

Architecture 4.411
Building Technology Laboratory
Spring 2004

Assignment 5 Balcony Design and Ventilation through
Chinese Apartments (or a more Western alternative)

March 3 and 4, 2004

The goal of this assignment, the first phase of the lab project that focuses on airflows and building ventilation, is to design, construct in model form, and test an enclosure (partial or full) for a typical balcony for a Chinese apartment. The motivation for this work is to propose feasible designs for Chinese residential buildings that are thermally comfortable and use a minimal amount of energy.

There are three tasks: balcony design, balcony construction, and airflow tests.

1. *Balcony design.* Assume the balcony faces south. The balcony should admit breezes and shade the sun in summer, but collect solar radiation during the cold Beijing winters. Ideally, the balcony would bring some air into the apartment whether or not there is cross- or through-ventilation. The balcony should also admit air into the apartment over a range of wind angles, relative to a direction normal to the balcony. Please at least consider being adventurous in your design, using large air scoops or other not-yet-developed ways of controlling airflow and sun.
2. *Balcony construction.* Please use a scale of 1:10. Your balcony should be 3.9 m wide, 2.7 m high, and 1.5-2.0 m deep. It should be modeled in sufficient detail to permit you to adjust openings for measurements, should be self-supporting, and should be reasonably sturdy. You will place your balcony against an opening in the outer wall of a model apartment, in which airflow measurements will be made.
3. *Airflow tests.* Please make two kinds of tests: quantitative measurements of air speed and qualitative sketches of airflow direction. For air speed, please use a hot-wire anemometer. The probe is both very fragile and very expensive (about \$1000), so give the task your full attention. It is best to work in pairs, with one person making measurements and the other recording the data. For airflow direction, use the quantitative measurements or a means of visualizing the airflow. Optionally, you are free to investigate techniques for flow visualization, including baby powder that we will provide. Experience has shown that these techniques do not work well without considerable care.

The goal of the measurements is to characterize airflows at the entrance to the apartment (from the balcony), throughout at least one room of the apartment itself, and at windows

where air exits the apartment. In each room, there will be holes in which to insert the anemometer probe. Through each hole, it will be possible to take several readings, as a function of the depth of insertion of the probe into the apartment. Measurement locations will be marked. You may have reason to add or subtract measurement points, and can punch small holes into the model as appropriate. For measurements over a three-dimensional grid, the number of data points increases as the cube of the number in one dimension. It is not unreasonable to work at a 3- or 4-point grid for a given room, thereby requiring 27-64 points per room.

Measurements at outlet windows, when combined with window area, will establish the bulk airflow through the apartment, an important metric. Please use the meter to record these air speeds.

The balcony, apartment windows, and wind direction can all vary in an occupied apartment. Balcony windows or wind baffles can be adjusted, apartment windows can be opened or closed, and wind directions can change. For a base case configuration (wind from the south, balcony and apartment windows configured in a manner of your choosing), please take data as noted above. Measurements are required for the living room. Feel free to take more data in other rooms, although this is optional. Please normalize the data by dividing all airspeed measurements by a measure of the free-stream air speed and by dividing the bulk airflow by the apartment volume (which we will provide). Tabulate both the raw and the normalized data. In addition, please sketch the airflow patterns or otherwise present the data in a visually appealing form.

Finally, please repeat the measurements and the analyses with winds at 30- and 60-degree angles to the normal. Knowing that your balcony should be able to scoop winds at an angle should have some influence on your design.

The fan speed can be adjusted. Pick a speed large enough to give you measurable results. Place the fan 1-3 meters away from the model. Draw-through (using the fan behind the model to pull air) rather than blow-through (pushing air) will likely reduce the impact of turbulence associated with the fan.

To conclude, the first phase of the second lab requires three sets of data for three different wind directions. In each data set, there should be quantitative measurements, normalized data, and a qualitative description of airflow direction.

Please construct your balcony during the coming week, in addition to preparing your lab report for the thermal tests. Those who are feeling frisky or who want to use the anemometers and fans in advance of peak demand are invited to take one set of measurements, and compute an air-change rate. Measurements and data analysis will be the focus of the second week of this lab.