

# Portable Ladders

## HIGHLIGHTS:

- Ladder setup
- Climbing
- Summary of findings

Following the information presented in this note, choosing the right type of ladder for the job and following common sense rules can ensure the safe use of ladders.

## Ladder Setup

- Check for damaged rungs or side rails, and loose, broken or bent hardware. Check the condition of extension ladder ropes and pulleys. If you think the ladder may be defective, tag it as out-of-service and report it to your supervisor. Do not use it.

- Clean wet or slippery rungs before using the ladder.

- Ask for help when moving or setting up heavy or awkward ladders.

- Check the proper slope:

1. Use the manufacturer's guide; a label with a large "L" on it. Erect so that the long leg of the "L" is parallel to the wall or the short leg is parallel to the ground.
2. While standing erect, with your toes at the base, hold your arms horizontally straight out to the front. The heel of your palm should comfortably reach the side rails.

- Always erect the ladder on a solid level surface. Do not put ladders on top of boxes, barrels or other unstable objects. Install a manufacturer approved "leveler" if the ladder will be used on uneven surfaces.

- Secure the base when raising an extension ladder, never set up when extended.

- Both side rails must rest equally at the top, never on the rung. Install a single support attachment at the top when the ladder cannot rest against a flat surface, such as a pole or corner.

- Protect the base from traffic. If you put the ladder in front of a doorway, make sure the door is locked or guarded. Emergency exits should be cleared quickly, and left clear when your job is finished.



- If you intend to step off at a higher level, the top of the ladder should extend at least 36 inches, but no more than 42 inches above that level, and should be tied off. This allows for a handhold when mounting and dismounting the ladder.
- Secure the ladder against displacement. Tying it at the top, bottom, or both, will depend on local conditions. When securing a ladder at the top, have someone “foot” the bottom until the top is tied off.
- Open stepladders fully and lock the spreader. All feet should contact a level supporting surface.
- Ensure the area around the top and bottom of the ladder is clear of debris and materials that could cause the user to slip when mounting or dismounting.

## Climbing

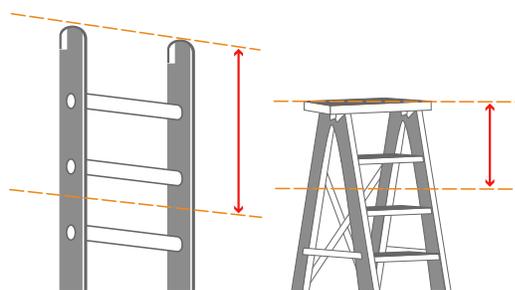


Figure 2

- The base is more likely to slip out as you near the top of the ladder. Nonskid feet may not be sufficient on wet or muddy concrete surfaces. Secure the base.
- If your shoes are muddy or greasy, clean them before you climb.
- Always face the ladder and use both hands while climbing up or down. Use the 3-Point Technique: move one hand or foot at a time, keeping both feet and one hand, or both hands and one foot on the ladder at all times. Carry tools in your pockets, in a tool belt or hoist them on a hand line.

- Keep your eyes on the ladder and watch where you put your hands and feet.
- Stay off the top two rungs of a straight or extension ladder, and the top step and cap of a stepladder (see Figure 2).
- Climb only on the steps of a stepladder, never on the back bracing.
- Climb at a consistent, moderate pace. Climbing too fast increases the chance of missing a rung and increases the friction needed to prevent the ladder from slipping.
- Use ladders only for their intended purpose.
- Never tie ladders together to gain additional height.
- Don't use ladders as braces, gangways or as substitutes for planks.
- Never use a folded stepladder as a straight ladder.

## Spotlight on Research

A study conducted at the Liberty Mutual Research Institute for Safety, in Hopkinton, Massachusetts, investigated the coefficient of friction at the base of a straight ladder needed to prevent slipping. This study evaluated the effects of inclined angle, climbing speed, ladder type, contact at the top and the user's weight.

Seventeen subjects, classified into three groups by body weight (light, intermediate and heavy), performed ladder-climbing tasks under sixteen different climbing conditions. For each condition, the subjects repeated the climbing tasks five times. For each trial, participants were required to climb the ladder a total of ten steps and then descend back to the floor. A force plate was used to measure the normal and tangential ground reaction forces at the bottom of the ladder.

## Summary of Findings

- Inclined angle and climbing speed were the most critical factors affecting the coefficient of friction requirement at the bottom of the ladder.
- The required friction almost doubled when the ladder's inclined angle was flattened to 65°.
- There was a 7% increase in the required friction as subjects increased their climbing speed from 55 to 75 steps per minute.
- The weight of the user affects the required friction, however, not to the same degree as the inclined angle or climbing speed.

## Conclusions

According to the study's findings, inclination angle is a critical parameter affecting the friction requirement at the bottom of a straight ladder. The American National Standard ANSI A14.2-2000 recommends a 4:1 ratio (75.5° angle). Most ladder users, however, have no way to measure the angle of the ladder. Results of other studies showed that when asked to set a ladder at 75° without a measurement device, the resulting angle varied from 67.3° to 76.2°. The data also suggests the importance of climbing speed with respect to safety during straight ladder use. It is critical that users not rush when climbing a ladder.

## Practical Guidelines

Practical guidelines and training are needed to help reduce the number of fall-related injuries from straight ladders.

- Secure straight (or extension) ladders by tying them off.
- Always work facing the ladder.
- Most ladders are designed for single-person use. Follow the manufacturer's instructions.
- Do not leave tools where they could fall on others.
- Do not drop tools; either lower them on a hand line or use a tool belt.
- Move the ladder instead of reaching out too far in any direction. Keep your belt buckle (belly button) between the side rails.
- Never move a ladder while standing on it.
- Ladder jacks can only be used with a type I or IA ladders.

## Remember

- Store ladders when not in use to prevent damage. Protect them from sun and weather.
- Ladder repairs should only be done by qualified people using replacement parts approved by the manufacturer.
- Only non-conductive ladders should be used near electrical conductors.

## References

W.R. Chang, C.C. Chang, S. Matz, D.H. Son, Friction Requirements for Different Climbing Conditions in Straight Ladder Ascending, *Safety Science*, 42 (9), 791-805, 2004.

W.R. Chang, C.C. Chang, Portable Ladders: Understanding and Preventing Slips at their Bases, *Professional Safety*, 50 (9), 26-31, 2005.

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