

SHAPED BY LIGHT: INTEGRATED DAYLIGHTING AT THE REID BUILDING AT THE GLASGOW SCHOOL OF ART

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ABSTRACT: This paper explores an integrated approach to daylighting design in the Reid Building at the Glasgow School of Art (GSA) by Steven Holl Architect (SHA). It considers how SHA has skillfully and creatively bridged the poetic and practical potentials and complexity of daylighting to artfully reconcile the physical and measurable attributes of site, climate, program, and ecological performance with the intangible qualities of atmosphere, aesthetics, and human experience. Daylight studies using Velux Daylight Visualizer explored how the daylight supports design intentions, program, and performance. SHA's Reid Building provides insight into an integrated approach to daylighting design strategies and methods to inform contemporary architectural practice and design education.

KEYWORDS: Daylighting Design, Glasgow School of Art, Steven Holl Architects

INTRODUCTION

To choreograph light is to create intentional relationships between the desired luminous qualities and other architectural design variables such as spatial sequence, activities, materials, structure, and performance. The dimension of time, while predictable in the apparent movement of the sun during the course of the day and the year, introduces an oftentimes unpredictable and transient beauty embodied in dynamic, fleeting, and momentary luminous phenomena. How does the choreography of daylight support the broader vision of a project, a program, and the desired qualities and performance criteria of light? How is time architectural and how might daylight be used to celebrate and respond to the changing diurnal and seasonal cycles? How do the movements of the body and the movements of time and light correspond? As with dance, music, or cinema, architecture can be orchestrated as a sequence of spatial, luminous, and experiential progressions to create desired atmospheric qualities while satisfying practical goals.

In the Reid Building at the Glasgow School of Art (GSA), in Scotland, by Steven Holl Architects (SHA), daylight is choreographed to support design intentions, program, and performance while celebrating the unique phenomena of light in place. Natural light and the movement of the human body is at the center of the architectural and spatial choreography. Movement along circulation pathways provides varied qualities of space, light, and view to foster interactions between students and faculty from diverse design disciplines. The building envelope, light shafts, circulation paths, spatial volumes, and structure encourage informal connections, afford rich interior and exterior views, create distinct atmospheric qualities, and define a “new language of light” in relation to Charles Rennie Mackintosh's historic 1909 Mackintosh Building. The building form was studied and sculpted to reveal how space can be shaped by light and how light can be shaped by space to integrate experiential, lighting, and energy goals.

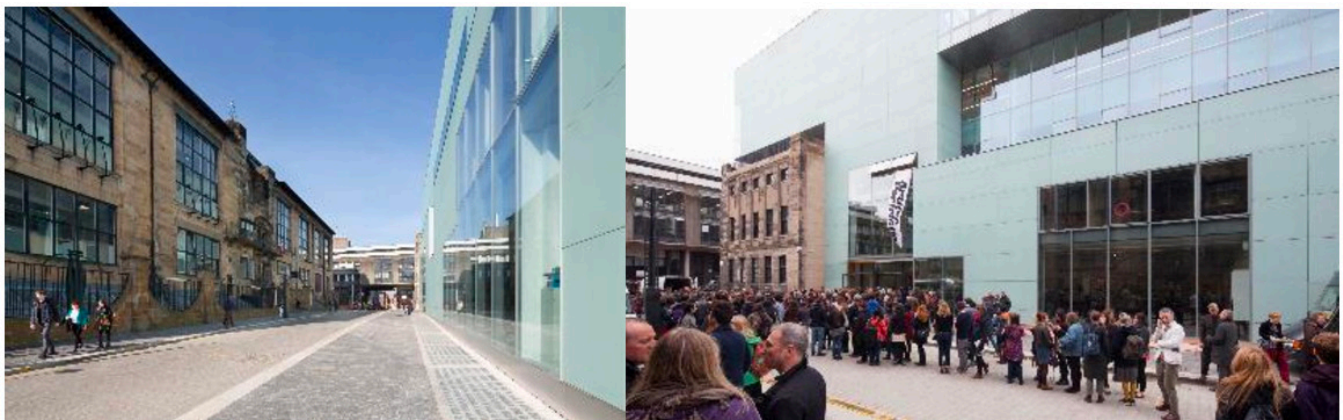


Figure 1: Charles Rennie Mackintosh's Glasgow School (left) and Steven Holl Architects (right); looking west.
Source: (SHA, 2016)

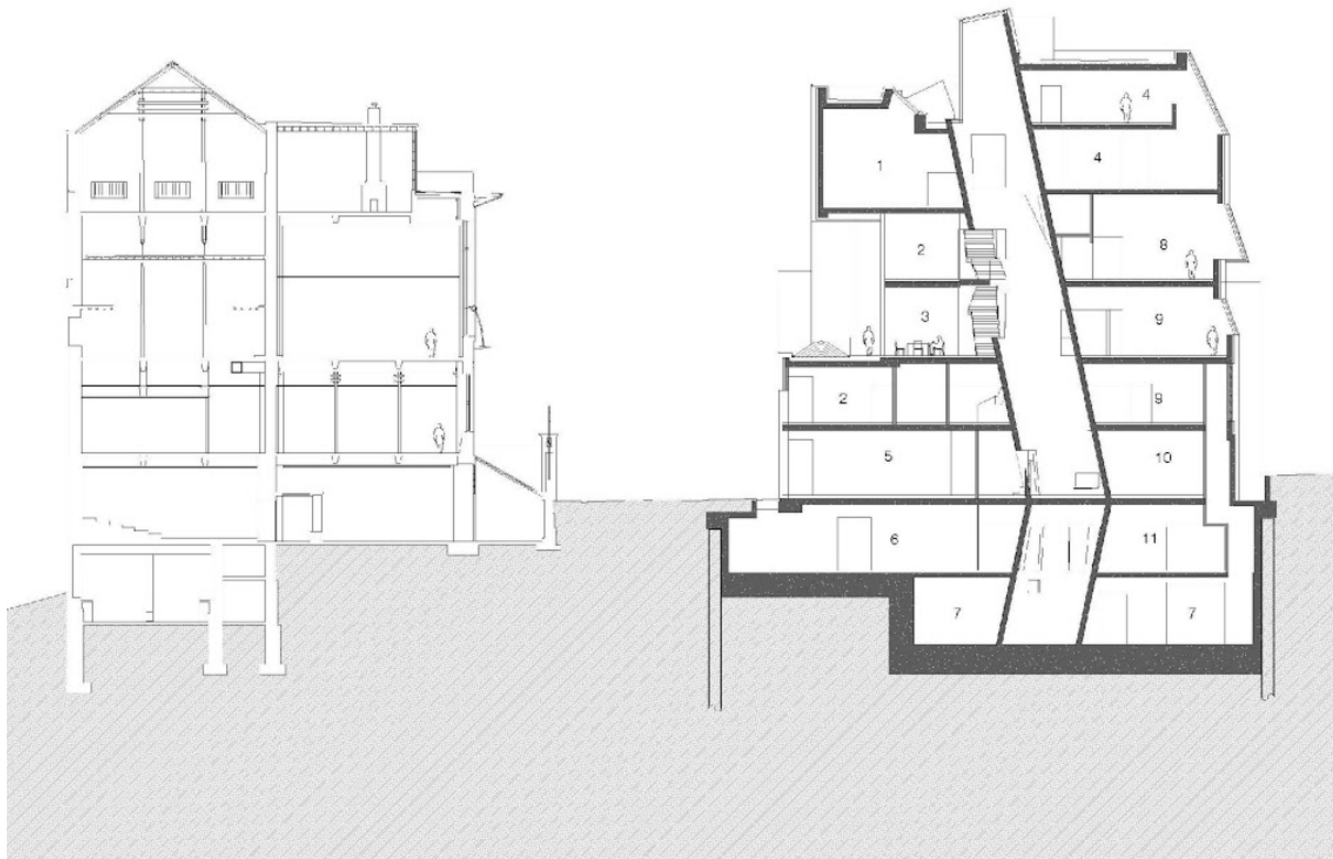
1.0 LIGHT AND PLACE

1.1. Glasgow School of Art

Located in the downtown core of Glasgow, the GSA is a center of creative activity within an international arts community. SHA, in collaboration with JM Architects and Arup, were responsible for developing GSA's new Garnethill Campus masterplan and the phase one design and construction of the Reid Building. Internationally renowned as a preeminent school for the study of fine arts, architecture, and design, the GSA's recent expansion reinvigorates the historic urban campus and fosters an animated conversation between Charles Rennie Mackintosh's 1909 architectural masterpiece, the Mackintosh Building, and Steven Holl's contemporary Reid Building.

As a precursor to the modern movement, Mackintosh's innovative use of natural light, simplicity of form, design restraint, and honest expression of materials were considered unprecedented for its time. SHA approached the Reid Building with the same spirit of innovation and a desire to define a "new language of light," which expresses the material and construction technologies of the day while remaining mindful of Mackintosh's historic legacy.

Chris McVoy, design architect at SHA, explains: "We began with studying the Mackintosh Building, in particular, the quality of light. There are twenty-five ways light comes into the spaces. . . . Mackintosh elaborated on the basic typologies of light: skylights, clerestories, figural diffuse light, side lighting, direct lighting. We studied daylight deeply (McVoy, 2015)." There are five organizing ideas for the new school of art: 1) create well-proportioned and flexible studios; 2) define a new "language of light" in relation to Mackintosh; 3) use materiality as a "complementary contrast" between the Mackintosh and Reid Buildings; 4) use circulation as a "circuit of creative abrasion" to encourage interaction and 5) foster ecological innovation (McVoy, 2015).



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|----------------------------|---------------------------------|--------------------|
| 1. Product design studio | 6. Wood workshop | 11. Metal workshop |
| 2. Offices | 7. Storage | |
| 3. Refectory | 8. Dye lab | |
| 4. Interior design studios | 9. Communications design studio | |
| 5. Exhibition space | 10. Service | |

Figure 2: Sections looking west: Charles Rennie Mackintosh (left) and Steven Holl Architects (right). Source: (SHA, 2016)

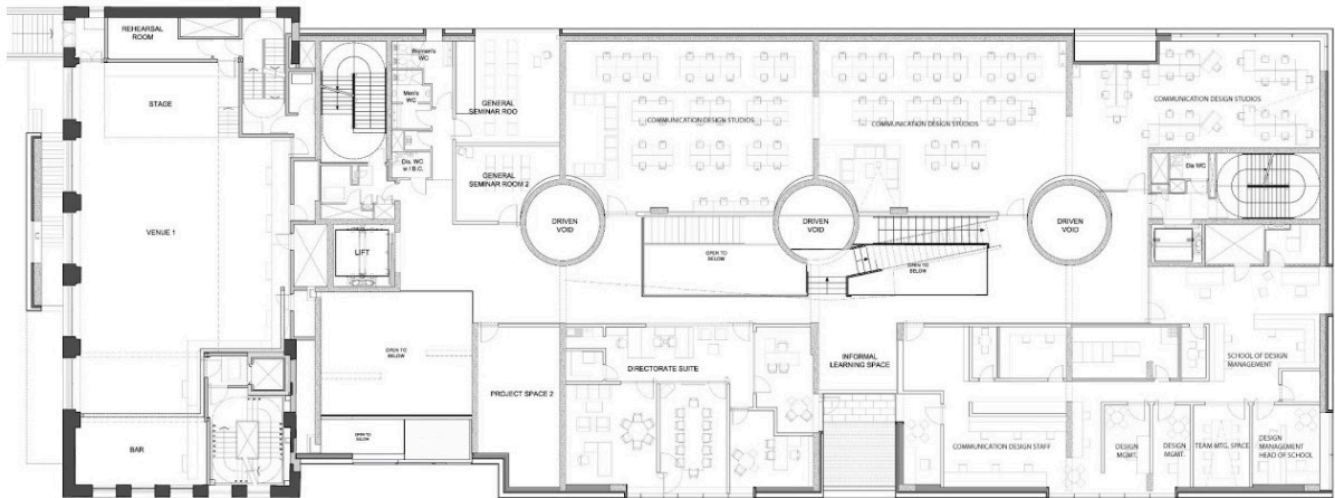
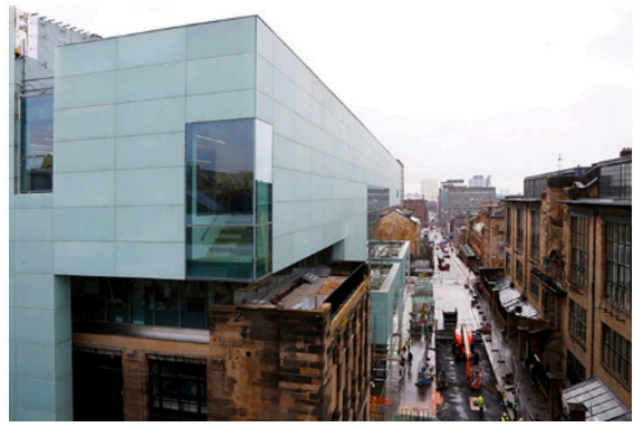


Figure 3: Site and ground floor plan with photograph looking east. Source: (SHA, 2016)

1.2 Light and Climate

The Reid Building, sited across the street and north of the historic Mackintosh Building, is oriented on an east-west axis, affording optimal solar access on a seasonal basis. The height and form of the Reid building responds to the particular climate and solar conditions of the geographic location. Glasgow is located at 55.9° north latitude with seasonal extremes of light and darkness, relatively low sun angles, and short winter days that contrast persistent summer daylight. All of these factors shape Glasgow's unique qualities of light and related architectural opportunities. During the winter solstice, there are just seven hours of daylight and the noon sun altitude is only 10.6° above the horizon. During the summer solstice, the sun rises to a noon altitude of 57.6°, daylight lasts for 17 hours, and twilight persists throughout the night.

While located at a fairly high latitude, Glasgow has a maritime temperate climate of cool winters and mild summers, with an average low of 0.5°C (33° F) in December and an average high of 19.4° C (67° F) in August (Weatherspark, 2016). High humidity and frequent precipitation are experienced throughout the year, resulting in a soft and misty quality of light as it is refracted and scattered by moisture in the air. The cloudiest month is typically January, while the sunniest months are May through July. Grey skies and overcast conditions dominate in the winter, yet clear and partly overcast skies can result in dramatic lighting qualities and cloudscapes throughout the year. Occasional snow occurs from January to April and prevailing winds are from the southwest and west. Despite the overcast climate, daylight and natural ventilation are effectively coupled with high performance construction to optimize energy performance and comfort throughout the year.

2.0 LUMINOUS INTENTIONS

2.1 Light and Program

The GSA challenged the architects to reconsider the nature of design schools in the 21st century and to explore how the architecture could foster collaborations between the disciplines, as former GSA Director Seona Reid explains: "The

chance meetings, the chance conversations, the chance opportunities to see somebody else's work doesn't happen as much as it should. These opportunistic meetings are often the spark of ideas of working relationships and partnerships (Future of GSA, 2016)." While the design studios are the heart of the GSA, virtually all spaces, including common spaces such as the entry, exhibition room, café and refectory, workshops, seminar rooms, and lecture hall, were designed to foster collaboration and support the creative process. The architects used "circuits of connection" (circulation ramps and stairs), "eddies of interaction" (niches and subspaces), "driven voids of light" (light shafts with openings), and interior views to encourage such informal exchanges and collaborations, while simultaneously increasing energy and lighting performance.

2.2 Choreographed Light

Daylight shapes the Reid Building from both the inside and the outside, with the movements of occupants and daylight carefully choreographed in space and time. While straightforward in organization, the building section, spatial variety, and atmospheric qualities of light are complex, as Holl explains: "If you look at our buildings in plan it looks very simple. A rectangle and three circles in a square. You can't get anything out of the plan, which I really like. Because I think that's the essence of architecture. It's spatial – it's three-dimensional (Spirit of Space, 2014)."

Three "voids," inserted into the rectilinear plan, are created by concrete cylinders tilted 12 degrees to the south to capture the low sun angles and often grey "Glaswegian" light. McVoy explains that the interior openings, which were subtracted from the surface of the Euclidean cylinders, created "incredible curves and shapes" with unexpectedly complex forms and patterns of light as daylight enters the volumes and is borrowed to adjacent spaces (McVoy, 2015). The circulation paths, ramps, and stairs move through and around the voids to create rich spatial qualities, changing views, dynamic lighting qualities, and varied gathering opportunities.

Holl explains how the historic masterpiece by Mackintosh inspired his approach to the Reid Building: "I studied all the ways that light comes in the Mackintosh building and discovered many different interesting things and one in particular is in the library where [there are] three story elements in glass – we call them 'driven voids of light' – and we transferred that into this idea of concrete 'driven voids' (Spirit of Space, 2014)" The Reid Building is organized by "circuits of connection" (circulation paths) that intersect three "driven voids" (light shafts) to create south and north zones with distinct daylight qualities and program activities. As Craig Tait, project architect with JM Architects, explains: "There are rich and varied spaces with niches within. People occupy the spaces in many ways, the building makes people gather in different ways. It's a joy to see how people react to space. The 'circuit' [circulation] doesn't have a prescribed function, people are influenced by the space (Craig Tait, 2016)."



Figure 4: Driven voids of light and circulation. Source: (SHA, 2016)

Glimpses through openings in the “voids” and movement along the “circulation circuits” provide changing perspectives on the studios and shared spaces. Exterior views are provided on all levels, with the third-floor terrace and refractory framing a new perspective on the Mackintosh Building, the city, and surrounding hills. The roof, a fifth façade, includes skylights to admit diffuse north daylight to the upper-level south studio and clear skylights at the top of the “driven voids,” which open to the south and zenith. The studio spaces also express a fresh interpretation of daylighting, as Henry McKeown, design director with JM Architects, explains: “It’s not just the traditional north light of an art school. It’s an idea of different kinds of light blending and working with each other to create all sorts of atmospheres and ambiances within the space itself (McKeown, 2014).” Direct sunlight is admitted to the south zone of the building, while the diffuse northern light in the design studios is complemented by borrowed light from the voids and circulation paths. This dynamic meeting of warm south light and cool north light creates varied daylight patterns and atmospheric qualities that change with the time and seasons.

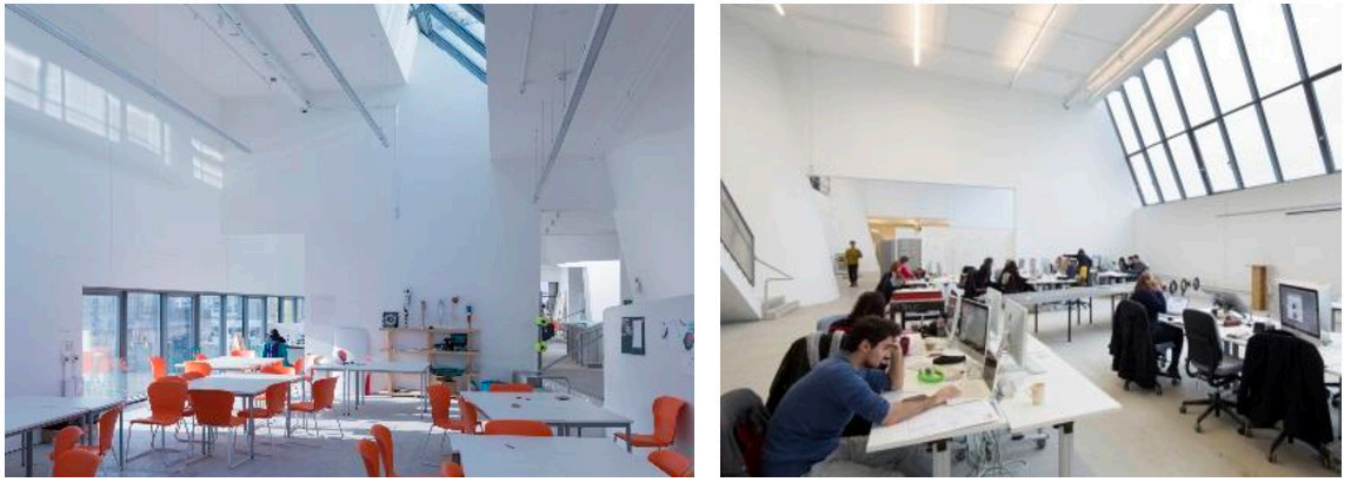


Figure 5: Fourth Floor: South studio looking west (left) and north studio looking west (right). Source: (SHA, 2016)

3.0 LUMINOUS STRATEGIES

3.1 A New Language of Light

Holl’s “new language of light” is revealed in his concept for the envelope and structure, which he characterized as “complementary contrast.” He describes the heavy stone cladding and steel frame of the Mackintosh Building as “thick skin and thin bones,” while the Reid Building’s delicate glass envelope and concrete structure are expressed as “thin skin and thick bones.” The “new language” emerges from the luminous effects of the translucent glass rainscreen and custom “ghost fittings” (which are subtly visible through the glass); a palette of transparent, translucent, and opaque materials; and aesthetically minimal details for windows, skylights, glass railings, and doors. In contrast to the underlying grid and uniform industrial windows of the Mackintosh Building, the seemingly idiosyncratic facades of the Reid Building are animated by windows of varied sizes, two and three-dimensional forms, and differing degrees of translucency and transparency.

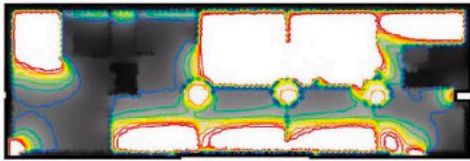
On the interior, the Reid Building’s three “driven voids” define a new precedent for interior light shafts by skillfully combining functions for illumination, ventilation, circulation, views, and structure. The robust sculptural geometry of the voids and the openings, with windows of varying size, proportion, and shape affords differing views through the building of ever changing patterns and qualities of light. At the lowest levels, the metal workshop takes advantage of indirect light from the “void” and north toplighting, while the basement woodshop on the south borrows light and a connection to the street above from glazed pavers in the ceiling. The studio sections are designed to combine borrowed light from the toplight voids with side lighting from north clerestory windows. Lower level studios and seminar rooms are illuminated either with side lighting from the north or bilaterally with a combination of light from east or west. The upper-floor studio windows tilt upward to increase the view of the sky to the north and optimize indirect daylight, while the fourth floor studio employs a three-dimensional north window with a glass sill to admit borrowed light to the third-floor studio window below.

3.2 Luminous Atmosphere

The Reid Building’s ephemeral translucent rainscreen captures the varied moods and colors of the sky and seasons. During an overcast day, the glass has a soft and misty quality, while the surfaces are animated on a sunny day with light, shadow, and subtle color variations as the sun is reflected from translucent and clear surfaces. The character of the envelope transforms at night to reveal a translucent enclosure surrounding opaque walls with windows of different

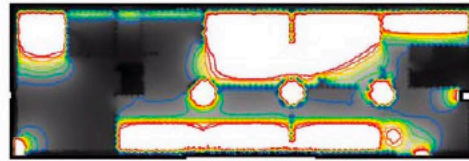
size and form that open to activities within. Direct daylight is admitted through clear glass windows while three types of glass create diffuse conditions, including clear glass behind the translucent rainscreen, translucent glass behind the rainscreen, and a glass cavity with an inner layer of translucent paint flush with the rainscreen (McVoy, 2015).

March/Sept 21 at 12:00 _ Sunny Skies

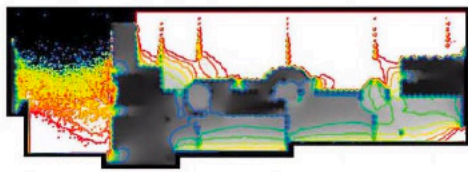


Fourth floor _ Sunny

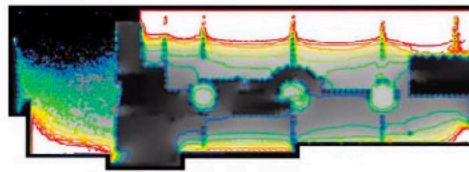
Overcast Skies



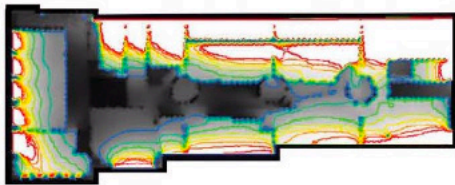
Fourth floor _ Overcast



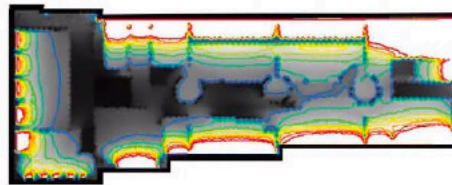
Third floor _ Sunny



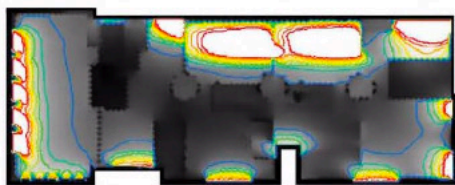
Third floor _ Overcast



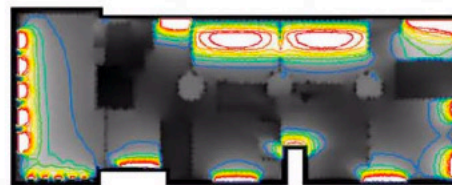
Second floor _ Sunny



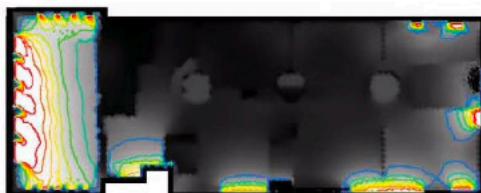
Second floor _ Overcast



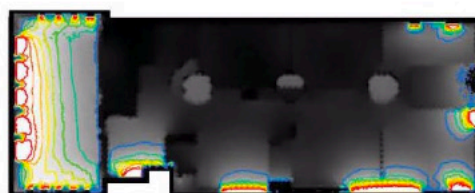
First floor _ Sunny



First floor _ Overcast



Ground floor _ Sunny



Ground floor _ Overcast

Illuminance (lux).

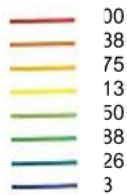


Figure 6: Illuminance study in plan; March/September 21 at noon, clear and overcast skies (lux). Source: L (Author, 2016)

McVoy stresses that natural light – including direct sunlight – is essential in even the most light-sensitive building types and programs: “We don’t see a distinction between the analytic and functional pragmatic aspects of light and the poetics of light. We see that natural light creates an atmosphere through time and through movement. And that a good space for every kind of activity benefits from generous natural light (McVoy, 2015).” The importance of “dynamic light” is emphasized, with the intensity, distribution, mood, and patterns of indirect daylight and direct sunlight celebrated and appropriately considered: “Our favorite building material is light. We believe in dynamic light . . . which registers the time of day and seasons and weather. A variation in daylight intensity is important (McVoy, 2015).”

3.3 Luminous Assessment

Daylight analyses under clear and overcast skies were conducted for “average conditions” in March and September at noon to assess light levels (illuminance studies in lux) and contrast ratios (luminance in candela/square meter) using Velux Daylight Visualizer. The studies explored how daylight is choreographed to support design intentions, program, and performance while celebrating the unique phenomena of light in place.

The illuminance studies illustrate a journey from lower daylight levels at the ground floor to increasing illumination in the upper level studios (Figure 6). As expected, daylight decreases quickly from the window wall in the sidelit spaces on the ground level and first floor, while the combined side lighting and toplighting on the upper levels provide an even distribution of daylight throughout the spaces under both sunny and overcast conditions. Although light decreases with distance from the skylights at the top of the “driven voids,” daylight is effectively gathered and redistributed through the lightwells to the ground level. Daylight meets ambient lighting needs on the upper floors while supplemental electric lighting is needed on the lower levels.

Luminance studies under clear and overcast skies in March/September at noon reveal minimal contrast ratios on the lower floors with the maximum ratio of 1:4 at the window wall (Figure 7). Luminance studies of the upper level north studio reveals a maximum contrast ratio of 1:8 along the south clerestory windows. This ratio falls within an acceptable range for visual comfort, with recommendations at a maximum of 1:10 ratio from task to the brighter distant background (IES, 2011, 12.20, Table 12.5). Given the high levels of daylight, operable interior shading in the studios would provide occupants a greater level of luminous control and visual comfort. Daylight is captured through the facades and within the “driven voids” to effectively receive and redistribute light throughout the building section.

Regarding the choreography and poetics of light, the studies reveal a vertical progression of daylight levels and an increased play of light and shadow. Given the predominantly overcast skies and urban context, the Reid Building’s white walls, concrete floors, and interior detailing of wood, steel, and glass create visually quiet environments that act as neutral canvases for the ever-changing atmospheric qualities.

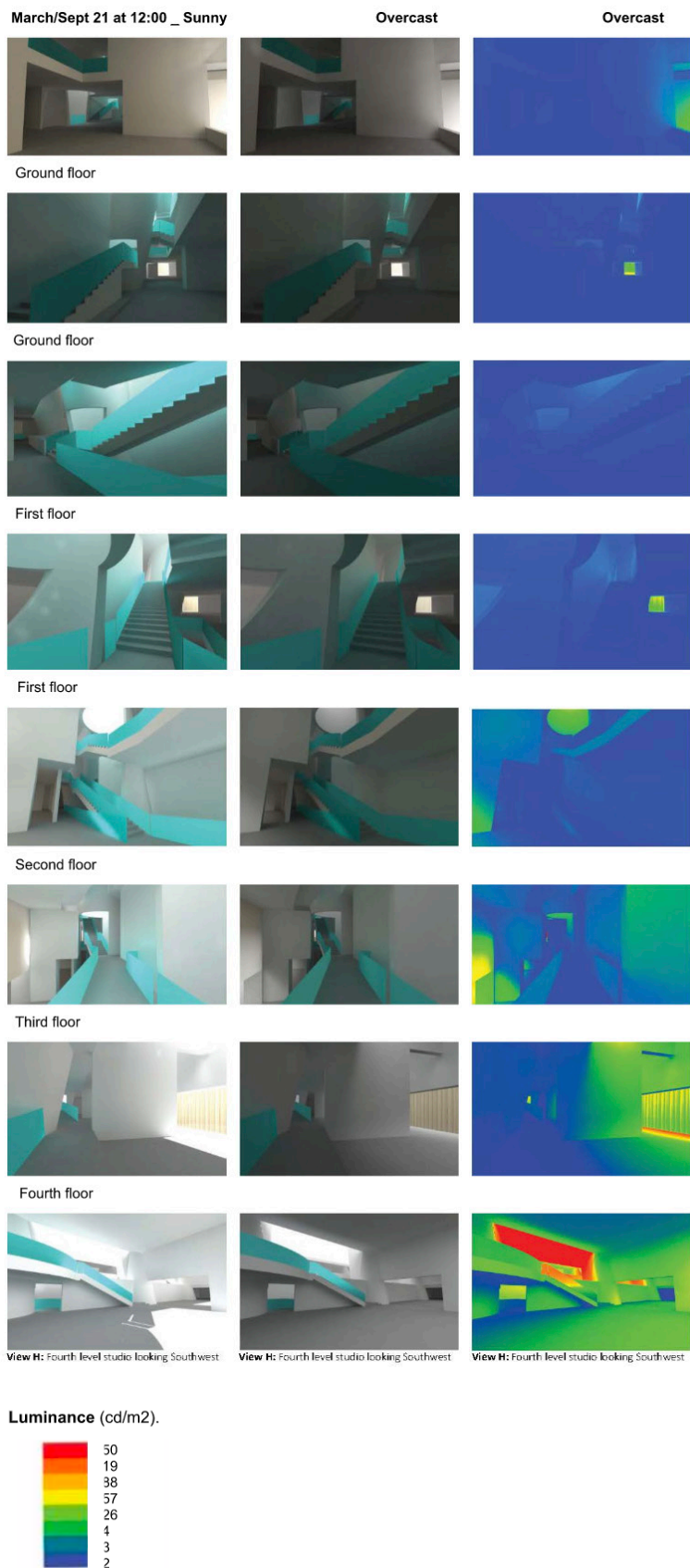


Figure 7: Luminance studies in perspective; March/September 21 at noon, clear and overcast skies (candela/m²). Source: (Author, 2016)

LIGHT CONSTRUCTION

4.1 Light and Integrated Design

Key to the integration of aesthetic and practical design concerns throughout the building interior and exterior are the “driven voids,” which Holl states “were designed to do everything,” by providing structural support, daylight, and ventilation while creating rich spatial and atmospheric experiences (Spirit of Space, 2014). Passive strategies for light and air are integrated into the voids, as McVoy explains: “[The Void] acts as a natural solar stack, with hot air rising and driving air up through it to draw air through studio windows. The building is completely naturally ventilated, there is no air-conditioning. When interior sensors get too warm they open up windows at the top of the voids (McVoy, 2015).”

The building envelope applies other innovative construction details. The rainscreen is a “thin shroud” of acid-etched laminated glass with translucent interlayers that are held 300 millimeters (11.8 inches) from the structural wall. To create a shroud effect, in which the brackets were not visible, SHA and JM Architects worked with Arup to design and test “ghost brackets,” custom glass fittings that enabled the team to create a subtle luminous and homogeneous envelope and to balance aesthetic and practical considerations.

The collaboration with Arup also included design and analysis of the energy and sustainability features. A radiant heating system is integrated into the concrete floor topping while the additional mass mediates thermal comfort on a seasonal basis. Passive strategies for daylight, natural ventilation, and cooling are coordinated with active mechanical, lighting, and ventilation controls. Ecological site strategies include a second-floor terrace and green roof with native landscaping and water feature, while a stormwater system on the north roof harvests rainwater for the sinks and lavatories. A shared biomass plant heats the Mackintosh, Reid, and nearby Bourdon Buildings. The integrated design strategies allow the building to meet the BREEAM Excellent standard and provide a reduction in energy consumption of 30 percent over current regulations – with an estimated annual energy consumption at 100 kWh/sq.m (31.7 kBtu sq ft.) and carbon emissions at 40 Kg CO₂/sq.m (430 Kg CO₂/sq ft.) (Steven Holl Architects, 2016).

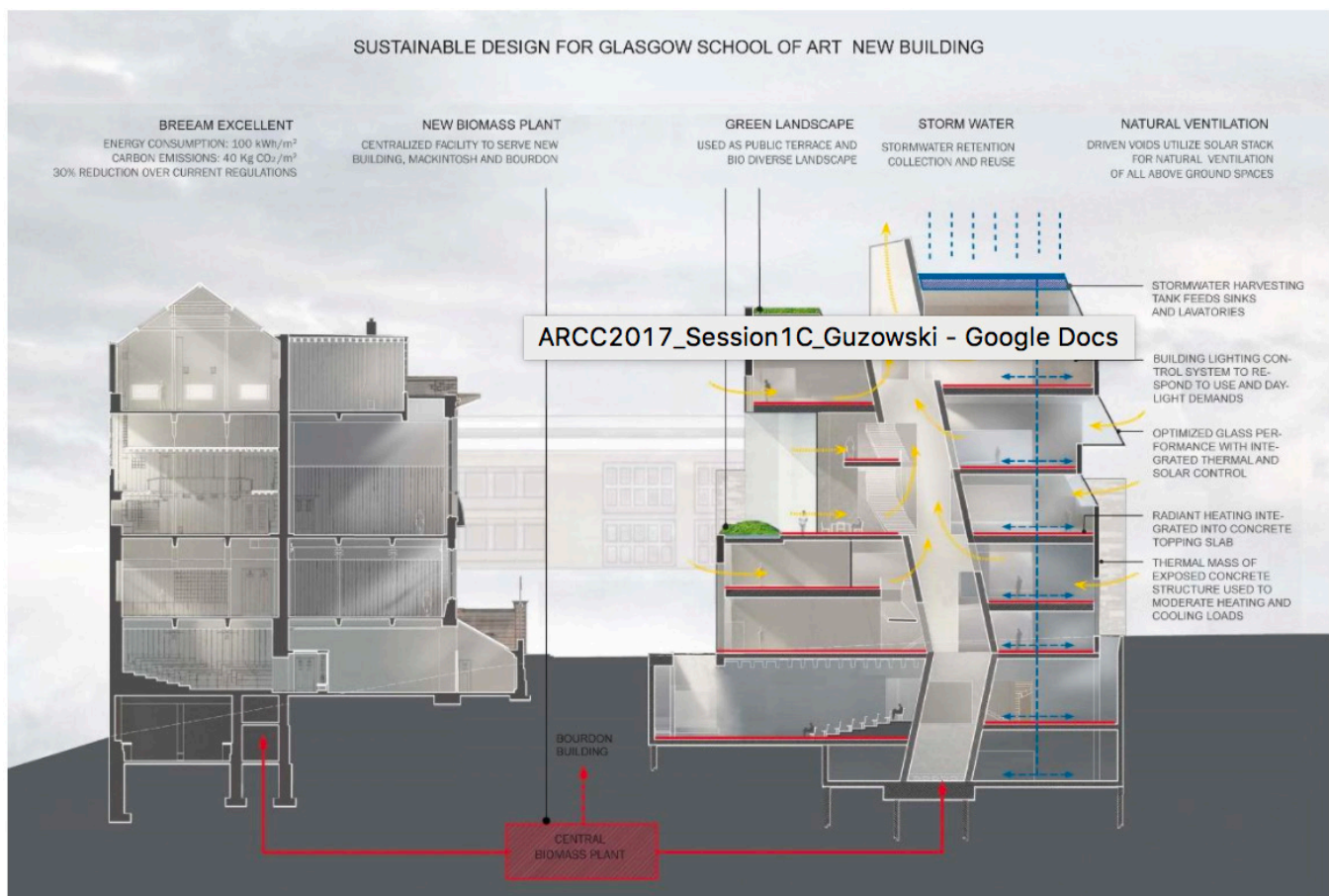


Figure 8: Sustainable design section looking west. Source: (SHA, 2016)

CONCLUSIONS

Architecture is a three-dimensional experience of the body in space, brought to life by the fourth dimension of time through the changing rhythms of day and night and the cycles of the seasons. Steven Holl Architects reveal that luminous experiences can be choreographed as an architectural journey that engage the body, awaken the senses, and foster relationships between people and the built and natural environments. The Reid Building skillfully relates to the scale, proportions, and sectional qualities of the Mackintosh Building while introducing a new language of light, materials, structure, and performance criteria. Atmospheric qualities of light are choreographed with practical and pragmatic considerations such as energy, solar control, visual comfort, and light distribution to ensure effective luminous experiences that support the program and aesthetic vision. The variety of spatial and atmospheric qualities successfully fosters the desired interactions and creative collaborations across the disciplines and with the broader art community of Glasgow. Respectful of the legacy of Mackintosh, the Reid Building confidently embodies a fresh architectural language with a new and ecologically creative vision for the GSA. As the GSA requested, the Reid Building acts as a source of inspiration and as a three-dimensional canvas for the design and exhibition of creative work.

ACKNOWLEDGEMENTS

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