

Building Aspect Ratio

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The decision to produce a building with an aspect ratio of 5.68 : 1 (71 feet by 403 feet) was based on a consensus recommendation by the interdisciplinary design team of Elements (BNIM LEED® Architects), Ensar Group, Clanton and Associates Engineering and Rumsey Engineers in order to maximize the environmental and long-term economic performance of the project. Collective experience has shown that buildings that maximize daylighting potential while minimizing unwanted glare and cooling loads greatly increase the efficiency and users' response to their environment. Careful attention was paid to the building's proportion, its orientation and the design of the envelope of the building. The aspect ratio chosen demonstrates the ideal balance between interior flexibility with high environmental performance. A long slender building sited in the east/west direction has several advantages over buildings that are wider.



The Lewis and Clark State Office Building's front facade and narrow, west-facing orientation are striking design signatures.

5.68:1 Aspect Ratio Advantages Include the Following:

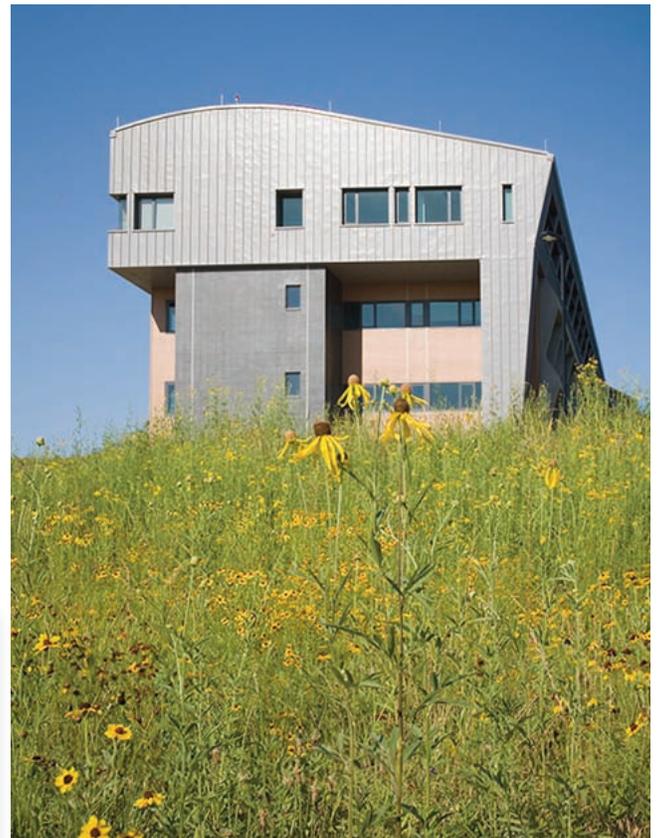
1. Reduced Operating Costs

Rumsey Engineers was asked by BNIM Architects and Elements to aid in the study of potential advantages and disadvantages in various building footprints. The goal was to determine the effect that an altered geometry would play in the over-all energy performance of the building. All three designs were modeled using Visual DOE, which has the capabilities of DOE 2.1, but better usability and ease of interface. The report is attached to this document for review. In summary, the three final designs tested showed the following annual operating costs:

5.68:1 -- **\$50,000/yr.** with natural gas or electricity

4:1 ----- **\$58,000/yr.** with natural gas or electricity

1:1 ----- **\$61,000/yr.** with natural gas or electricity



2. Reduced Environmental Impact

By minimizing the lighting loads and blocking unwanted solar gain, the proposed design has a lower environmental impact associated with it. This impact is often greater than what projected energy savings would suggest due to the low cost of energy. For MoDNR this has been mandated as a high priority showcasing the building as a model of environmental performance. A government agency is also concerned with the “external” costs to society that are caused by pollution which, for clean up and health related causes ends up being paid by government and taxpayers.

For example conservative estimates for the economic effect of the major pollutants have been shown to be the following:

CO₂ ----- **\$41** per ton
NO₂ ----- **\$16,900** per ton
SO₂ ----- **\$10,600** per ton

Based on the three scenario’s modeled, the building would have the following amounts of pollutants and external costs to society on a yearly basis. For our study, only CO₂ and NO₂ were available which results in a very conservative answer.

Scheme	CO ₂	NO ₂	Annual Cost
5.68:1	800 tons	19 lbs.	\$32,960
4:1	900 tons	23 lbs.	\$37,094
1:1	1,000 tons	26 lbs.	\$41,219

3. Cost

What is the cost of having the footprint of the proposed design?

The design team determined the width of the building based on many factors including balancing the cost of the skin. The proposed plan is 71 feet by 403 (average) feet for a 5.68 : 1 width to length ratio. Comparing the cost of the proposed scheme to the 4:1 ratio building and the 1:1 ratio building, all modeled in the energy report. Comparing a 4:1 ratio to the proposed schematic design the additional cost is approximately \$146,436. A sustainable building requires an efficient skin, and with a 4:1 or a 5.68:1 building ratio the most important factor is the efficiency of the skin.

The following chart shows the additional cost factors:

	ASPECT RATIO	AREA OF SKIN \$27.62 / sq. ft.		ADDITIONAL COLUMNS \$3,948 each		COSTS COMPARED
Proposed Design	5:68:1	60,600 sq. ft.	\$1,673,772	0	\$0	Current Estimate
Comparison A	4:1	54,000 sq. ft.	\$1,491,480	9	\$35,856	-\$146,436
Comparison B	1:1	43,200 sq. ft.	\$1,193,184	1	\$3,948	-\$484,536.

4. LEED® Credits

The aspect ratio of the building was also designed to maximize our LEED rating. By changing the aspect ratio from 5.68:1 to 4:1 we lose the IEQ credit for daylight and put two other energy LEED credits at risk.

The LEED credit for daylight requires the following:

Achieve a minimum daylight factor of 2 percent (excluding all direct sunlight penetration) in 75 percent of all space occupied for critical visual tasks, not including copy rooms, storage areas, mechanical, laundry, and other low occupancy support areas. Exceptions include those spaces where tasks would be hindered by the use of daylight or where accomplishing the specific tasks within a space would be enhanced by the direct penetration of sunlight.

The proposed building footprint provides for the majority of the workstations to be daylit, which we believe will allow us to achieve this credit. The 4:1 and 1:1 schemes preclude this credit. The additional credits that are at risk include dropping one level in energy (which accounts for two credits).

Ensar Group:

60' – 70' allows for better bi-lateral illumination (daylight penetration from both the north and the south). Useful daylight typically penetrates 2.5 times the head height of the window. With a window head height of approximately 10 feet, this equates to a useful penetration of approximately 25 feet. (Note: light levels do drop and electric light is needed deeper into the interior). The north follows the same rules of thumb as the south, because the typical penetration of 2.5 is based on overcast conditions. Overcast skies provide the most uniform illumination and are generally brighter than clear skies, except in the quadrant where the sun is located.

Clanton Engineering:

With a narrow building, daylighting potential is maximized, allowing more people access to daylight and outside views. With the perimeter zone larger, a greater portion of the electric lighting will not be required on sunny days. Therefore, the electric lighting can be dimmed down or turned off thus saving energy and reducing the internal heat gains from the lighting.

5. Enhanced Work Environment and Productivity

While hard to quantify, emerging research is consistently showing that daylit buildings and access to views are critical components of worker satisfaction and productivity as anyone with a windowless office will attest. The current design allows the majority of building occupants immediate access to daylight as the primary light source creating a more positive work environment. Although it is hard to quantify, small improvements in productivity quickly turn into significant economic gain.



The building length and width ratio of 5.68:1 allowed designers to daylight 75-90 percent of all spaces within the building. This also reduced electrical costs and affords most occupants a closer connection to outside views.

According to the book, *Cool Companies*, by Joseph Romm and research from the Rocky Mountain Institute, productivity enhancements from factors such as daylighting and quality lighting can boost productivity between 7-15 percent while reducing absenteeism and sick leave.

The 5.68:1 ratio will allow the majority of workers access to quality lighting conditions and a closer connection to views outside. It will in short be a better place to work. The 4:1 ratio will reduce the daylit area by approximately 3,900 gross square feet per floor, yielding 2,340 net useable square feet per floor. Using 80 square feet per workstation, the proposed schematic design compared to the 4:1 ratio building will have approximately 29 more people per floor with natural daylighting, or 20 percent more occupants. The 1:1 building further reduces the quality of the interior environment.

In conclusion, we believe we are providing the best building designed to accomplish the goals set forth in the program and goal setting charrette. We are confident that this shape will be efficient for the client in terms of expended energy, cost of the skin and to create the best worker environment.



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