# Exterior Shade Rating Strategy

**Background and Suggestions by**
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For NFRC Exterior Attachments TG

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Comments are invited and will be welcomed as we struggle to figure out the best way to develop a reasonable, fair, and somewhat accurate rating system for the country

# Background

- It has been decided to rate attachment products by reference to a set of representative but generic whole windows
- My focus here is on suggesting a logical division between:
  - Truly **attached** exterior shading devices that are **co-planar** (meaning flat and parallel to the window's glazing system) and can reasonably be said to be attached to the window
  - **Attached** shading devices that are **projecting**, like awnings with and without sidefins and angled planes
  - **Detached** shading devices that are **projecting**, like patio awnings attached to eaves and walls above windows

# Window 6

- NFRC currently uses LBNL's Window 5 program, primarily, to determine relevant energy properties of conventional fenestration systems composed of planar glazings and conventional frames
- Even when the relevant properties of product categories can be calculated using Window 5, measured component property values will be needed for input to the program. These include glass and frame material conductivities and solar optical properties, the latter usually measured with an integrating sphere spectrophotometer
- LBNL is developing Window 6 to include Window 5 but also to include additional algorithms for calculating the properties of fenestration systems that incorporate diffuse glazings, interior blinds and roller shades, interior Venetian blinds, between-the-panes blinds, and exterior insect screens, shade screens, and other coplanar exterior shading devices

# Test Versus Calculate

- Though calorimeter and hot box testing are always options for determining solar heat gain and conductive heat transfer properties of complex window systems, including those with shades, any calculate-only method that can be developed and shown to be accurate will be less expensive for manufacturers
- The burden is on the research community within and outside of NFRC to develop test and calculational methods and prove that they are sufficiently accurate to be used for reliable comparisons of the energy performances of competing products

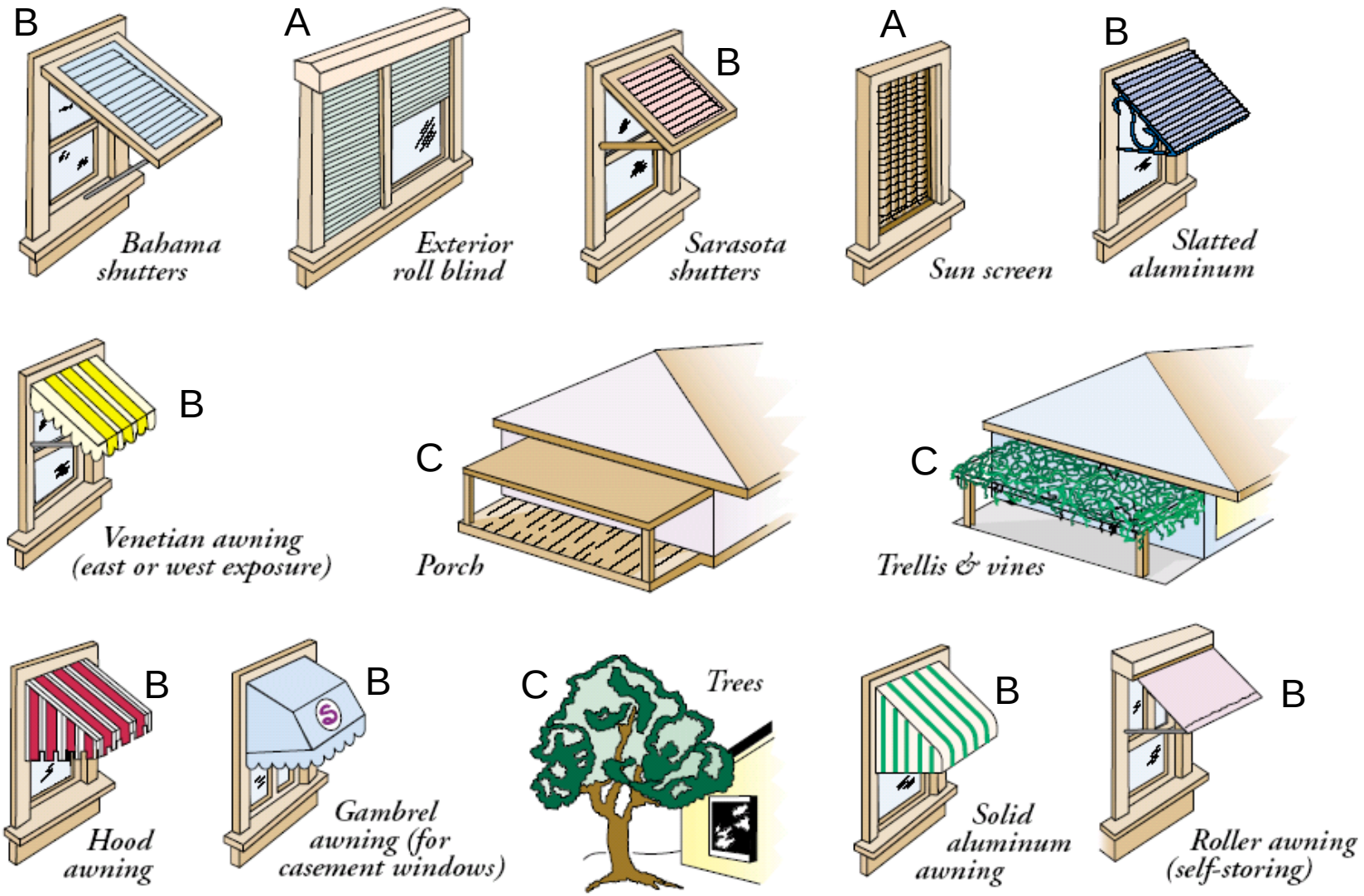
# The NFRC Process

- Product categories not currently included in existing NFRC rating and labeling procedures must be proposed
- NFRC either agrees or rejects a proposed product category for its rating system
- If accepted, research will be needed to find existing test or calculate procedures suitable for NFRC's requirements
- If a found procedure is clearly acceptable, it is a relatively straightforward process to provide testimony from experts in support of that methodology, thereby improving the chances for its acceptance by NFRC as the standard rating methodology.
- If it is not that clear that an existing method is acceptable, a modest research project may be required to support the work of experts in that field to determine technical validity and practicality for NFRC use.
- In some cases, where the products are somewhat complex, a more extensive research project will likely be needed to develop a procedure suitable for NFRC and prove that it is sufficiently technically sound for NFRC adoption.
- If a proposed new procedure can be incorporated in a future revision of the Window 6 program, everyone becomes happy, but this will require both that a calculational procedure be developed and that its accuracy be verified with experimental tests for confirmation of its efficacy.

# Exterior Shade Classification Characteristics

- A. Co-planar attached exterior shading devices
  - Have some effect on the base case window U-factor
  - Parallel layer systems are much easier to include in Window 6 and some of these systems are already being added to the program
- B. Projecting attached exterior shading, such as conventional awnings
  - Being attached to the window, it would be difficult for NFRC to claim they are not part of the window so will most likely have to decide to find a way to include them in the NFRC rating and labeling program
- C. Projecting detached shading devices
  - Being detached, it will be easier for NFRC to claim they are not part of the NFRC program so no attempt to rate them should be made by NFRC
  - However, if most of these devices can be rated by the same methodology used for rating conventional attached awnings, it will be more difficult for NFRC to exclude them

# Some exterior shades & their classifications

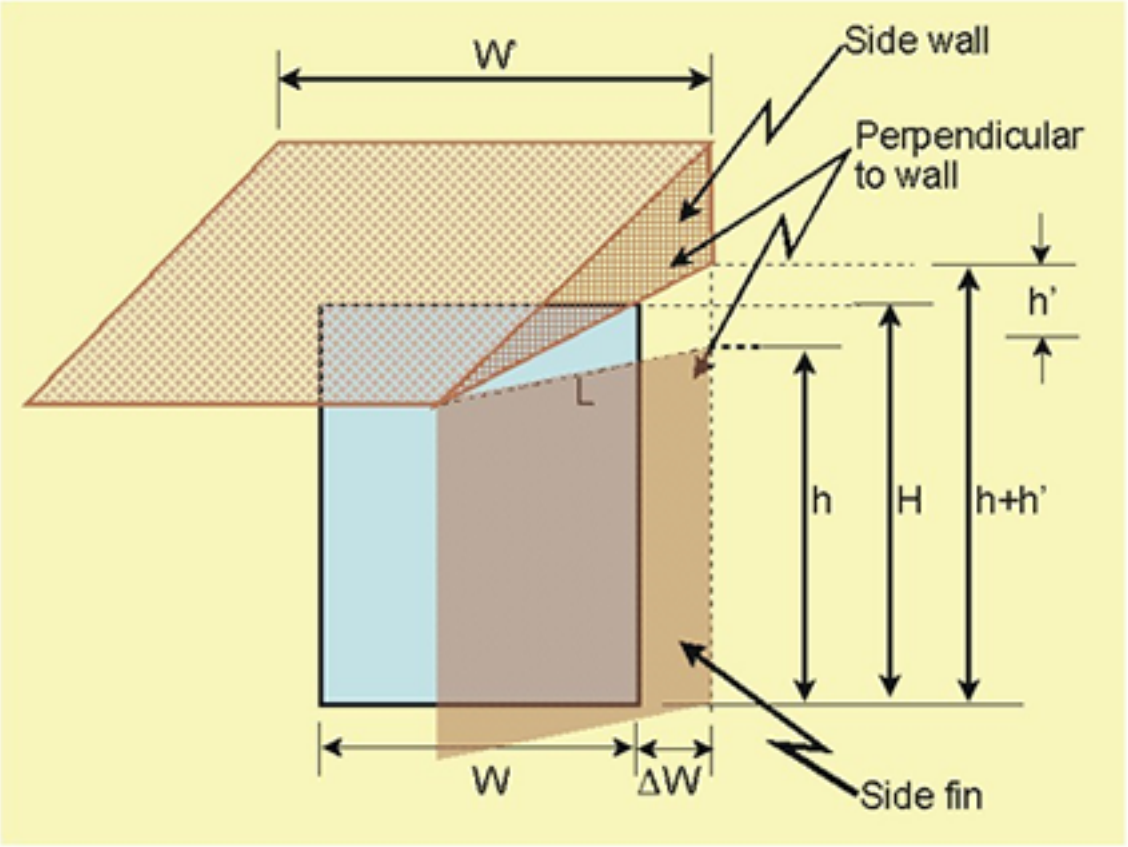


# TG Approach for Exterior Shades

- Ask NFRC to add Category A shades to its rating and labeling program
- Take whatever research and other steps are needed to help LBNL add Category A shades to the Window 6 program. Since LBNL is already pursuing this, the additional work should be minimal
- Develop scopes, goals, and suggested methodologies for research in support of adding Category B and C shades to the NFRC rating and labeling program (excepting the shade tree option ☺ which I exclude from all that follows)

# Observation

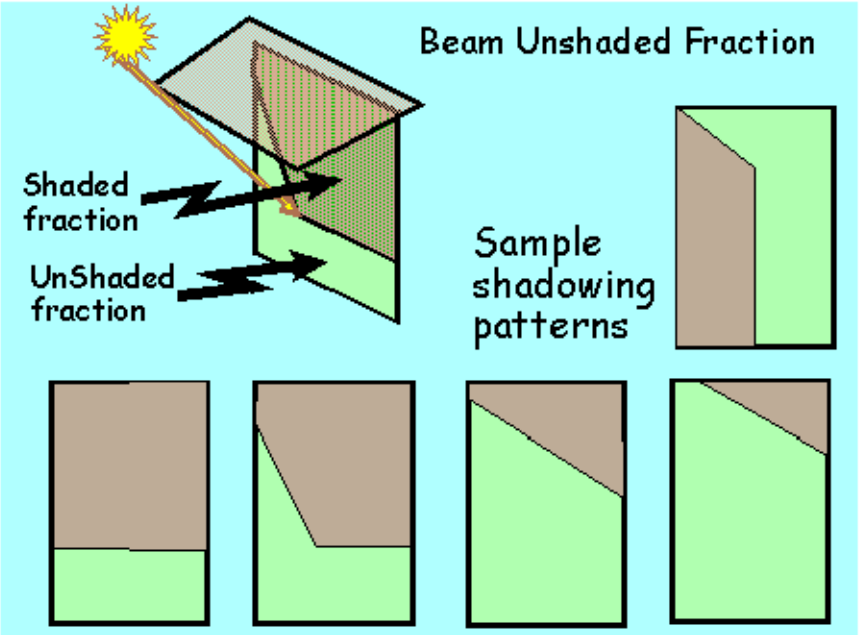
- Both the B and C class shades on the previous slide share a common geometrical characteristic (except for the shade tree)
- They can each be represented numerically by 6 numbers, as illustrated in the drawing below.




**The five dimensions of importance:**
**W** window width
**W'** shade width
**L** projection from the wall
**H** height of the window
**h** height from window sill to lower front edge of shade & height of side fin
**h'** difference in heights of side of awning at front edge and at wall

# Significance of the Observation

- A variety of research papers has been published, describing algorithms for determining the shading characteristics of this type of shade
- My paper on the subject, “Awning Shading and Algorithm for Window Energy Studies,” *1986 ASHRAE Transactions*, V.92, Pt. 1, Paper No. 2964, pp. 430-438 explains how to calculate the unshaded fraction of the window area for a shading device of this geometry for any solar altitude and relative azimuth angle. “Awning Shading Algorithm Update,” *ASHRAE Transactions* 1990, Vol. 96, Pt. 1, Paper No. 3302, pp. 34-38 added the effects of side-fins to the calculation procedure.
- Thus, it is a matter of simple analytical calculation to determine the shading of a window by Class B and C shades, if their geometries can be described as on slide 9.




In my research I created drawings showing all the possible ways awnings and overhangs with and without side-fins can shade a rectangular window. I developed formulas for the unshaded fraction in each case. A number of conditional tests was created and included in the computer program to determine for each sun position what shading case was involved and hence which combinations of area formulas was needed.

# Sky and Ground-Reflected Radiation

- Though the algorithm I developed was mainly for shading from the direct beam sun only, radiation from the sky can easily be treated by dividing the sky into N small solid angles and repeating the calculation for each of these, resulting in an effective diffuse unshaded fraction value, giving what fraction of the incident irradiance from the diffuse sky incident on an unshaded window would reach it beneath a class B or C shade, including a simple roof overhang of any width
- The same approach can be used to determine the fraction of diffuse ground-reflected radiation reaching the window, presuming that the ground reflectance or albedo is known
- The computer program AWNSHADE which I developed to perform these calculations included both the diffuse sky and ground-reflected components, assuming uniform radiance from sky and ground
- There is no reason, however, that a nonuniform sky or ground radiance could not be incorporated in the calculation, presuming the directional distributions of sky and ground radiance are known

# Technical Complication

- The shading algorithms just mentioned assume that the shading device is completely opaque
- For shades that are not opaque, we have three subcategories of shading devices:
  - i. Shade materials that transmit beam radiation through holes in them of known size and completely absorb all other incident radiation
  - ii. Shade materials that transmit beam radiation through holes of known size and scatter all other radiation diffusely
  - iii. Shade materials that transmit all radiation incident on them diffusely

# Suggested Research Approach

- Inclusion of all kinds of shades in categories B and C could involve a fairly large research project, due to the computational and experimental complexities of dealing with subclasses i., ii., and iii.
- Subclass i. would not be that difficult. To treat it one would divide the window area into two known portions, the shaded and unshaded areas. Instead of multiplying the incident irradiance on the shaded area by 0 for the opaque shade case, one would multiply it by the ratio of hole to total shade area, the “transmittance” of the shade material
- Subclass ii. and iii. would require a more complex research strategy, to deal with the diffuse transmittance effects. This could probably be handled by computerized optical ray tracing, as I did in devising my exterior insect screen transmittance model.

# Suggested Research Strategy

- To keep research costs modest and make the research program more palatable to NFRC, it is suggested that the research program be divided into several sequential phases, each funded separately
- Phase I. Opaque shading devices only
- Phase II. Translucent shading devices with no diffuse scattering characteristics
- Phase III. Translucent shading devices with diffusely transmitting characteristics