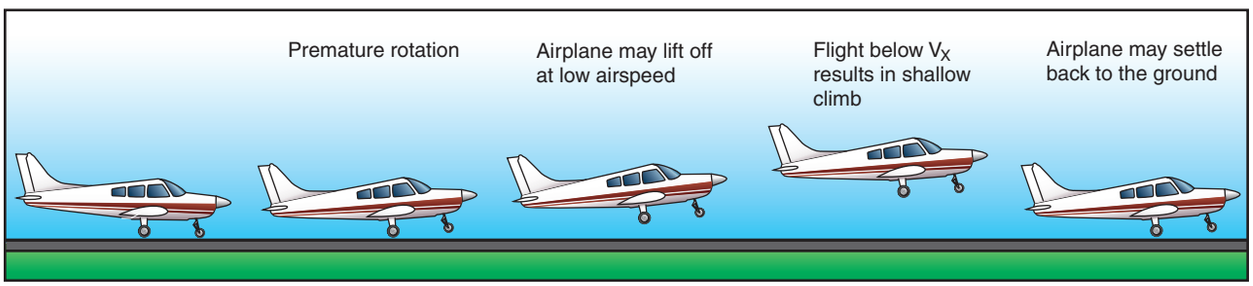

Figure 5-8. Effect of premature lift-off.

- Fixation on the airspeed indicator during initial climb.
- Premature retraction of landing gear and/or wing flaps.

SOFT/ROUGH-FIELD TAKEOFF AND CLIMB

Takeoffs and climbs from soft fields require the use of operational techniques for getting the airplane airborne as quickly as possible to eliminate the drag caused by tall grass, soft sand, mud, and snow, and may or may not require climbing over an obstacle. The technique makes judicious use of ground effect and requires a feel for the airplane and fine control touch. These same techniques are also useful on a rough field where it is advisable to get the airplane off the ground as soon as possible to avoid damaging the landing gear.

Soft surfaces or long, wet grass usually reduces the airplane's acceleration during the takeoff roll so much that adequate takeoff speed might not be attained if normal takeoff techniques were employed.

It should be emphasized that the correct takeoff procedure for soft fields is quite different from that appropriate for short fields with firm, smooth surfaces. To minimize the hazards associated with takeoffs from soft or rough fields, support of the airplane's weight must be transferred as rapidly as possible from the wheels to the wings as the takeoff roll proceeds. Establishing and maintaining a relatively high angle of attack or nose-high pitch attitude as early as possible does this. Wing flaps may be lowered prior to starting the takeoff (if recommended by the manufacturer) to provide additional lift and to transfer the airplane's weight from the wheels to the wings as early as possible.

Stopping on a soft surface, such as mud or snow, might bog the airplane down; therefore, it should be kept in continuous motion with sufficient power while lining up for the takeoff roll.

TAKEOFF ROLL

As the airplane is aligned with the takeoff path, takeoff power is applied smoothly and as rapidly as the powerplant will accept it without faltering. As the airplane accelerates, enough back-elevator pressure should be applied to establish a positive angle of attack and to reduce the weight supported by the nosewheel.

When the airplane is held at a nose-high attitude throughout the takeoff run, the wings will, as speed increases and lift develops, progressively relieve the wheels of more and more of the airplane's weight, thereby minimizing the drag caused by surface irregularities or adhesion. If this attitude is accurately maintained, the airplane will virtually fly itself off the ground, becoming airborne at airspeed slower than a safe climb speed because of ground effect. [Figure 5-9]

LIFT-OFF

After becoming airborne, the nose should be lowered very gently with the wheels clear of the surface to allow the airplane to accelerate to V_Y, or V_X if obstacles must be cleared. Extreme care must be exercised immediately after the airplane becomes airborne and while it accelerates, to avoid settling back onto the surface. An attempt to climb prematurely or too steeply may cause the airplane to settle back to the surface as a result of losing the benefit of ground effect. An attempt to climb out of ground effect before sufficient climb airspeed is attained may result in the airplane being unable to climb further as the ground effect area is transited, even with full power. Therefore, it is essential that the airplane remain in ground effect until at least V_X is reached. This requires feel for the airplane, and a very fine control touch, in order to avoid over-controlling the elevator as required control pressures change with airplane acceleration.

INITIAL CLIMB

After a positive rate of climb is established, and the airplane has accelerated to V_Y, retract the landing gear and flaps, if equipped. If departing from an airstrip with wet snow or slush on the takeoff surface, the gear should not be retracted immediately. This allows for any wet snow or slush to be air-dried. In the event an obstacle must be cleared after a soft-field takeoff, the climb-out is performed at V_X until the obstacle has been cleared. After reaching this point, the pitch attitude is adjusted to V_Y and the gear and flaps are retracted. The power may then be reduced to the normal climb setting.

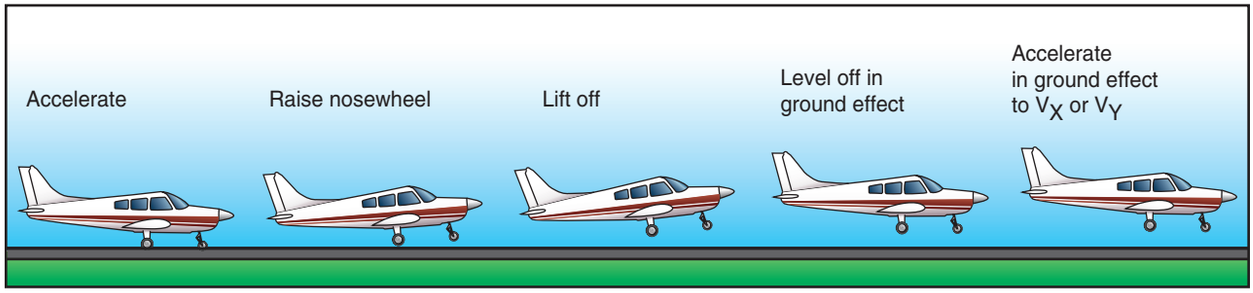

Figure 5-9. Soft-field takeoff.