Using Overhangs to Reduce Building Facade Exposure to Rain

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Acknowledgements

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Most provisions of the building codes (British Columbia Building Code and the Vancouver Building By-law) have not been specifically referenced. Always review and comply with the specific requirements of the applicable building codes and bylaws for each construction project. Nothing in this publication is an endorsement of any particular product or proprietary building system.

Overview

Overhangs are a traditional approach used to protect building facades from rain. Despite their long use, their effectiveness to protect a building from wetting due to wind-driven rain has never been quantified under field conditions, especially mid-rise and taller buildings. This is the first attempt at such research.

To quantify the effectiveness of overhangs, a six-storey BC Housing building in British Columbia's Lower Mainland was fitted with a retractable overhang and instruments to measure weather and wetting. This building has customized wind-driven rain (WDR) gauges on the facade facing the prevailing wind to quantify the wind-driven rain. On-site weather data and WDR wetting on the facade were measured over four and a half years for five periods under five different conditions: no overhangs, 0.3-metre, 0.6-metre, 0.9-metre, and 1.2-metre overhang.

Figure 1: Northwest corner of test building.

Figure 2: A 0.6-metre overhang.

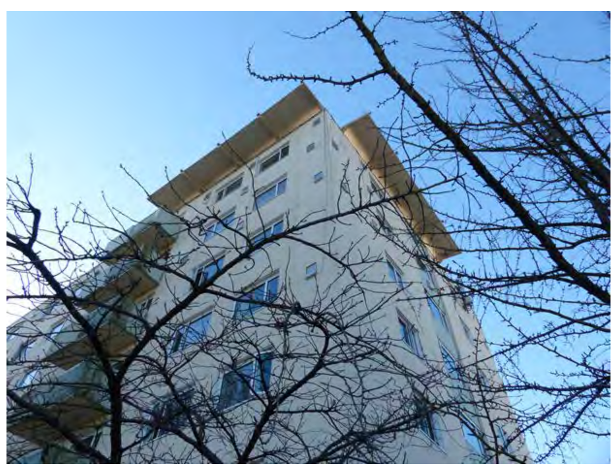


Figure 3: A 1.2-metre overhang.

Wind Driven Rain

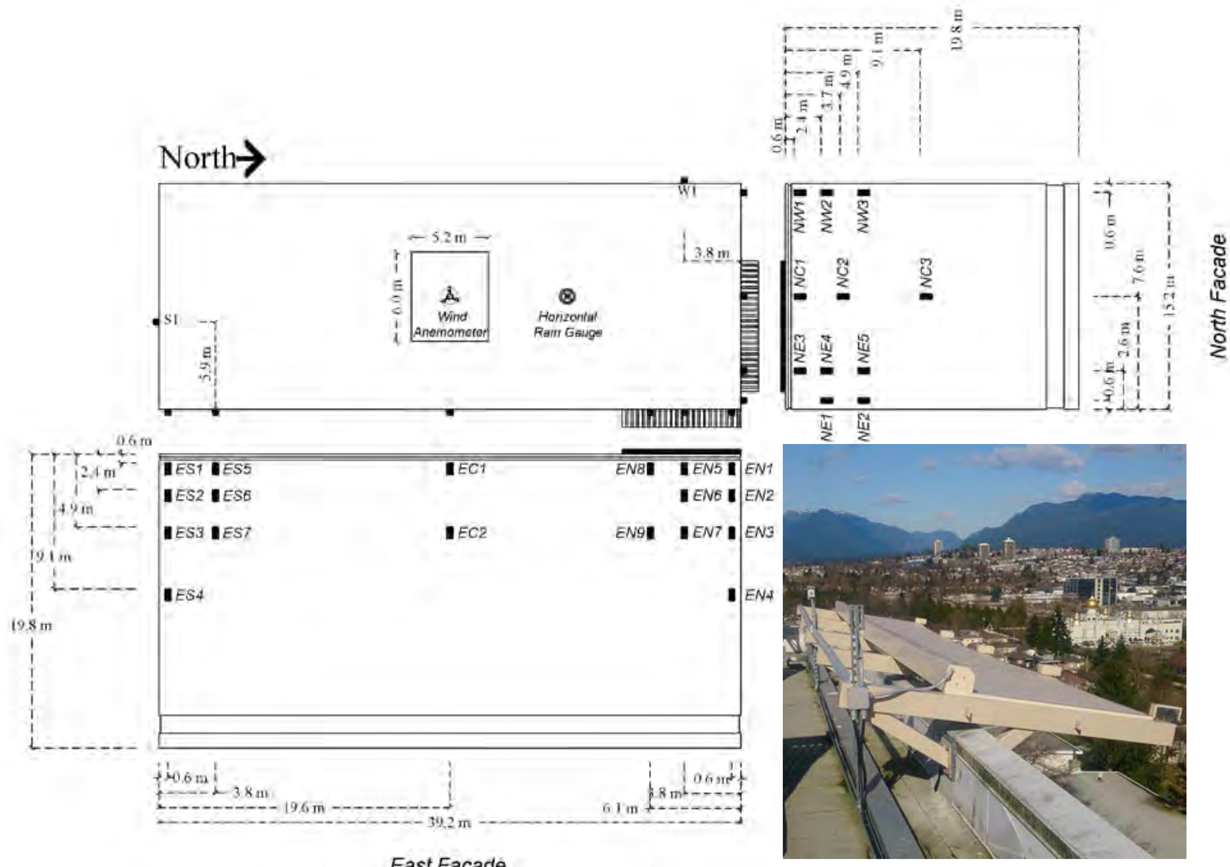
Wind-driven rain (WDR) falls at a horizontal angle on a building due to wind. It is one of the most significant sources of moisture that affects the long-term durability of building facades and other components of a building envelope. Excessive moisture accumulation on porous materials can lead to water penetration, freeze-thaw damage, efflorescence, cracking, and facade soiling. Water penetration into the wall structure can also lead to mould growth, wood decay, metal rust, and reduce the effectiveness of insulating materials.

To analyze the hygrothermal and durability of a building envelope, it requires the quantification of WDR loads. The amount of WDR that falls on building facades is impacted by several wind and rain characteristics, including: rainfall intensity, duration and frequency of rain events, wind speed, and wind direction. Building characteristics such as building geometry, sheltering by surroundings, facade orientation, and location on the facade also affect the WDR load. To better quantify the effectiveness of overhangs at protecting buildings from WDR, field tests were conducted on a six-storey BC Housing building.

Figure 4: Wind-driven rain (WDR) has a horizontal velocity component due to wind.

Building Instrumentation

Retractable overhangs were installed on the north and east roof on the corner of the building. A weather station was installed on the roof of the building to measure wind speed and direction and the amount of rain received, including a gauge to measure the horizontal component of the rainfall. Thirty-one gauges were installed on the east and north facades to measure the amount of WDR falling.



Retractable overhang installed

Figure 5: Location of on-site weather station and WDR gauges installed on the east and north facades.

Overhang Performance

The catch ratio evaluates the wind-driven rain wetting on a facade. This is the total amount of WDR collected on a wall surface divided by the total amount of horizontal rainfall over a given time. The following figure shows the average catch ratios on the east facade with no overhang and with different sizes of overhangs. .

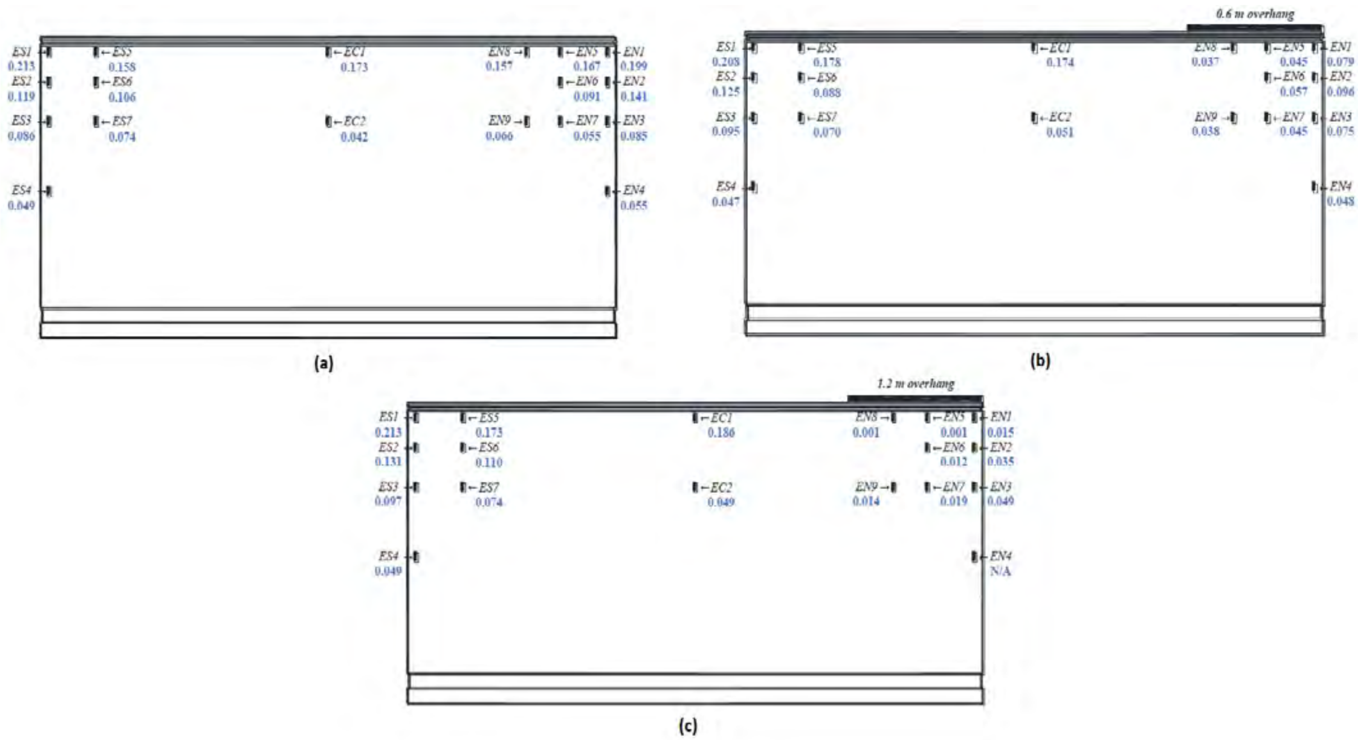


Figure 6: Catch ratios on the east facade: (a) no overhang, (b) 0.6-metre overhang, and (c) 1.2-metre overhang.

The results show that the amount of rain deposited on the building facade varies by location. However, a symmetrical distribution of WDR across the east facade occurs when the wind is blowing to the wall when there is no overhang. The classic wetting pattern is observed where:

Seventy percent of WDR falls on the top 30% of the facade. Overhangs can effectively protect that top 30%, making them effective at reducing WDR exposure.

- The top corners are the most wetted, followed by the top and side edges
- Wetting increases from the bottom of the facade to the top, and from the middle of the facade to the sides
- Adding the overhang reduces the catch ratios underneath the overhang
- The wider the overhang, the greater the reduction of catch ratios

The effectiveness of the overhang can be quantified by comparing the catch ratios with and without overhang. As shown in Figure 6 above, the catch ratios are symmetrical on the east facade, since the predominant wind direction is from the east when it rains.

A symmetrical distribution of WDR can be used to evaluate the effectiveness of an overhang by directly comparing the catch ratios at gauge locations underneath the overhang on the north side of the facade (EN1 to EN7) to those on the south side of the facade (ES1 to ES7), which are not covered by an overhang. The effectiveness of the overhang is defined as the percentage reduction in catch ratios with and without the overhang (i.e. North-end vs South-end of facade).

As shown in the figure below, the overhang is quite effective in reducing wind-driven rain wetting on a facade, especially for locations immediately beneath the overhang (EN1, EN5, EN8 at 0.6 m below the roofline, i.e. 3% of the building height). For example, a 1.2-m overhang can reduce the WDR amount by 90-99% for locations around 0.6 m below the roofline. The effectiveness of the overhang decreases when moving from the upper edge towards the ground and from the centre towards the side edge of the facade.

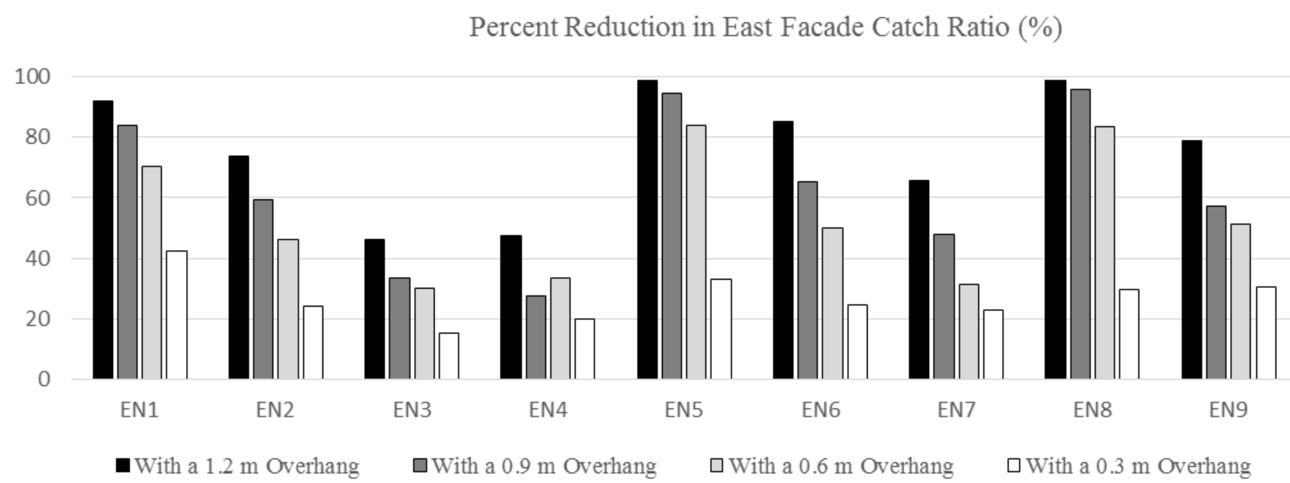


Figure 7: Effectiveness of overhang on east facade

To quantify the effect of the overhang on the reduction of WDR on the facade, the area-weighted overhang effectiveness was calculated for four areas representing 15%, 30%, 60%, and 100% of the facade area, respectively (Figure 10, below).

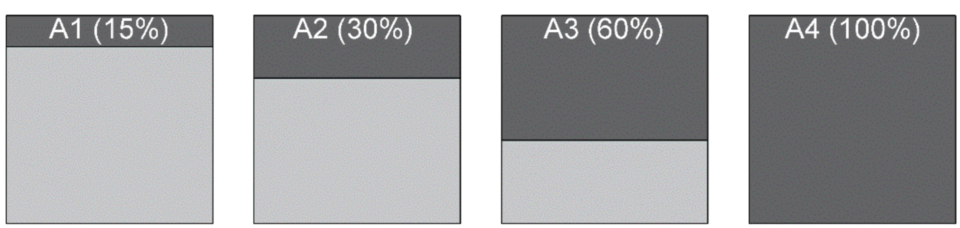


Figure 8: Areas on the east facade for the calculation of area-weighted overhang effectiveness.

An exponential relationship exists between the overhang width and the amount of WDR deposited on a facade, as shown in Figure 9, below. Since the top 15% of the facade area gets 56% of the total WDR, the provision of an overhang is effective in reducing the total amount of WDR on a facade.

A 0.3-metre overhang can reduce the WDR on the upper 15% of the facade by 30% and the entire facade by 20%, while a 1.2-metre overhang can reduce the WDR on the upper 15% of the facade by 90% and the entire facade by 60%. The results for the north facade are similar to those on the east facade.

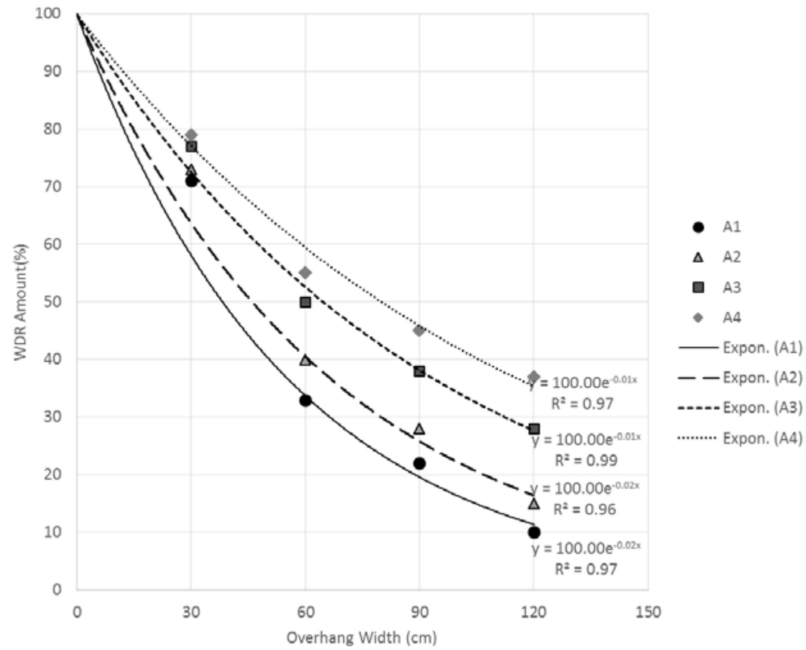


Figure 9: Relationship between overhang width and the amount of WDR deposited on the east facade for four different areas.

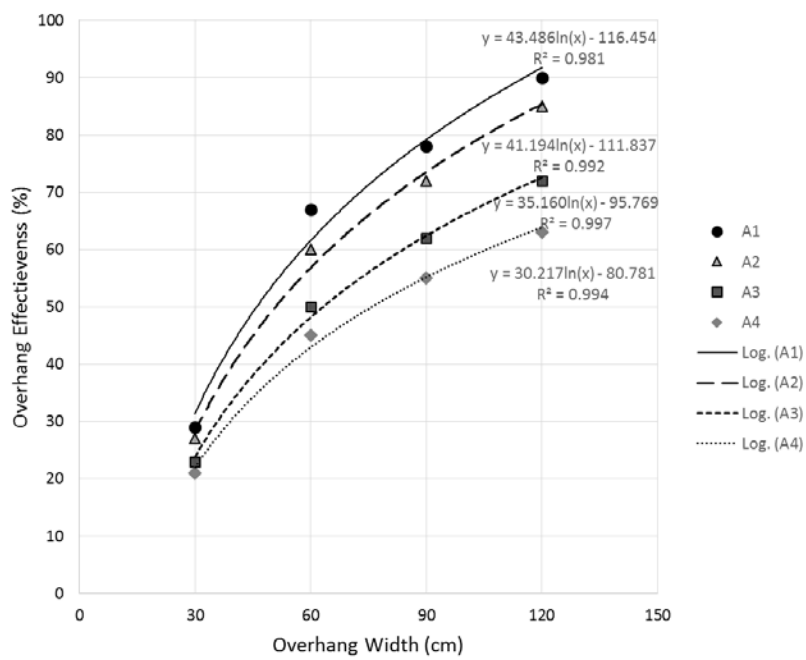


Figure 10: Relationship between overhang width and overhang effectiveness on the east facade for four different areas.

The effectiveness of the overhang is influenced by wind speed and wind direction. As wind speed increases, the overall effectiveness reduces (Figure 11, below).

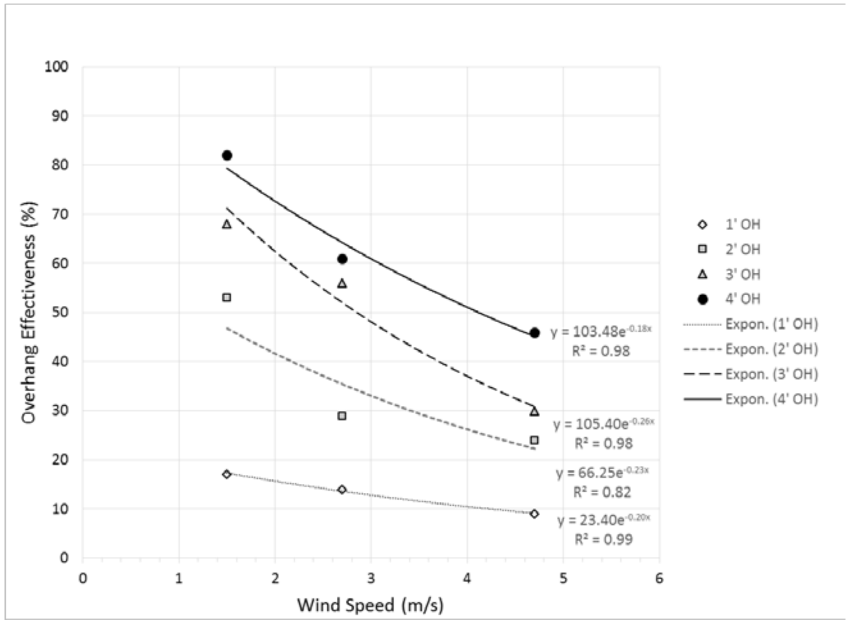


Figure 11: Relationship between wind speed and overhang effectiveness for different overhang sizes.

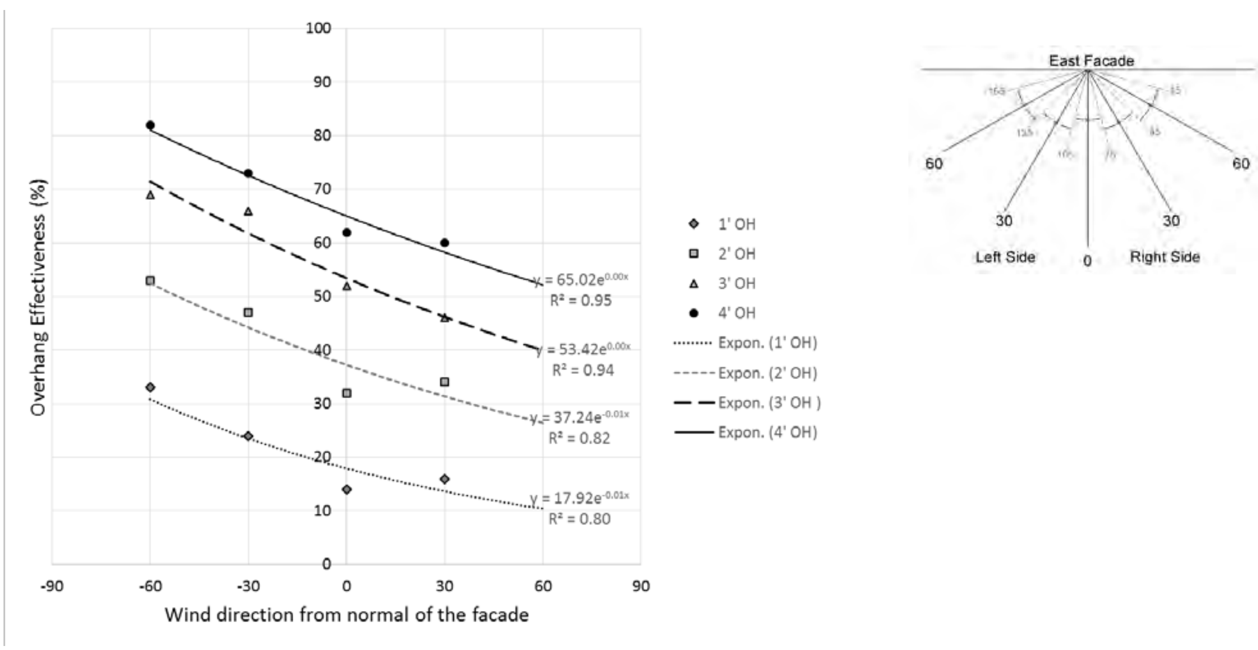


Figure 12: Relationship between wind direction and overhang effectiveness for different overhang sizes

The influence of wind angle on the overhang effectiveness is not as consistent as the wind speed. The overhangs are more effective in reducing WDR wetting for oblique winds than winds that blow normally to the facade. For locations better protected by the overhang, the effectiveness increases with the increase of wind incidence angle no matter which direction the wind comes from.

Since the top 30% of the facade gets more than 70% of the total amount of WDR on the facade, overhangs that can shelter that top 30% can effectively protect the facade from WDR wetting.

Future Work

The long-term goal is to develop a methodology to predict the WDR loads on any given mid-rise building, and to develop correlations between overhang widths and the level of protection they provide for the facade below it. This will help designers make recommendations for roof overhang widths to protect mid-rise buildings from rain damage. Further research into different overhang widths and building locations will develop these correlations and design guidelines.

Key Points

- The climate in southern British Columbia is characterized by long winters with mild winds and rain. This makes an overhang effective and significantly reduces WDR for a six-storey building, in particular for those areas immediately beneath the overhang.
- The larger overhang provides greater protection. Longer overhangs would be best on more exposed facades and on those facing the prevailing wind.
- The effectiveness of an overhang decreases as you move away from the overhand towards the ground, and from the centre towards the side edge of the building.
- Since the top 30% of the facade area gets more than 70% of the total amount of WDR, overhangs that can shelter that top 30% can effectively protect the facade from WDR wetting.
- The larger overhang provides greater protection. An exponential relationship with good correlation of overhang width and its effectiveness has been observed based on the data points available.
- Higher wind speeds usually reduce the overhang effectiveness and the protected distance from the roof top, while more oblique wind increases the effectiveness.

For More Information

- *Wind-driven Rain Study in the Coastal Climate of British Columbia*, available at www.bchousing.org.

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