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From Industrial Waste to Building Commodity

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Aller au sommaire du numéro

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From Industrial Waste to Building Commodity

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Prior to the establishment of Canada's National Ambient Air Quality Objectives (NAAQO) in the 1970s, desulfurization—the process by which sulfur is removed from crude oil—was a major source of the nation's air pollution and acid deposition. Stricter regulations imposed at the time prohibited oil refineries from burning the element, but alternative modes of desulfurization resulted in vast stockpiles of solid-form sulfur. Between 1970, when Canada began to restrict emissions, and 1975, stockpiles of sulfur in the country ballooned from 3.5 million to 20 million tons, stored primarily in the oil-rich Canadian Prairies. Professors Samir Ayad, Álvaro Ortega, and Witold Rybczynski, founders of McGill University's Minimum Cost Housing Group (MCHG), saw this "commodity in glut" as an opportunity to develop new sustainable building technologies (fig. 1).[1]

The MCHG believed that certain properties of sulfur, including its imperviousness and capacity as a strong binding agent, "point[ed] to [its suitability] as a building material in the contemporary context of ecological concerns and needs for energy conservation."[2] In 1971, the group designed their first "waste-material, low-energy, quick-fix, easy-assemble, universal building block" made of sulfur. By 1975, they had constructed three structures using sulfur building technology: *Ecol*, a demonstration home in Sainte-Anne-de-Bellevue, Quebec (1972); the *Round House*, a community building in Saddle Lake, Alberta (1973); and *Maison Lessard*, an orphanage in Saint-François-du-Lac, Quebec (1974–1975).[3] This paper examines MCHG's sulfur building initiative as a convergence of Canada's robust extractive industry, the federal government's burgeoning environmental sensitivity, and the ethos of the Appropriate Technology, or AT, Movement in the early- to mid-1970s, a project that exploited a byproduct of the still largely unchecked oil business without attempting to dismantle the larger pollutive system or push for greater political change.[4]

Canada's Petroleum Industry and Environmental Response

Canada has seven hydrocarbon regions—the most productive being the Western Canada Sedimentary Basin, which encompasses the entirety of Alberta, and parts of Saskatchewan, British Columbia, Manitoba, the Yukon, and the Northwest Territories.[5] From its beginnings in the 1850s, the Canadian oil industry was plagued by the so-called sourness of its petroleum deposits, that is, deposits "with significant quantities of sulfur compounds."[6] The sulfur content in the earliest discoveries of petroleum, in the Petrolia oilfields in Lambert County, Ontario, was especially high. While sour crude oil and natural gas could perform similarly to so-called sweeter deposits without intensive refining to remove the sulfur, the burning of such fuel resulted in malodorous fumes. According to the chemist W. A. E. McBryde, mercaptans (sulphur analogues of alcohols) were to blame: "Mercaptans...contribute to the smell of onions and garlic; and butyl mercaptan...is the principal source of the odour secreted by skunks."[7] This odour resulted in limitations on petroleum exports from the nation and a lack of competitiveness in the open market, and so, as early as 1868, industry executives and chemists sought new processes to sweeten Canada's oil.[8]

FIG. 1.
“BUILDING WITH MATERIALS WHICH WOULD OTHERWISE CAUSE POLLUTION WHEN DISCARDED AS INDUSTRIAL WASTE...” FROM THE ECOL OPERATION: ECOLOGY + BUILDING + COMMON SENSE, (MCMG, DECEMBER 1972, 9).
COURTESY OF VIKRAM BHATT ON BEHALF OF THE MCGILL UNIVERSITY MINIMUM COST HOUSING GROUP.

FIG. 2.
TURNER VALLEY, ALBERTA, 1929, (CU182927) BY UNKNOWN.
COURTESY OF GLENBOW LIBRARY AND ARCHIVES COLLECTION, LIBRARIES AND CULTURAL RESOURCES DIGITAL COLLECTIONS, UNIVERSITY OF CALGARY.

As the industry expanded into the Western Sedimentary Basin at the turn of the century, speculators found petroleum that was sweeter, but not devoid of odour. In the 1920s, drilling in Alberta, specifically in Turner Valley (fig. 2), led to the discovery of major petroleum deposits that contained fewer sulfur compounds than those in Ontario[9] but were still sour (and less marketable) compared to products in other nations.[10] The glut of oil in the region led to the use of sour petroleum condensate, or naphtha, in vehicles and sulfurous natural gas in homes and street lights. Moreover, a great deal of unwanted gas was burned in massive flare pits, giving Turner Valley the moniker "Hell's Half Acre" (fig. 3).[11] Historian Robert D. Bott suggests that inhabitants of the region simply learned to live with the odour, which they referred to as "the smell of money."[12]

FIG. 3.
HELL'S HALF ACRE, TURNER VALLEY, ALBERTA. CA. 1930S, (CU1134562) BY UNKNOWN.
COURTESY OF GLENBOW LIBRARY AND ARCHIVES COLLECTION, LIBRARIES AND CULTURAL RESOURCES DIGITAL COLLECTIONS, UNIVERSITY OF CALGARY.

Although useful to Albertans on a local scale, such deposits were not as lucrative on the open market without further refining to reduce the skunk-like odour of sulfur emissions. Thus, scientists developed a process by which they "scrubbed" the sulfur from petroleum through burning the element and releasing the sulfur dioxide emissions into the air. Of course, this scrubbing process resulted in higher levels of sulfur within oil-producing and refining regions and perpetuated the noxious "smell of money." In 1952, as companies such as Shell Canada and British American Oil uncovered other major deposits in Canada, scientists found an alternative method to sweeten natural gas that recovered elemental or solid-state sulfur for use in "fertilizer, mineral refining, and pulp and paper industries."[13] This method became popular practice in some refinery operations, but it was not used by all companies and so did not entirely eliminate emissions at the time. Recognizing the possibility of greater control over corporations in its jurisdiction and the potential for reduced odour, Alberta's provincial government passed one of Canada's first air quality regulations in 1961. Overseen by the Provincial Board of Health, these regulations required Board review of any new industrial plants and pipelines prior to construction, and limited toxic emissions, based on smoke density, length of emission, and whether emissions were released in urban or rural areas.[14] Since production of elemental sulfur was far from ubiquitous in the area, many refineries simply raised their exhaust stacks to disperse sulfur dioxide in a less concentrated manner, fulfilling the regulations but not addressing overall atmospheric pollution.[15] As additional, stricter air quality regulations appeared in the later 1960s in Saskatchewan, Manitoba, and British Columbia, however, solid-state sulfur recovery, as opposed to scrubbing, became the norm, and this standard became even more codified when, in 1971, the federal government passed Canada's Clean Air Act, establishing National Ambient Air Quality Objectives (NAAQO) for sulfur dioxide and other toxic emissions.[16]

While Canada's federal government initiated a more aggressive policy to confront the detrimental effects of unchecked air pollution on public health and the environment, the nation's citizens were also calling for greater environmental action. Activist groups, including Pollution Probe and Greenpeace, fought for change and protested against the environmental destruction wrought by the petroleum industry, among others, on Canada's air, land, and waterways.[17] Meanwhile, at a local level, Canada's countercultural youth adopted a more self-sufficient, ecologically-friendly way of living, not only through moving "back to the land" to establish utopian communes and rural homesteads but also through smaller-scale lifestyle changes such as recycling, backyard organic gardening, or bicycle use.[18] This environmentalist fervour seeped into architectural practice, as Canadian architects and experimental collectives, including McGill University's Minimum Cost Housing Group and the New Alchemy Institute, began to integrate ecological perspectives into their work.[19]

Intermediate or Appropriate Technology?

The Minimum Cost Housing Group was established in 1970, by Colombian architect Álvaro Ortega, whose work with the United Nations on housing projects in 'developing' nations inspired him to found a program at his alma mater. Ortega was joined by a group of architects and recent McGill graduates, including Witold Rybczynski, Samir Ayad, Wajid Ali, and Arthur Acheson, who shared an interest in finding solutions to international housing problems. The MCHG (fig. 4) sought to undertake research that would address the problem of the sanitary aspects of housing in rural and urban areas in which water supply plays an important role, and the development of alternative uses for locally available building materials, particularly binding agents, to decrease the building cost and increase the quality of construction in self-built housing.[20]

FIG. 4. THE MINIMUM COST HOUSING GROUP, JUNE 1974 (LEFT TO RIGHT: VIKRAM BHATT, WITOLD RYBCZYNSKI, BERNARD LEFEBVRE, BEHROOZ NOURNIA, MAKRAM HANNA, WAJID ALI, ALVARO ORTEGA) FROM *USE IT AGAIN, SAM* (1975). COURTESY OF VIKRAM BHATT ON BEHALF OF THE MCGILL UNIVERSITY MINIMUM COST HOUSING.

The MCHG's aforementioned goals were not overtly ecological and, moreover, tended toward an international development context. Its ambitions, in fact, echoed the ideas of British economist E. F. Schumacher—in particular, his concept of "intermediate technology"—more than those of Greenpeace or other environmentalist organizations. Informed by his experience as an economic advisor to the governments of Myanmar and India in the 1950s and 1960s, Schumacher devised what he believed to be a more prudent development strategy for rapidly industrializing nations, which he presented in a British *Observer* article of August 1965, problematically titled "How to Help Them Help Themselves." His plan, as expressed in the essay, was designed to remedy harmful contemporary development practices by promoting small-scale, inexpensive, regional industries reliant upon production processes that required minimal skill, depended upon scant financing, and utilized local materials.[21]

Although Schumacher's theory went unmentioned in the literature of the MCHG, it certainly paralleled the ideology of the collaborative group, the members of which likely would have been familiar with the economist's scholarship.

Indeed, by 1968, two years prior to the foundation of the Minimum Cost Housing Group, countercultural guru Stewart Brand had published an excerpt from Schumacher's essay "Buddhist Economics" in his influential *Whole Earth Catalog*.[22] As presented in the *Whole Earth Catalog*, "Buddhist Economics" focused less on the economic development of non-Western nations than the fuller versions of the article found in *Asia: A Handbook* (1966) and the British magazine *Resurgence* (1968). Instead, it concentrated primarily on issues of technology and materialism, which applied more directly to the *Catalog*'s American readership. Stripped of its focus on the 'developing' world, Schumacher's work offered solutions to Western overdevelopment that resonated with radical countercultural youth, who condemned the socio-economic and ecological 'pollution' wrought by irresponsible corporate and governmental technocrats. In North America, the practice of 'intermediate technology' was infused with a countercultural ethos and became better known as 'appropriate technology,' or AT; the economist's new American disciples embraced his ideas, even if Schumacher's texts did not explicitly integrate ecological concepts or turn toward issues of overdevelopment until his seminal work, *Small is Beautiful: Economics as if People Mattered*, published in 1972.[23] Among countercultural youth, who already had a penchant for activism, the practice of AT became a potential mechanism for local, regional, and national environmental change.

The MCHG did not directly affiliate itself with the AT Movement or Schumacher's earlier, "intermediate" approach in its texts; nevertheless, its work on sulfur housing bears striking parallels with both. Sulfur housing, on the one hand, responded to Western overdevelopment—exploiting the vast caches of Canadian solid-state sulfur, a consequence of the modern petroleum industry, to design buildings for Canadians—while on the other, looked toward the ways in which discoveries in Canada could be applied at an international scale. Schumacher, American appropriate technologists, and the MCHG were all committed to the implementation of small-scale, inexpensive, simply constructed, and low-impact technologies, albeit for differing ends. As revealed in the MCHG literature of the early 1970s, the Group's work and rhetoric seemed to vacillate between the sort of nationally focused, ecological, activist modality of the American AT Movement and the international-scale, technocratic manner of Schumacher's original theory. As such, the MCHG did not fully clarify the stakes of various projects or, for that matter, the intended stakeholders. To some extent, this opens *Ecol*, the *Round House*, and *Maison Lessard* to common critiques of AT and intermediate technology; scholars such as Kevin Willoughby, Harvey Brooks, and Carroll Pursell, among others, have noted that certain aspects of the practice "inevitably embody some form of totalitarianism in which the subtly elitist preferences of minorities are imposed on majorities."[24] By the mid-1970s, even MCHG founding member Witold Rybczynski criticized the Movement (if not the work of the Group), asking, "Has any underdeveloped country actually espoused Appropriate Technology on its own?"[25]

Sulfur Housing

Supported by a grant from the Canadian federal government's Central Mortgage and Housing Corporation in 1971, the MCHG undertook a major project to discover the possibilities of using elemental sulfur as a raw material in the production of minimum cost housing. The group's ambitions in experimenting with sulfur concrete units of construction were to develop: 1. "low cost building techniques using inexpensive equipment, unskilled labor, and a maximum use of locally produced building materials"; 2. "inexpensive binding agents [capable of] assembling...small scale building components"; and 3. "building concrete that uses no water."[26] Elemental sulfur, the MCHG noted, existed naturally in many regions the world over but was over-abundant (and thus inexpensive) in nations such as Canada that had recently passed clean air legislation (fig. 5). Moreover, by their estimation, should sulfur prove a valuable building resource, nations experiencing housing shortages may also be enticed to recover sulfur from their refineries, instead of polluting the atmosphere—a potential opportunity for a building material to drive environmental legislation. In its 1974 text *Sulphur Concrete & Very Low Cost Housing*, the MCHG mentioned that other major benefits of sulfur concrete included a rapid curing period, non-porosity, and waterproofness.[27]

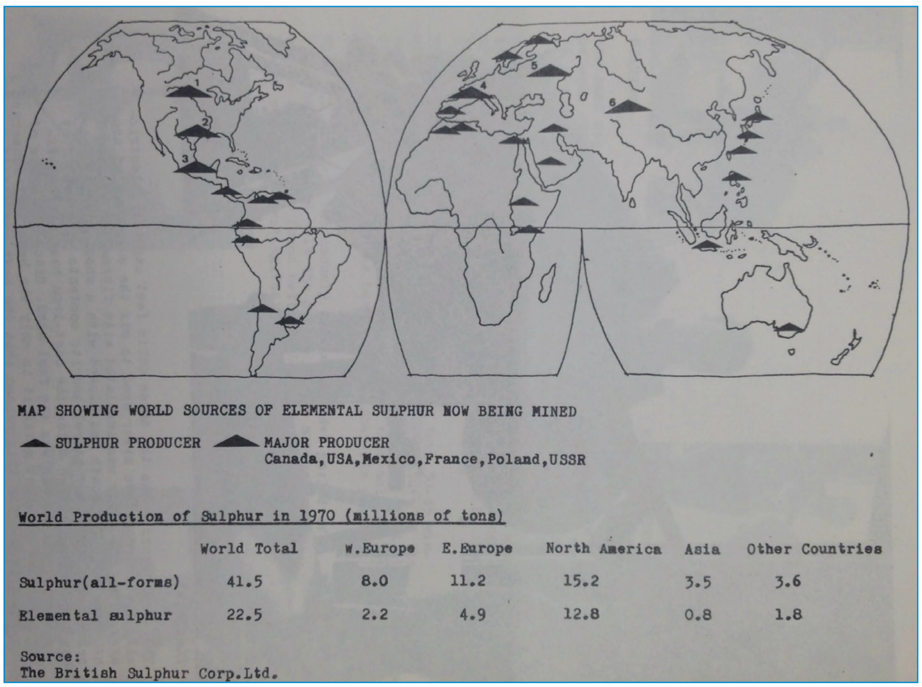

FIG. 5.
"WORLD PRODUCTION OF SULFUR IN 1970," FROM *THE PROBLEM IS...* (MCHG, DECEMBER 1972, 44).
COURTESY OF VIKRAM BHATT ON BEHALF OF THE MCGILL UNIVERSITY MINIMUM COST HOUSING GROUP.

Sulfur concrete, the MCHG admitted, was not new and could be traced to medieval Europe and seventeenth-century South America, but it was once more gaining traction as a solution to housing needs.[28] In the 1960s, scientists J. M. Dale and A. C. Ludwig researched "the mechanical and elastic properties of sulfur/sand composites [and] ...develop[ed] fire retardant additives and techniques for mixing" at the Southwest Research Institute, while creating "a machine for spraying pure plasticized sulfur and chopped glass fibers as a coating, to join lightweight concrete blocks."[29] Ludwig also assisted the United Nations in testing the possibilities for use of the material in Guatemala.[30] However, the MCHG criticized the UN for its initiatives and other contemporary work in countries such as Colombia, asserting that these projects "with respect to sulfur concrete...largely confirmed the initial findings, without demonstrating whether or not anything could actually be built out of this material."[31] Thus, the Group sought both to extend previous scientific research in regard to melting, mixing, and moulding the material and to test its practical use in built demonstration projects.

During subsequent years, the MCHG, assisted by McGill architecture students as well as other university departments and outside organizations, followed a procedure in which it, first, would design "prototypes of building components..." then "develop them as full-size pilot models, so as to evaluate the steps of component fabrication, erection, and integration into a structure, as well as subsequent performance in use."[32] In the prototypical components, the MCHG could test the limits of sulfur concrete's aforementioned rapid curing period, non-porosity, and waterproofness, while in the pilot models, it could examine whether sulfur concrete units embodied the sort of inexpensive, simply constructed, and, most importantly, functional domestic spaces they imagined. In the remainder of the paper, I will briefly examine this process through three case studies highlighted by the MCHG in its own literature: *Ecol*, a demonstration home in Sainte-Anne-de-Bellevue, Quebec (1972); the *Round House*, a community building in Saddle Lake, Alberta (1973); and *Maison Lessard*, an orphanage in Saint-François-du-Lac, Quebec (1974–1975).[33]

As described, the initial phase of the sulfur concrete initiative involved material experimentation and component-building (fig. 6). The MCHG employed an electric concrete mixer with a capacity of three cubic feet to combine the sand, sulfur, and aggregate that would make up their building components; a butane gas heater, placed under the mixer barrel, heated the sand prior to adding elemental sulfur. Once the mix was complete, the group tested its function using moulds of various shapes and textures, discovering that metal and glass moulds gave sulfur concrete a "shiny finish" and that wood or plastic moulds could be used with proper heat-resistant finishes.[34] It cast tiles, slabs, and three-dimensional shapes, finding an "exceptional quality in all cases" and comparing the material to marble for its smoothness and non-porosity.[35] In collaboration with National Research Council Canada, the MCHG also tested the "freeze-thaw durability" of sulfur concrete, determining that additives such

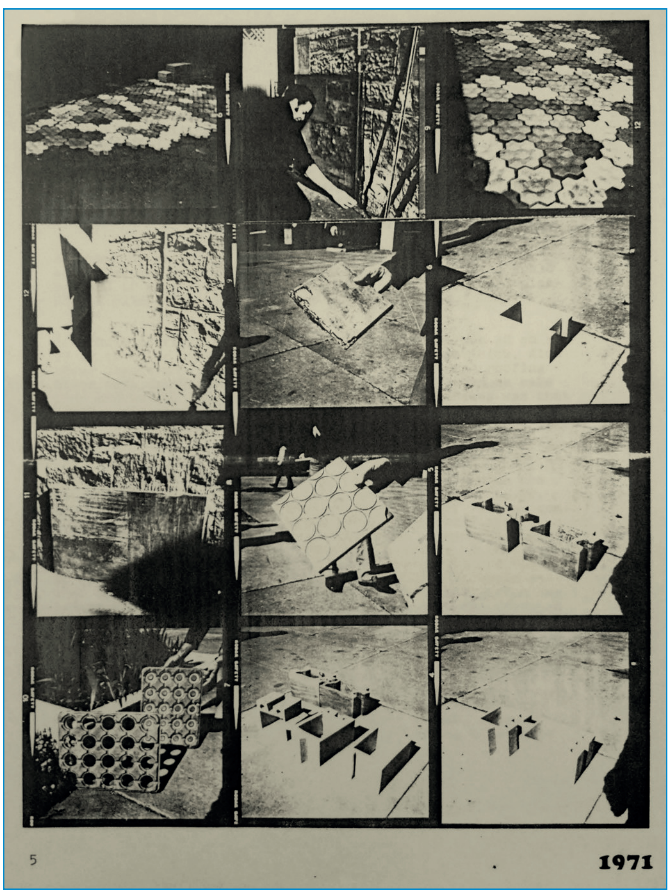

FIG. 6.
MCHG, SULFUR BLOCK EXPERIMENTS, 1971, FROM *SULPHUR CONCRETE & VERY LOW COST HOUSING* (MCHG, 1974).
COURTESY OF VIKRAM BHATT ON BEHALF OF THE MCGILL UNIVERSITY MINIMUM COST HOUSING GROUP.

as pyrite, CTLA, and PL-41 would enable the material to withstand up to 600 freeze-thaw cycles—an important factor in using such building components in Canada.[36] Having successfully completed the first phase of its established procedure, the MCHG moved on to design what they called "full-size pilot models."

FIG. 7.
MCHG, *ECOL,* 1972, SAINTE-ANNE-DE-BELLEVUE, QUEBEC, CANADA, FROM *THE ECOL OPERATION: ECOLOGY + BUILDING + COMMON SENSE* (MCHG, DECEMBER 1972, COVER PAGE).
COURTESY OF VIKRAM BHATT ON BEHALF OF THE MCGILL UNIVERSITY MINIMUM COST HOUSING GROUP.

During the spring and summer of 1972, the MCHG first tested sulfur concrete at a large scale in a self-sufficient, minimal cost house dubbed by Buckminster Fuller as *Ecol*, on McGill's Macdonald Campus[37] in Sainte-Anne-de-Bellevue, Quebec (fig. 7).[38] *Ecol* consisted of one fully sulfur concrete module and, for comparison, a low-cost timber module of equal size on the opposite side of the building, as may be seen in Figure 7. These were connected by a patio covered by an asbestos[39] cement roof made from sewage pipes, their bolts waterproofed with sulfur coating. Utilizing an aluminum mold, the MCHG created a mortarless, self-aligning system of interlocking bricks for the 3.6 × 3.6-metre exterior structure, the entirety of which was erected by two people in one day (fig. 8). The kitchen countertop and floor tiles were also made of sulfur concrete, as were the tiles and washbasin of the free-standing asbestos sheet bathroom unit. Designers also experimented with the finishes of the blocks, allowing some to remain beige from the traditional mixture while adding slag or carbon black to other mixes, resulting in shades of gray and black; they even discovered that, since sulfur attracts metals, the concrete bricks would permanently transfer metallic ink from magazines or other sources to its own surface (fig. 9).[40] They called this technique "a poor man's fresco."[41] Describing *Ecol* in the autumn of 1974, the MCHG had little criticism for the home; it had "passed through two winters" (although it was unoccupied except during the summer months); was "easy to clean"; "show[ed] no sign of wear"; and "the pleasant and unique appearance of unpainted sulfur concrete...remain[ed] a constant source of pleasure."[42] In comparison, they noted, the timber module—exposed to the same conditions—appeared weathered and dirty.

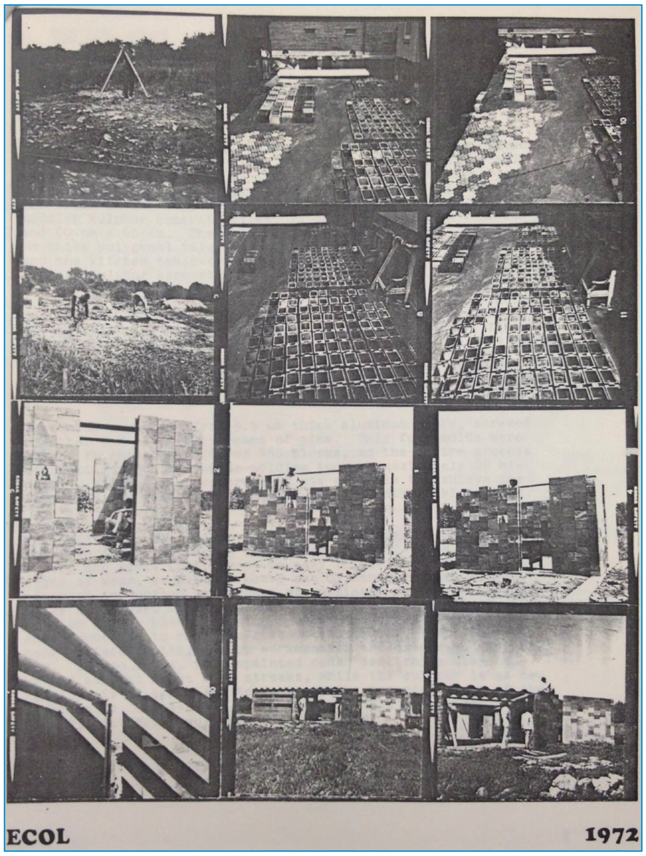

FIG. 8.
MCHG, *ECOL* PROCESS PHOTOS, 1972, FROM *SULPHUR CONCRETE & VERY LOW COST HOUSING* (MCHG, 1974).
COURTESY OF VIKRAM BHATT ON BEHALF OF THE MCGILL UNIVERSITY MINIMUM COST HOUSING GROUP.

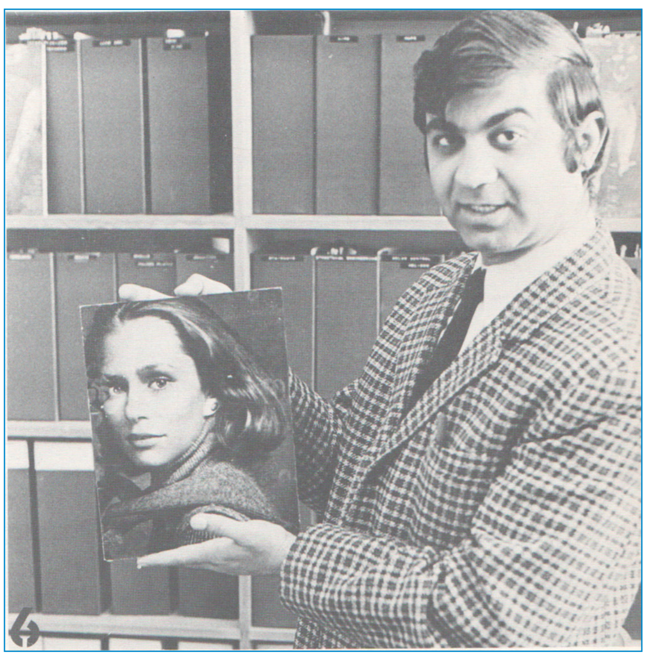

FIG. 9.
"A POOR MAN'S FRESCO" SULFUR BLOCK, C. 1972, FROM *THE ECOL OPERATION: ECOLOGY + BUILDING + COMMON SENSE,* (MCHG, DECEMBER 1972, 43).
COURTESY OF VIKRAM BHATT ON BEHALF OF THE MCGILL UNIVERSITY MINIMUM COST HOUSING GROUP.

In the epilogue of *The Ecol Operation: Ecology + Building + Common Sense*, the MCHG integrated ecological issues into its mission, explaining their intention to build in "an ecologically non-destructive way, and thus avoid the errors of the past."[43] Furthermore, it became clear that this initiative was taken in the service of the international community more than Canadians. Indeed, the Group described its globalist perspective as follows:

> We are more than ever convinced, after having built the house, that the substitution of labour and low-cost materials for capital and automation must be the basis of development for developing countries.[44]

This explanation, reminiscent of Schumacher's goals in 1965, underscored the broader dimensions of the *Ecol* project and infused the remainder of the epilogue. The MCHG authors mentioned with pride that *Ecol* "was built by architects from four continents...[who] spoke six mother tongues," noting that "[they] did this together and felt no need for treaties or visas," while failing to acknowledge the fact that their work was a pilot demonstration model, supported by the Canadian government, and was designed to be inhabited by two middle-class, white Canadian architects, only during the spring and summer months.[45] While *Ecol* was an experimental success, the MCHG's confidence in sulfur housing as an international solution suggests that a Western-based group of academics were convinced that they could affect positive change for unnamed stakeholders in the 'developing' world.

Building upon the success of *Ecol*, the MCHG moved into the heart of Canada's petroleum industry in the summer of 1973 with a project called the *Round House* in Saddle Lake, Alberta. The Special Assignments Group of the Department of Indian and Northern Affairs[46] had invited the MCHG "to determine the potential for the production of small building components out of sulfur concrete by members of the Band, for their own needs," and the Group believed that the best way to determine such a potential was to undertake another full-size pilot model and demonstration project in collaboration with the Band.[47] Master of Architecture student Jon Boon, who worked on the project alongside Rybczynski and Wajid Ali, was especially interested in how sulfur concrete could play a role in collaborative community development and was committed to establishing a collaborative relationship with the Cree People residing at Saddle Lake.[48] According to historian Michèle Curtis, this collaborative project was successful, as the MCHG helped the Band Council to build a structure for their own expressed purpose—"a community food and refreshments pavilion"—in a public location. The MCHG invited representatives of the Saddle Lake Cree Nation, Lawrence Large and Elmer Cardinal,[49] to the McGill University campus to learn about the sulfur building process. The project "helped to improve living conditions on [the] reserves, led to educational benefits for the communities, and fostered collective involvement"[50] (fig. 10). For the MCHG, the *Round House* was also the "first field trial" to establish "in a remote area, a small factory...to process a raw material into building components...with a capital investment in machinery of less than $200 and a maximum use of human initiative."[51] The Saddle Lake reserve, where the *Round House* was based, was not far from Imperial Oil's refineries in Redwater, Alberta, which made it ideally positioned as a case study in site-specific, local material use. In fact, Imperial Oil delivered molten sulfur directly to the reserve, establishing an ironic relationship between the Saddle Lake Cree Nation people and the company, especially in light of 1960s-era government policies that attempted to strip Indigenous people of their land rights in favour of corporate interests.[52] The proximity of elemental sulfur allowed the MCHG and their Cree collaborators to set up a lakeside shelter for the mixer and brick storage as well as to build the entire *Round House* in just three weeks. In the *Round House*, like in *Ecol*, the MCHG employed a mortarless, interlocking system of brick construction, but it diverged from the earlier project in its curvature, which added structural stability to the community building. The *Round House* confirmed, once more, that sulfur concrete construction was an efficient, practical building methodology that allowed for formal and aesthetic variety and suggested that the process could fulfill the housing needs of rural or low-income communities. At the same time, the MCHG's primary literature on the Saddle Lake pavilion did not offer

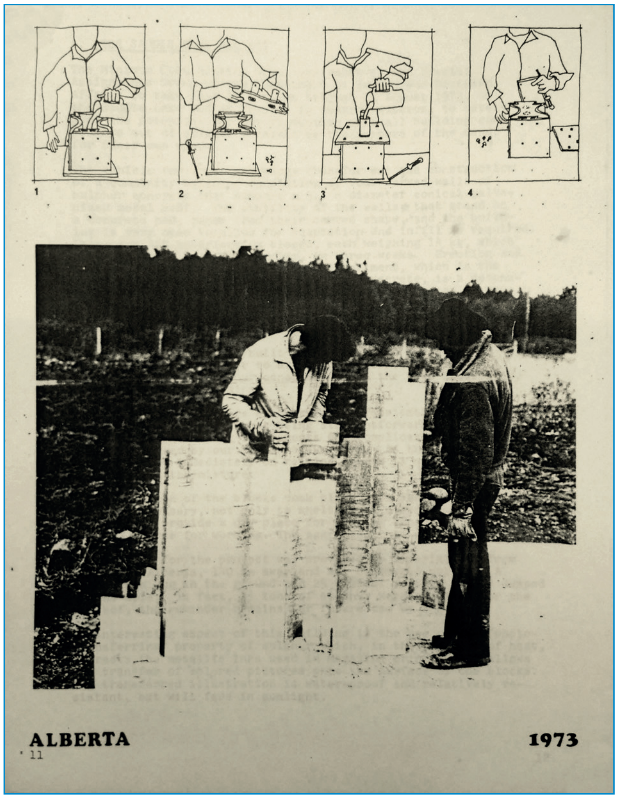

FIG. 10.
MCHG, THE *ROUND HOUSE*, 1973, SADDLE LAKE, ALBERTA, CANADA, FROM *SULPHUR CONCRETE & VERY LOW COST HOUSING* (MCHG, 1974).
COURTESY OF VIKRAM BHATT ON BEHALF OF THE MCGILL UNIVERSITY MINIMUM COST HOUSING GROUP.

information on the larger socio-political stakes of the project for Indigenous Canadians—once again envisioning the project more as a scientific exploration of the possibilities of sulfur housing for global housing crises.[53] In so doing, the Group inadvertently exploited the Cree people as stand-ins for the global "Other," without acknowledging the band's own minority status and troubled history of colonization and injustice.

While both the *Round House* and *Ecol* affirmed the structural and environmental performance of sulfur concrete, neither were winterized, and so, by 1973, the MCHG had yet to prove that sulfur bricks were a practical solution for year-round housing in colder climates. At the behest of the Franciscan priest Father Marius Lessard, the MCHG was able to address this issue in a family-style orphanage in Saint-François-du-Lac, Quebec. Called *Maison Lessard*, the orphanage was to be fully winterized in order to prove the value of sulfur housing in less temperate climes. To assist the MCHG in brick-making, Father Lessard recruited a group of eight local high school students, supported by an Opportunity for Youth government grant, and the priest also enlisted local builders and carpenters to finish the house, once the MCHG oversaw the sulfur components. For *Maison Lessard*, the MCHG filled hollow sulfur concrete blocks with granular insulation; battens with fibre insulation and plasterboard were attached to the interior walls, and the timber roof was covered in asbestos cement shingles. This project, more than *Ecol* and the *Round House*, led the MCHG to reflect on the advantages and disadvantages of sulfur concrete building due to its thermal requirements and greater material and design complexity. At one level, *Maison Lessard* fulfilled the goals of appropriate and intermediate technology: it was inexpensive to build, used simple equipment, drew upon local materials, and employed unskilled labour. Indeed, Rybczynski even noted "[t]hat eight enthusiastic teenagers"[54] with virtually no training or supervision could manufacture durable building components, thus indicating "the extraordinary promise of this material for self-help applications" and was convinced that mortarless, interlocking systems were a better building solution for their simplicity of construction.[55] On another level, he admitted that "the rigors of a northern climate complicate and reduce the advantages of block construction, compared with its use in tropical or temperate conditions."[56] Here, Rybczynski confronted a common issue in the practice of intermediate or appropriate technology: its inability to function as a holistic solution to global problems. At the same time, his assertion that block construction is suitable for "tropical or temperate conditions" also implicitly suggested that the building strategy was less relevant domestically than abroad. Similar to the MCHG's apolitical description of the *Round House*, the treatment of *Maison Lessard* also failed to acknowledge the stakes that led Father Lessard to invite the Group to build the orphanage, almost painting the priest as a collaborator, interested in testing the thermal limits of sulfur concrete, instead of an active leader with a responsibility to the community. Once again, this positioning could be read as an unconscious "othering" in the service of international ambitions.

The Minimum Cost Housing Group's significant research and development of sulfur concrete building components and full-size pilot models from 1971 through 1974 provided, in some ways, a symbiotic architectural response to a newly abundant Canadian resource, steeped in the principles of intermediate and appropriate technology. Its flagship projects—*Ecol*, the *Round House*, and *Maison Lessard*—responded to the ecological challenges faced by Canadians and the resources available, albeit with a larger international vision that emphasized global over domestic implementation. In his 1975 article, "Garbage Housing: U.S.A.," British architecture critic Martin Pawley suggested that by applying the "abundances (garbage)" to the "scarcities (housing)" of the developed world, "a balance in resource utilization might be reached which would not require the wholesale dismantling of the mechanism of consumption."[57] Pawley's prediction was corroborated in the sulfur concrete work of the Minimum Cost Housing Group, which tacitly acknowledged that Canada's petroleum industry would not be entirely dismantled—the goal of many environmentalists at the time—by creating a method to build low-cost housing that could exploit the industry's wasteful byproduct: elemental sulfur.

The MCHG did not address the apparent termination of their sulfur concrete program only three years after it began. Under the supervision of Group member Bernard Lefebvre, international students constructed sulfur houses in Manila and Dubai, but these achievements remained unpublished and were only recently addressed in Mya Berger and Leticia Brown's edited volume, *A Concrete for the "Other Half"?*[58] Certainly, the glut of solid-state sulfur endured in Canada as environmental regulation increased under the government of Prime Minister Pierre Trudeau, and governmental funding for intermediate technology projects even increased in the mid-1970s. In the absence of a direct explanation for the termination of the MCHG's sulfur housing initiative, we might turn to Rybczynski's discussions of appropriate and intermediate technological design shortly following the conclusion of the projects. By the mid-1970s, Witold Rybczynski had attempted to wash his hands of the sort of appropriate or intermediate technological ideology the early sulfur housing work arguably represented, without admitting his initial complicity in the more problematic aspects of the practice. He cast appropriate technologists as religious zealots, who were "long on polemic, and pitifully short on actual accomplishments" and questioned the merits of the movement itself.[59] Noting "that the Appropriate Technology devotees in the underdeveloped countries are by and large financed by the Mother Country," Rybczynski wrote, "Likewise visits by Appropriate Technology advocates to advise Third World bureaucrats are rarely financed by their hosts...Is it still up to Us to show Them?"[60] Rybczynski stridently asserted that the answer was "no," and yet his critique clearly applied to the MCHG's sulfur housing project. In his 1980 text, *Paper Heroes: Review of Appropriate Technology*, he expanded upon this stance, explaining that an "imposition [of intermediate technology] *from outside*...instead of being a stepping stone to further development...[might be] a millstone around the necks of the poor in less developed countries."[61] His assessment aligns with those of the later critics mentioned above; however, it also fails to recognize the negative effect of AT imposed by well-intentioned academic elites on low-income communities within so-called developed nations. How, for example, did the MCHG expect the Saddle Lake Cree Nation to use the twenty-five tons of sulfur off-loaded by Imperial Oil on the reserve?

As this paper has demonstrated, the MCHG project, from its origin, viewed its sulfur block construction experiment as a solution to the problems of "developing" nations rich with solid-state sulfur. Even in descriptions of its ostensibly community-based second and third projects—the *Round House* and *Maison Lessard*—the MCHG promoted sulfur housing as an international rather than a domestic solution, relegating their Saddle Lake and Saint-François-du-Lac collaborators to experimental actors in a larger global enterprise. Since some of the MCHG's projects following its sulfur housing initiative maintained an international focus, it is unclear whether an organizational reckoning on par with Rybczynski's assessments occurred or whether—less dramatically—the Mortgage and Housing Corporation's grant simply dried up and the Minimum Cost Housing Group opted to discontinue the initiative in favour of pursuing other compelling projects. No matter the reasoning, 1974 marked the conclusion of the MCHG's public investigation of sulfur housing and an end to an experiment in which sustainable architecture converged with Canada's powerful oil industry.

FIG. 11.
SULFUR PYRAMIDS, C. 2010, ALBERTA, CANADA.
JASON WOODHEAD.

While the MCHG's major work with sulfur concluded in the mid-1970s, Canada's production of solid-state sulfur continued apace. Today, five million tons of solid sulfur sit in Fort McMurray, Alberta, formed into massive flat pyramids that dwarf those of Giza, with some 1,700 tons being added each and every day (fig. 11).[62] And yet this pales in comparison to

Kazakhstan's nine blocks of over 7.8 million tons, which purportedly can be seen from outer space.[63] These astronomical caches are not only malodorous eyesores—or "modern-world wonders," as some may say; in Canada, the erosion of mountains of sulfur in Alberta threatens to contaminate the water and in Kazakhstan, ironically, flakes of sulfur contribute to air pollution.[64] Now, industry-supported technocrats—not experimental architectural collectives—are promoting the use of sulfur to make concrete. At the same time, contemporary students, such as those at the Dessau-based Bauhaus Lab, have begun to reconsider the role of sulfur in building. Current conditions demonstrate Ortega, Rybczynski, and Ayad's prescience in finding a building solution for the stockpiles of sulfur that were a natural consequence of 1970s environmental regulation, but the MCHG's experience in the early 1970s also calls attention to the difficulty of negotiating an ecologically-minded, humanistic approach to development and design within an industrial and political system that unrepentantly perpetuates pollution and inhumanity.

Notes

1. Rybczynski, Witold, December 1975, "Sulphur Building," *Architectural Design*, vol. 45, p. 723.
2. Rybczynski, December 1975, p. 724.
3. Rybczynski, December 1975, p. 724.
4. Much of this paper depends upon the comprehensive documentary work of the MCHG through its *The Problem Is...* series (1971–1980). Articles by MCHG members and their own publications offer great insight into the group's work during the early 1970s. Berger, Mya and Leticia Brown (eds.), 2021, *A Concrete for the "Other Half"?*, Leipzig, Spector Books, 144 p., published on the occasion of an exhibition at the Bauhaus Lab in 2020, did much to contextualize the projects with regard to economic development work. Although MCHG's *Ecol* has been a subject of some scholarly work, Berger and Brown's edited volume sheds light on the other two buildings I discuss in this paper.
5. Bott, Robert D., 2004, *Evolution of Canada's Oil and Gas Industry,* Canadian Centre for Energy Information, p. 5.
6. Bott, p. 33.
7. McBryde, W. A. E., 1991, "Petroleum Deodorized: Early Canadian History of the 'Doctor Sweetening' Process," *Annals of Science*, vol. 48, nº 2, p. 103.
8. Taylor, Graham D., 2019, *Imperial Standard: Imperial Oil, Exxon, and the Canadian Oil Industry from 1880*, Calgary, University of Calgary Press, p. 27. For more information on the "doctor sweetening" process at the turn of the century, see McBryde, p. 103-105.
9. Taylor, p. 215.
10. Bott, p. 33. There is a discrepancy between Taylor and Bott's accounts of the petroleum in the Turner Valley, with Taylor calling the oil found there "light" (or sweet) and "largely devoid of sulphurous content" (Taylor, p. 215) and Bott emphasizing its sourness and odour. Bott mentions that 1.5 percent hydrogen sulphide was found in Turner Valley natural gas, which is significantly less than in the Ontario petroleum.
11. Gould, Ed, 1976, *Oil: The History of Canada's Oil & Gas Industry*, Saanichton, B. C., Hancock House Publishers, p. 82.
12. Bott, p. 33.
13. Bott, p. 34.
14. Katz, Morris, and W. B. Drowley, 1966, "Canadian Activities in Ambient Air Quality Criteria and Development of Standards," *Canadian Journal of Public Health*, vol. 57, nº 2, p. 78.
15. Bott, p. 34.
16. Powell R. J. and L. M. Wharton, 1982, "Development of the Canadian Clean Air Act," *Journal of the Air Pollution Control Association*, vol. 32, nº 1, p. 62-65. In Boyd, David, 2003, *Unnatural Law: Rethinking Canadian Environmental Law and Policy,* Vancouver, University of British Columbia Press, p. 94. Boyd critiques the NAAQOs, noting that because they are objectives but not standards, they are largely unenforceable and do not go far enough in preventing air pollution. Nevertheless, between 1980 and 1995, sulfur emissions did decline by 43 percent, in large part due to changes in industrial processes.
17. Bratishenko, Lev and Mirko Zardini (eds.), 2016, *It's All Happening So Fast: A Counter-History of the Modern Canadian Environment*, Montreal, Canadian Centre for Architecture, offers a history of Canadian environmental issues and activism through a curated list of case studies.
18. For an excellent compendium of essays on Canadian countercultural groups and environmentalism, see Coates, Colin M. (ed.), 2016, *Canadian Countercultures and the Environment*, Calgary, University of Calgary Press.
19. See Borasi, Giovanna, et al., 2007, *Sorry, Out of Gas: Architecture's Response to the 1973 Oil Crisis*, Montreal, Canadian Centre for Architecture, for a catalogue of such projects.
20. Minimum Cost Housing Group, 1971, *The Problem Is...*, Montreal, McGill University School of Architecture, p. 1.
21. Schumacher, E.F., 1965, "How to Help Them Help Themselves," *The Observer*, August 29, p. 17.
22. For more information on the history of the *Whole Earth Catalog*, see Kirk, Andrew, 2007, *Counterculture Green*, The Whole Earth Catalog and American Environmentalism, Lawrence, University of Kansas Press, and for excellent readings on the relationship between the counterculture and American architecture, see Maniaque-Benton, Caroline, 2011, *French Encounters with the American Counterculture 1960-1980*, London, Routledge; Sadler, Simon, 2008, "An Architecture of the Whole," *Journal of Architectural Education*, vol. 61, nº 4, p.108-129; and Scott, Felicity D., 2007, *Architecture or Techno-Utopia, Politics after Modernism*, Cambridge, MIT Press.
23. An expanded, chapter-length version of "How to Help Them Help Themselves" is included in the volume. See Schumacher, E.F., 1973, "Social and Economic Problems Calling for the Development of Intermediate Technology," in *Small is Beautiful: Economics as if People Mattered*, New York, Harper & Row, p. 171-190.
24. Brooks, Harvey, 1981, "A Critique of the Concept of Appropriate Technology," *Bulletin of the American Academy of Arts and Sciences* 34, nº 6, p. 18. See also Willoughby, Kevin, 1990, *Technology Choice: A Critique of the Appropriate Technology Movement,* London, Westview Press; and Pursell, Carroll, July 1993, "The Rise and Fall of the Appropriate Technology Movement in the United States, 1965–1985," *Technology and Culture*, vol. 34, nº 3, p. 629-637.

25. Baldwin, Jay and Stewart Brand (eds.), 1978, *Soft-Tech*, San Francisco, CA, POINT, frontispiece.
26. Minimum Cost Housing Group, October 1971, *The Problem Is...*, vol. 1, p. 3.
27. Minimum Cost Housing Group, September 1974, "Sulphur Concrete & Very Low Cost Housing," *The Problem Is...*, vol. 5, p. 3.
28. Minimum Cost Housing Group, September 1974, p. 2.
29. Minimum Cost Housing Group, September 1974, p. 2.
30. See Ludwig, A. C., July 1969, "Utilization of Sulphur and Sulphur Ores as Construction Materials in Guatemala," New York, United Nations Report TAO/GUA/4.
31. Minimum Cost Housing Group, September 1974, p. 2.
32. Minimum Cost Housing Group, September 1974, p. 3.
33. By focusing on primary texts, I am better able to critique the perspective of the MCHG during the era in question, looking at elements not directly addressed by the Group at that time. Moreover, I have uncovered very few critical secondary sources focusing on MCHG's sulfur housing. The exceptions in this regard are: Berger and Brown's edited volume titled *Concrete for the "Other Half"?* along with Lisa Chow's work on alternative technologies and Michele Curtis' examination of the architecture of Indigenous People in "The Problem Is Still...The Environment." All are cited in the text. I would like to mention that both the Canadian Centre for Architecture and McGill University have rich archives upon which I relied to obtain the sources used for this paper.
34. Minimum Cost Housing Group, September 1974, p. 6.
35. Minimum Cost Housing Group, September 1974, p. 6.
36. Minimum Cost Housing Group, September 1974, p. 6.
37. Chow, Lisa, September 3, 2016, "Minimum Cost Housing Group, 1970–1980," Issuu, [https://issuu.com/lisa_chow/docs/minimum_cost_housing_group_timeline], accessed June 1, 2024.
38 . Minimum Cost Housing Group (MCHG), December 1972, "The Ecol Operation: Ecology + Building + Common Sense," *The Problem Is...*, vol. 2, p. 99.
39. Despite its now well-known toxic properties, asbestos featured prominently in *Ecol*, comprising both the roof and bathroom unit of the home. In the 1970s, asbestos mining was another of Canada's lucrative extractive industries. See Dubois, Samuel & Heather Braiden, 2024, "Se souvenir de l'amiante: Architecture, identité et patrimoine historique à Thetford, Québec," *Journal of the Society for the Study of Architecture in Canada*, vol. 49, nº 1, this issue. The Group did not provide a rationale behind using asbestos, but it likely represented an inexpensive solution to the MCHG's needs.
40. The Canadian Centre for Architecture holds a series of these bricks within their Vikram Bhatt archives. Geoff Manaugh has written about them in the article "Image Concrète" on his BLDGBLOG. See Manaugh, Geoff, Image Concrète, BLDGBLOG, June 25, 2010, [https://www.bldgblog.com/2010/06/image-concrete/], accessed March 3, 2023.
41. Boon, Jon, April 1973, "Ecol Operation," *Architectural Design*, vol. 43, p. 243.
42. Minimum Cost Housing Group, September 1974, p. 8.
43. Minimum Cost Housing Group, December 1972, p. 99.
44. Minimum Cost Housing Group, December 1972, p. 99.
45. Minimum Cost Housing Group, December 1972, p. 99.
46. The Indian Act of 1876 established racist housing policies that prohibited Indigenous People from providing and choosing their own housing on reserves, instead endowing Indian agents of the Department of Indian and Northern Affairs with the task. This led to an artificial perception that Indigenous People were incapable of or unwilling to establish well-kept, sturdy housing for themselves, which, in turn, perpetuated racist housing policy. Government on-reserve welfare housing programs have, historically, been poorly funded and inequitably managed. Indigenous People have been denied mortgages and inspections. It is ironic, then, that the Department of Indian Affairs invited the MCHG to educate the Band on building their own structures. For a brief history of this long-term racist housing policy, see Olsen, Sylvia, et al., 2012, "The blueprint for systemic racism in First Nations' housing," April 8, *Policy Options,* [https://policyoptions.irpp.org/fr/magazines/april-2021/the-blueprint-for-systemic-racism-in-first-nations-housing/] accessed April 18, 2023.
47. Minimum Cost Housing Group, 1974, p. 12.
48. See Boon, Jon, 1974, *Sulphur as an Intermediate Technology for Housing within Community Development*, Master of Architecture thesis, McGill University.
49. Schwindling, Martha, 2020, "When Ideas Become Concrete," In Maya Berger and Leticia Brown (eds.) *A Concrete for the "Other Half"?*, Leipzig, Spector Books, p. 65.
50. Curtis, Michèle, 2016, "Notes on the History of Architectural Collaboration with First Nations Peoples," *The Problem Is Still...The Environment*, Summer 2016, p. 7-8.
51. Minimum Cost Housing Group, September 1974, p. 12.

52. The relationship between the petroleum industry, the Canadian government, and Indigenous peoples is far beyond the scope of this paper. It should be noted, however, that tensions between the government and Indigenous peoples had intensified during the 1960s and 1970s, with more active protest against corporate and government incursion on Indigenous land and in response to environmental injustice. Until 1974, with the Indian Oil and Gas Act, the Department of Indian Affairs and Northern Development oversaw mineral resource management on Indigenous land, mostly to the detriment of Indigenous communities. Thus, while Imperial Oil did deliver molten sulfur—an unwanted byproduct—to the reserve, this did not symbolize the establishment of harmonious relations between the parties.

53. Boon's thesis does address Indigenous precedents for work similar to the MCHG's Saddle Lake project, but these go unmentioned in the Group's broader-based publications.

54. Martha Schwindling, in her overview of the MCHG's sulfur projects, suggests that the high school students were, in fact, unenthusiastic, slowing down the project and effectively forcing the MCHG to complete the brickwork after their grant ran out. Schwindling, p. 67.

55. Rybczynski, December 1975, p. 726.

56. Rybczynski, December 1975, p. 726.

57. Pawley, Martin, 1975, "Garbage Housing, U.S.A.: The Work of Mike Reynolds," *Architectural Design*, vol. 3, p. 170. Republished by MCHG's journal *The Problem Is...*, nº 6, 1975. See, also, Pawley, Martin, 1975, *Garbage Housing*, London, Architectural Press, for a more extensive history and international perspective on the topic.

58. Berger and Brown.

59. Baldwin, Jay and Stewart Brand, frontispiece.

60. Baldwin, Jay and Stewart Brand, frontispiece. Stewart Brand criticized Rybczynski, writing directly beneath the MCHG founder's quote: "If AT is a religion, Witold Rybczynski is one of its founding saints.... Here he is carping away like every saint in history long-lived enough to see his technique decay into a belief," (frontispiece).

61. Rybczynski, Witold, 1980, *Paper Heroes: Review of Appropriate Technology*, New York, Anchor Books, p. 59. Rybczynski's specific usage of "stepping stones" may be a reference to a popular AT text, namely De Moll, Lane and Gigi Coe, 1978, *Stepping Stones: Appropriate Technology and Beyond*, London, Marion Boyars.

62. Barrionuevo, Alexei, November 4, 2003, "A Chip Off the Block Is Going to Smell Like Rotten Eggs; Sulfur Is Piling Up in Alberta, Millions of Tons Nobody Needs or Can Get Rid Of," *Wall Street Journal*, Eastern edition, November 4, p. A1. accessed December, 14, 2023, [https://www.proquest.com/newspapers/chip-off-block-is-going-smell-like-rotten-eggs/docview/398851546/se-2.], accessed December, 14, 2023.

63. Barrionuevo, p. A1. NASA contends that this sighting may be an "urban legend."

64. Barrionuevo, p. A1.