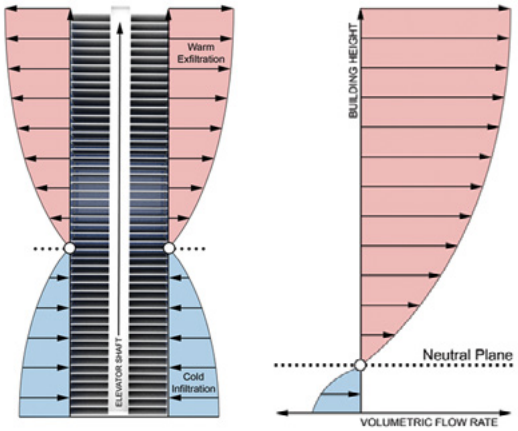
STACK EFFECT

Understanding, mitigating and exploiting the effects of temperature differences within a building



Stack effect is a phenomenon that occurs whenever the temperature inside a building and outside it are different.

Sometimes stack effect can be useful: It contributes to natural ventilation. However, it often has adverse effects that reduce the quality of the occupant experience in a building.

When poorly managed, stack effect can exert strong pressure force on doors, partitions and facades. This pressure causes irritating, costly and dangerous conditions: whistling noises; doors that slam shut or are difficult to open, causing safety issues; migration of odors; uncontrolled energy loss, via loss of conditioned air; and a tendency for elevator doors to jam.

The problem becomes especially pronounced in tall buildings and in designs where the building envelope is not tightly sealed.

Our Service

We help you understand how to “design out” stack effect problems in new construction or mitigate problems in existing buildings. With careful consideration, most adverse effects can be avoided or moderated. We can also help determine whether stack-effect ventilation will help or hinder the energy performance of your building.

We have conducted stack effect studies of many buildings—of all types and heights, in all climates, with all manner of issues. We know the full range of problems that can occur and use this experience in all our studies. We can, on the basis of looking at a set of plans for a building, tell immediately whether there is a risk that stack effect issues may occur.

In working to avoid or resolve these issues, one of our key tools is our powerful, custom-built diagnosis software. This tool allows us to model all of the relevant physics very quickly, even for very complex buildings. As a result, we can easily test different options to make sure you get a solution that best balances cost and benefit.

STACK EFFECT

RWDI is a valuable partner to clients seeking to...

Explore Innovations

- Use natural ventilation effectively within a sustainable design strategy
- Design out stack effect problems

Create Opportunities

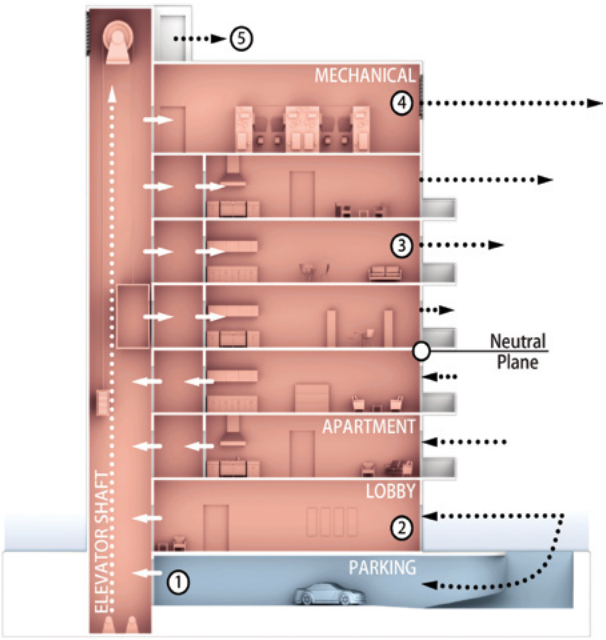
- Increase market appeal by integrating desirable outdoor features without adverse effects
- Reduce operating costs by controlling energy loss

Meet Challenges

- Choose cost-effective strategies to mitigate irritating and dangerous adverse effects (whistles, difficult-to-use doors)

Fulfill Expectations

- Verify designs will meet building code requirements for door force
- Observe recommended noise levels by using design adjustments to reduce the likelihood of whistling



How we work

About the effect

Stack effect is a pressure difference that causes uncontrolled air flow. It occurs when the temperature differs from outside to inside a building. The direction of air flow depends on whether the building is being heated or cooled.

In heating climates, air is drawn in at the base of the building and driven out at the upper levels. The air rises within the building through vertical flow passages, such as elevator shafts, stairwells, atria, risers, cracks in the floor slabs and through any other opening. This air movement is not a result of “hot air rising.”

Rather it occurs because the temperature difference outside to inside results in a density difference outside to inside. This density difference means that air weighs more outside the building than it does inside the building. Thus, at the bottom of the building, the air pressure is higher outside than inside. This differential causes “air infiltration.” That is, it draws air into the building through any opening in the building façade, creating pressures. In a cooling climate, the reverse occurs.

The stack effect pressures must be taken up by the combination of exterior doors, inner vestibule doors, elevator doors and other openings within the air-flow network. It is these pressures that cause elevator doors to seize and doors to whistle.

The greater the temperature difference, the greater the pressures. In addition, the pressures are directly related to building height. Thus, strong pressures are more likely in tall buildings and in very hot or cold climates. However, a building need not be very tall to experience adverse consequences. Some of these consequences include:

- Whistling at doors, to the point where the noise level exceeds recommended noise levels for the space type (residence, school, etc.)
- Doors that slam
- Cold lobbies at the ground floor, when infiltration of cold air overwhelms the heating system
- Uncomfortably hot spaces at the top of a building, when infiltration of hot/humid air overwhelms the air conditioning
- Doors that are hard to open or close, sometimes to the point where the force required to open the door may be higher than code allowances for emergency egress
- Uncontrolled energy loss, as conditioned air is pushed out by infiltrating air
- Odor migration from outdoors or between units in an apartment building
- Problems with elevator operability (jammed doors).

Analysis and design

The analysis of stack effect in a building is complex because it requires the assessment of interacting and parallel flow paths. Diagnosing and mitigating stack effect has been compared to repairing a leaky dam: After you plug one hole, another becomes more important. The flow network in a building is very complicated, and resolving weaknesses in one part of the building can cause a new area to become the leading contributor to problems. In fact, there are times when it is not useful to mitigate one problem area unless all areas on a floor are treated. In such cases, the cost and effort to resolve one problem does not lead to relief in another part of the building.

We have extensive experience with many types of buildings in many climates. We've translated this experience into a proprietary tool that permits us to build a detailed model of a building, of any complexity, very quickly and to rapidly run simulations of different scenarios. With this modeling tool, we can represent all flow paths, including door cracks and shafts (including elevators, stairs and HVAC risers). We can also represent the impact of wind and HVAC pressurization on a zone-by-zone basis. Through scenario testing, we can inspect different aspects of the building to find an effective combination of remedies. In past studies, we have made recommendations such as these:

- Add doors
- Remove unnecessary interior doors
- Add vents to reduce whistling
- Adjust HVAC pressurization
- Change performance specifications on facades and door hardware.

Stack effect studies can also support sustainable building design. We recently extended the stack effect diagnosis tool so that it can run an entire meteorological year. This means that we can now evaluate annual energy losses associated with stack effect. These losses can then be compared to mitigation scenarios to demonstrate the expected energy savings.

