PART TEN

A Case for Increased
Regulation of Relocatable Buildings
in the Province of Ontario

by
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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of

Master of Architecture
in
Engineering

Waterloo, Ontario, Canada, 2015

Author's Declaration

I hereby declare that I am the sole author of this thesis.
This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public

Abstract:

This thesis addresses the role that building regulations and codes have in shaping the way that the pre-fabricated building industry designs, manufactures and installs Relocatable Buildings (RB) used within the Institutional, Commercial and Industrial (ICI) sectors. It looks at the history and development of the Relocatable Building industry with particular focus on their application and use in the Province of Ontario, within the larger North American context. Familiar typologies under the umbrella of relocatable buildings include: Manufactured Homes, Emergency Shelters, Portable Classrooms and Industrial Accommodations[1]. Of these categories, the latter two will be the focus addressed within this work.

The majority of relocatable buildings are manufactured and constructed without the direct involvement of the architectural profession. Many of these buildings barely meet the basic requirements of health, safety, durability, and occupant comfort that is expected of contemporary construction for all other occupied building typologies[2]. This problematic building type needs to garner greater attention from designers, regulators and building officials in order to set in place the framework for clearer regulatory guidelines and requirements for these structures. Such a framework has the potential to lead to overall improvement of the quality of construction and product delivery within this sector.

This thesis illustrates proposed modifications of the primary documents which set the current regulatory framework for these buildings in Canada: the Canadian Standards Association (CSA) Z240 Standard for Manufactured Homes[3]; the Canadian Standards Association CSA A277 Standards for Factory Built Buildings; the Ontario Building Code (OBC) 2012 edition[4]; and the National Building Code of Canada (NBCC) 2010 edition[5]. Amendments amassed from existing precedent codes and model voluntary standards, intend to increase and improve the baseline expectations and requirements of building construction in this category with the intent of directly improving the quality of product being generated by this billion dollar annual Canadian industry. The goal being that design and construction improvements based on changes in regulation, extend to benefit the lives, and day-to-day experiences, of users and occupants of these relocatable structures. This thesis examines the potential, details and positive outcomes for revising the OBC to reflect the addition of this new chapter to the code**.**

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1 www.modular.org Modular Building Institute

2 www.epa.gov US EPA Study on Portable Classrooms

3 www.csagroup.org Canadian Standards Association

4 www.mah.gov.on.ca Ontario Ministry of Municipal Affairs and Housing

5 www.nrc-cnrc.gc.ca/eng/solutions/advisory/**code**s_centre_index.html National Building Code of Canada

Acknowledgements:

I would like to sincerely and gratefully acknowledge the assistance of my Thesis Supervisor, Professor Terri Meyer Boake as well as my committee professors Lloyd Hunt and David Lieberman, for their advice, and support in completing this thesis. I would also like to thank my external reader Paul Dowsett of Sustainable TO for his time and insight. Thanks as well to the administration of the UW School of Architecture.

I would like to thank my current employer for providing an opportunity to develop knowledge and experience in the field of pre-fabricated buildings.

The North House Project was made possible in part through the research funding of MITACS & the Ontario Power Authority (OPA) and the University of Waterloo. I would like to acknowledge and thank these organizations as well as our many other sponsors for facilitating new and innovative research in the field of architecture through their monetary and in-kind donations.

The North House project was a unique and exciting experience. One, I will never forget, and from which I will take many lessons well into the future. Thanks to the faculty leaders of the North House Project: Geoff Thun, Kathy Velikov & David Lieberman for spearheading this venture.

Not enough can be said for the fantastic student team, which pulled together to be the driving force of North House, leading up to and, throughout the Washington Competition. Including: Lauren, Maun, Chloe, Chris, Jen, Brad, Andrea, Sonja, Dave, Lindsey, Jamie, Allan, Matt, Brent, Andrew, Ivan, Sebastien, Bart, Brittany, Toktam, Humphrey, Aya, Fabio, Johnny, Kevin, and Rob, as well as many other student volunteers who contributed to the completion and success of the North House Project

I would also like to thanks the many people outside the school who played critical roles in the realization of the North House project - Our sponsor list is extensive, but of particular note, I would like to thank our construction team from MCM 2001 - especially our construction coordinator Jacek Debski who worked to bring our project to reality.

Finally, and most importantly I thank my family: my parents Brian and Barb Jackson, my sister & brother-in-law Kate & Bryan, my husband Brian Kielt, and my friends and extended family for their encouragement, love, support and their steadfast patience throughout this entire process.

Dedication

For my best friend Manda and my two wonderful Grandmothers, Dorothy and Florence.

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Acronyms

ABC	– Alberta Building Code
API	– American Petroleum Institute
CHPS	– Collaboration for High Performance Schools
CMHC	– Canadian Mortgage and Housing Corporation
CSA	– Canadian Standards Association
ICI	– Industrial, Commercial & Institutional (with reference to the construction sector type)
MOECC	– Ontario Ministry of Environment and Climate Change
MOL	– Ontario Ministry of Labour
NBCC	– National Building Code of Canada
PMC	– Permanent Modular Construction
OBC	– Ontario Building Code
RB	– Relocatable Building
RC	– Relocatable Classroom
US EPA	– United States Environmental Protection Agency

Key Terms

Camp for housing workers – means a camp in which *buildings* or other structures or premises are used to accommodate five or more employees[6]

Classroom - a room in which a class of students is taught[7]

Industrial Construction - though a relatively small part of the entire construction industry, is a very important component. Owners of these projects are usually large, for-profit, industrial corporations. These corporations can be found in such industries as medicine, petroleum, chemical, power generation, manufacturing, etc. Processes in these industries require highly specialized expertise in planning, design, and construction. As in building and heavy/highway construction, this type of construction requires a team of individuals to ensure a successful project.[8]

Manufacture - the making of articles especially in a factory etc.[9]

Manufactured homes – completely built in a factory, generally single storey, and transported to a building site in one or two complete sections and assembled with little on-site construction on surface mount foundations.[10]

Modular – A method of construction that utilizes pre-engineered, factory-fabricated structures in three-dimensional sections that are transported to and tied together on a site.

Portable - a) easily movable or transportable, convenient for carrying; b) not fixed; movable (portable classroom)

Portable Classroom – a transportable, single- or multiple-section, one-storey classroom space ready for occupancy on completion of set-up in accordance with the manufacturer's instructions.[11]

Prefabrication – the manufacture of whole buildings or components in a factory or casting yard for transportation to the site.[12]

Relocatable – adjective: constructed so as to be movable; portable, prefabricated, or modular: *relocatable classroom units;* a structure that can be relocated.[13]

Relocatable Building – a transportable, single- or multiple-section, one-storey building ready for occupancy on completion of set-up in accordance with the manufacturer's instructions.[14]

Relocatable Industrial Accommodation – factory-built structures that provide accommodation for an industrial work force living and working in a temporary location, but does not apply to manufactured homes, prefabricated single-family dwelling units, or other types of prefabricated or manufactured buildings. These structures are also used for Group D (business and personal service) and Group F Division 3 (low hazard industrial) occupancies for a work force working in a temporary location.[15]

Structure – noun: mode of building, construction, or organization; arrangement of parts, elements, or constituents: *a pyramidal structure*.; something built or constructed, as a building, bridge, or dam.; anything composed of parts arranged together in some way; an organization.[16]

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[6] Ontario Building Code – 2012 edition. Division A, Part 1, Pg. 9.
[7] Ontario Building Code – 2012 edition. Division A, Part 1, Pg. 9.
[8] Ontario Construction Secretariat www.iciconstruction.com/resources/dictionary.
[9] Oxford English Dictionary. Toronto. 1998. Pg. 879.
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[11] CHPS – High Performance Relocatable Classroom Standard, Best Practices Manual. Pg. 5.
[12] The Penguin Dictionary of Architecture. Pg. 349.
[13] Oxford English Dictionary. Toronto. 1998. Pg. 1219.
[14] The Modular Building Institute. Modular.org
[15] Adapted from the Alberta Building Code, 2007 Part Ten.
[16] Oxford English Dictionary. Toronto. 1998. Pg. 1440.

PART TEN

A Case for Increased Regulation of Relocatable Buildings
in the Province of Ontario

Prologue: Situating the Thesis

This thesis emerges from a combination of interdisciplinary projects, both academic and professional, that I had direct involvement with over the course of my graduate school education and subsequent employment. This range of experiences led to the investigation of relocatable structures: a topic that repeatedly emerged as critical to a particular segment of the built environment, fraught with issues being struggled with by designers, municipalities, clients, and occupants alike.

This investigation of prefabricated construction and its related regulatory framework began with my involvement in the development of a 100% solar powered, custom designed and built 'house of the future' -- the North House. My work was part of a much larger team initiated by a faculty-led research project to design, build and transport this house to the U.S. Department of Energy Solar Decathlon competition in Washington D.C. The North House was an innovative demonstration of the potential for prefabricated energy efficient residential construction. Within that team, my focus was centered on design of the exterior landscape elements, planning and logistics, as well as health and safety of team members and construction crew. Through my subsequent industry experience, this study evolved to look at a segment of the prefabricated building industry with much less media coverage and glory, but much more current and real issues to be resolved – relocatable industrial accommodations.

The goals of investigating the current relocatable building industry are three-fold. First: to highlight the gaps in the existing regulatory framework for these buildings. Second: to identify an approach to developing improved minimum standards that could facilitate better building products for the owners and occupants of these relocatable buildings. Finally to level the playing field between manufacturers, installers and designers, by providing consistent guidelines to be met. These changes would serve to provide local municipalities with a more robust and definitive set of regulations on which to review and approve applications for these types of structures and developments in their own communities.

The focus on Relocatable Buildings (RBs) in this thesis is intended to generate meaningful discussion about the role of legislation and regulation in shaping the temporary built environment. Also, it intends to highlight how such laws and standards can facilitate change, and improve quality for buildings that shelter large numbers of people within our society including students, teachers and industrial workers. The thesis acknowledges the budgetary constraints and the fundamentally pragmatic role that relocatable buildings fill, while advocating for better quality of their construction and resultant occupied spaces.

Figure 1: Typical Construction Trailer

CHAPTER 1:

INTRODUCTION, HISTORY & CONTEXT OF RELOCATABLE BUILDINGS

What is a Relocatable Building?

Who should be concerned with the state of Relocatable Buildings?

- **Who is involved in designing, procuring and manufacturing Relocatable Buildings?**
- **Who is using and occupying relocatable buildings?**

What are Relocatable Buildings Used for Today?

What were Relocatable Buildings used for Historically?

Where are Relocatable Buildings Used?

- **Globally**
- **North American Context (U.S. Examples)**
- **Canadian Context (Ontario Examples)**

Why are Relocatable Buildings selected over Permanent Construction Solutions?

- **Time Constraints**
- **Budget Constraints**
- **Limited Access to Building Materials & Skilled Trades**

Why are there concerns with the Relocatable Building Type?

- **Quality of Space**
- **Durability**
- **Safety**
- **Comfort**
- **Energy Efficiency**

How can these concerns be address?

- **Voluntary Standards**
- **Mandatory Regulations**

Figure 2:
Manufactured Homes – Manufactured Home Sales

INTRODUCTION, HISTORY & CONTEXT OF RELOCATABLE BUILDINGS

What is a Relocatable Building?

Relocatable Building – a transportable, single- or multiple-section, one-storey building ready for occupancy on completion of set-up in accordance with the manufacturer's instructions.[17]

> "The term modular in the world of architecture and construction has often been used to refer to largely completed or whole sections of building built at a factory and trucked to site for quick deployment [.….] There have been a few "sweet-spots" in modular buildings mostly found in low-end, cost-driven housing or short life-span institutional or commercial buildings that need to meet short-term needs at lowest possible costs, such as construction site offices or temporary classrooms that are intended to be replaced as soon as 'real' buildings can be completed. The fact is that many of these structures remain in place long after their intended lifespan, becoming poorly planned and placed buildings clinging tenuously and awkwardly to their sites."[18]

As highlighted in this statement by Anderson and Anderson Architects, in their book Prefab Prototypes, the implementation of modular techniques within the institutional, commercial and industrial construction sectors needs much improvement. Clients are seeking out low-cost, quick solutions to imminent space shortages and little consideration is paid to the longer term use of the buildings and strategies for their relationship with the surrounding site and adjacent structures. These structures are requested, procured, installed and commissioned for use within an extremely limited time frame. As such, the typical process of site evaluation, concept design, design development and detailed design resolution for construction documents is seldom followed. These units are ordered and installed in the manner of a piece of furniture, selected from a catalogue of predetermined design options with standard factory finishes; minimal consideration for the true needs of the clients are addressed.

Prefabrication Categories

There are two main categories of pre-fabricated buildings within the current North American market: Permanent Modular Construction (PMC) and Relocatable Buildings (RB).[19] This research begins with a brief outline of the historical context of the prefabricated building industry, followed by a review of two key typologies of RBs: Portable Classrooms and Industrial Accommodations. The use and applications of these two building types, and their affiliated user-groups, is explored through the lens of minimum required standards and resultant construction quality offered by these building solutions. While not an exhaustive survey of the companies and techniques operating within this industry, this research will identify the similarities and differences between the two categories of relocatable buildings.

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17 www.modular.org Modular Building Institute – Definition of Relocatable Buildings. Accessed April 2015.

18 Anderson and Anderson. Prefab Prototype. Pg. 183.

19 www.modular.org Modular Building Institute - Summary of the Industry. Accessed April 2015.

Anderson & Anderson allude to the strong perception among users of relocatable buildings, as well as the public, that temporary classrooms and other relocatable buildings are not 'real' buildings, and are therefore less deserving of the level of attention to detail and quality of space that would be afforded to similar occupancies in permanent buildings.[20]

> "Most cities and towns in North America have significant trailer park communities. Though these are relatively permanent… they are perceived by society at large as poor cousins to 'real' housing."[21]

Dean Goodman of Levitt Goodman Architects highlights similar findings, in his 2002 chapter, of Robert Kronenburg's compendium, Transportable Environments 3. Despite the perception that these structures are not 'real' buildings, they are still required to fulfill the primary functions of any building including provision of a safe shelter, that is fit for continuous human occupancy, that protects the occupants from the exterior environment and the elements, as well as providing thermal comfort, access to views and natural lighting.

Relocatable Buildings include a wide array of building typologies used both historically and in contemporary society for a variety of uses. The reasons for selecting RB solutions over permanent construction are often tied to the perception that this type of structure can provide the necessary accommodations and amenities of a permanent building, but in a faster, cheaper and more flexible approach. The uses range from single module construction trailers pulled up to the job site on wheels, and "parked" for the duration of the project, to sprawling commercial or industrial developments of modular units installed for use as offices or employee lunch and locker spaces. This category of building can also include short term military barracks, temporary presentation show rooms for larger scale developments such as condominiums, low income housing in the form of the familiar park-model manufactured home, and the infamous portable classroom.

Who should be concerned with the state of Relocatable Buildings?

Everyone in society has an indirect stake in the quality of Relocatable Buildings. These structures are used in a wide range of sectors within our communities, however those individuals and groups that are directly involved with Relocatable Buildings have the most to lose when these buildings are ignored or neglected. Conversely, these groups also have the most to gain, when improvements to these structures are made. Whether on the design/procure/install side or on the occupant/user group side there is a vested interest in ensuring quality products are created. On the manufacturing side: fostering a happy, satisfied group of repeat clients and positive referrals to new clients serves to bolster the business and increase the potential for profit. On the client side: obtaining buildings which meet appropriate quality and durability, that are fit to purpose and effective in meeting the need for shelter and accommodation in a timely manner without endangering the health and safety of the occupants means less problems post construction which avoid costly litigation.

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[20] Anderson and Anderson. Prefab Prototype. Pg. 8.
[21] Dean Goodman – Transportable Environments 3, Robert Kronenburg Ed. Pg. 108

Who is involved in designing, procuring and manufacturing Relocatable Buildings?

> "The construction industry is the single largest economic sector in the world, of which prefabrication is an enormous sub-industry."[22]

Contemporary Relocatable Buildings in North America are developed within the context of a substantial, prefabricated assembly line style construction industry geared to the design, construction, dissemination and installation of these standardized units to potential clients as quickly and cheaply as possible. Manufacturing companies have a few standard layouts, which are produced on mass and then marketed to potential customers based on their speed of assembly and quick turn-around from time of order to time of occupancy. These units are developed for both sale and leasing opportunities to various client groups across North America and typically manufactured in locations with low labour wages and suppressed labour laws.

Who is using and occupying relocatable buildings?

The 2007 "Annual Report on Ontario Public Schools" conducted by the organization: People for Education compiled survey information from all of Ontario's publicly funded schools and demonstrated that of the almost 5000[23] publicly funded schools, 42% of them had at least one portable classroom on their premises.[24] Reports from the Ontario Ministry of Education indicate that on average ten percent of Ontario students (roughly 175,000 children) within the public education system receive their lessons in Portable Classrooms.[25] In the industrial sector, especially within resource development fields, relocatable buildings constitute a significant volume of employee office and residential accommodations. As of 2014, there were 385 000 portable classrooms installed on school sites across the US[26], and in some states the portion of portable classrooms in use can account from 10% in Texas to almost 30% in some California Districts. Relocatable Building makeup a small, but significant portion of the construction market in the Canadian context. Given the sizable existing and growing impact of these types of relocatable buildings on our built environment, more concerted effort and focus should be directed towards this building manufacturing sector as a means to improve the types of space within which we live, work and learn.

What are Relocatable Buildings Used for Today?

Relocatable Buildings constitute many familiar typologies within the contemporary built environment: Manufactured Homes -- including the commonly referred to "Single-Wide" and "Double-Wide" trailers typically located in rural and remote Communities; Portable Classrooms -- found at K-12, College and University Institutions across North America; and Industrial Accommodations – used most frequently in

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22 Anderson and Anderson. Prefab Prototype. Pg. 8.
23 People for Education. The Annual Report on Ontario's Public Schools. Pg. 26.
24 People for Education. The Annual Report on Ontario's Public Schools. Pg. 26.
25 Ontario Ministry of Education –
26 Inside the Box. Earthfix. May 2014.

resource extraction and development. Though familiar, these widely stigmatized and often ignored structures each conjure images of under-insulated, metal sided boxes which hover above the ground unsure of their footings or their future. As a type of shelter, they are a physical manifestation of "making-do".

What were Relocatable Buildings used for Historically?

As outlined by Jennifer Siegal, in her book: MOBILE – the Art of Portable Architecture, prefabrication of buildings emerges out of three basic forces: convenience, necessity for shelter, and a lack of local resources.[27] She argues that one of the first documented portable relocatable structures, whose purpose was self-sufficient housing, was Noah's Ark[28]. Other archetypes, of the historic relocatable building, include military barracks such as the barrel vault metal sheds commonly referred to as Quonset Huts after one of the early developers of this building system. Another example is the frontier shelters such as covered wagon housing used by the early pioneer settlers, and mobile homes used through out North America as nomadic vacation residences.

Figure 3:
Quonset – T-Rib Hut

Military Applications

The need for, and development of, the contemporary relocatable building typology emerged from the necessity for impermanent, transportable, structures to provide shelter and accommodations for people in disparate parts of the world during both World Wars of the Twentieth Century. One of the iconic examples includes the 'Quonset Hut', designed and built during the 1940s to provide military housing and shelter for a wide range of

[27] Jennifer Siegal. MOBILE – the Art of Portable Architecture. Pg.
[28] Jennifer Siegal. MOBILE – the Art of Portable Architecture.

other uses by troops at home and overseas. This need, for transportable shelter is rooted in much older traditions of nomadic cultures who relocated the dwellings, which they inhabited, from season to season, or to follow the patterns of their prey.

> "The original, or T-Rib, Quonset hut was modeled closely on the World War I Nissen hut. Both were sixteen feet in diameter and utilized almost identical steel arch frames. The principal difference between the two was in the wall system. In the T-Rib Quonset, the interior wallboards were Masonite®. Its exterior was corrugated metal panels, lapped and mounted to wood purlins, with a core layer of paper insulation. The Nissen hut, on the other hand, had a more complicated system of corrugated metal panels both inside and out and depended solely on the air space between the two for its thermal barrier. T-Rib Quonsets instantly provided U.S. troops with a greater level of comfort than could be provided by tents with wooden platforms typically used at that time.
>
> Less than three months after initiating the hut design project, the U.S. military had in its arsenal a new demountable structure that could be shipped in twelve crates and put up in one day by ten men. It required no special skills to erect.
>
> By the end of 1941, approximately 8,200 T-Rib Quonset huts were produced. Huts sent to Iceland proved their success in their first winter of use. According to George A. Fuller Co.: "A night gale of hurricane proportion that wrecked shipping in the harbor, tossed crumpled PBYs on the beach like paper hats, and ripped the covering completely off of many British Nissen huts, left the Quonset huts practically undamaged."[29]

Where are Relocatable Buildings Used?

Globally: Relocatable Building are used around the world as forms of shelter for work, education and living accommodations. The quality, size, and construction type vary to some degree although, with increasingly globalized companies, operating in multiple locations, that diversity is waning. Other forms of global relocatable buildings in the contemporary built environment include the conversion of international steel shipping containers into an assortment of dwellings and emergency shelters in areas of war, political upheaval with large numbers of dislocated people.

North American Context: In North America, the majority of Relocatable Buildings are found in three categories: industrial, educational and residential. The industrial Relocatable Buildings are set up for Construction Sites, Primary Resource Extraction, and Secondary Resource Development (both renewable and non-renewable). Occasionally these building types are use in a commercial context for condo showrooms, trade show trailers, or other short-term occupancies. Portable Classrooms for all age groups constitute a large portion of the relocatable buildings constructed for the education sector. Low-income and seasonal housing make up the remaining portion of the relocatable market.

Canadian Context: The Canadian, and specifically the Ontario based use of Relocatable Buildings, mimics that of North America as a whole. They are found on remote industrial facility sites, primary resource extraction sites, in schoolyards throughout the province, and in housing developments including seniors' retirement developments, trailer parks and many Aboriginal reserves.

[29] Quonset: Metal Living for a Modern Age. www.quonsethuts.org huts/index.htm

Why are Relocatable Buildings selected over Permanent Construction Solutions?

1. **Time Constraints**
2. **Budget Constraints**
3. **Limited Access to Building Materials & Skilled Trades**

While time and budget constraints go hand in hand, generally speaking, time constraints have a larger impact on industrial projects, while budget constraints have a larger impact on educational projects. The issue of limited access to building materials and skilled trades is a very real factor in the use of relocatable buildings, but is a less important factor in the southern and central portions of Ontario due to the higher concentrations of population and cities. In northern Ontario, and the northern portions of Canada as a whole, the remoteness of some mining or logging sites might form the deciding factor of using a relocatable building solution over conventional construction techniques.

Why are there concerns with the Relocatable Building Type?

> "A common perception of portable building is that it is generally a poor quality product and unfortunately in many cases, this image can be seen as accurate, as economy has been high on the agenda for those who plan to discard the building when it is no longer required."[30]

When relocatable buildings are designed and constructed with poor end quality in mind, the industry is further exacerbating the issue of designed obsolescence and increasing the quantity of waste that we as a society are generating. This is not a reasonable approach to responsible resource use and has negative implications from a financial as well as an environmental perspective. In addition to addressing durability, this thesis proposes revised minimum standards for acceptable construction materials including types and thicknesses of sheathing, insulation and cladding. It also highlights and reinforces issues around Limiting Distances and affiliated Fire Resistance Ratings of building assemblies. While present in the Ontario Building Code (OBC) 2012 edition[31], these requirements need to be more explicitly listed in their application along with increased enforcement with regards to this type of construction. It calls for a re-evaluation of the way the building codes address Fire Resistance Ratings (FRR) of construction assemblies in relation to relocatable structures. It argues for a re-evaluation of potential sources of fire exposure through the consideration of external hazards as well as hazards that occupants may be exposed to from within. Recognizing that changes in the surroundings over time, may compromise the integrity and performance of the building if FRR and combustible material use are not carefully considered in the design from the beginning.

Specific technical issues outlined in this research relate to the current state of the relocatable building industry, and include examples such as:

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30 Robert Kronenburg. Transportable Environments 2: Theory, Context, Design & Technology. Pg.
31 Ontario Building Code Compendium 2012. Vol. 2. SB-3 Various Tables.

Quality of Space

- Improved access to Natural Daylighting and Views to the Exterior
- Increased Ceiling Heights
- Use of Colour, Texture and Materiality

Durability

- Increased durability & reduced life-cycle costs.
- Improved sealing of structure to prevent ingress of air, vapour and other pests;

Safety

- Fire Resistance Ratings (FRR) of exterior building envelope assemblies;
- Limiting Distances and siting requirements of grouped modules;
- Improved Material Selection and Indoor Air Quality (IAQ)
- Reduction of occupant exposure to emissions, VOCs and other indoor toxins

Comfort

- Increased levels of Building Insulation;
- Improved mechanical ventilation requirements (including the use of HRVs & ERV)
- Improved natural ventilation through increased Use of operable windows

Energy Efficiency

- Increased Energy and Water efficiency of Appliances, Equipment and Fixtures
- Improved Efficiency of the building envelope
- Improved Siting and Orientation of Building to reduce cooling loads

Issues of Responsible Energy, Resource and Material Use

Recognizing the role that buildings and construction have in the larger societal issues of energy and material use and efficiency, the Relocatable Building industry needs to continue to strive for improvement. By producing higher quality, and more durable, units, mandated by such regulatory changes, as are presented in this work, the need for frequent repair of poor quality units would be greatly reduced. An additional benefit to improved construction quality would be that units would not require the same level of maintenance, or wholesale replacement after short-term occupancy due to poor durability. The emphasis on low initial cost and use of economic production processes to maximize manufacturer profits should not out-weigh other considerations. While initial capital costs are an important factor to the relocatable building industry and their clients; in the context of temporary office requirements for industrial setting, speed of installation and reduction of employee down-time and logistical considerations can be more critical, than a building project's initial capital expenditures. In the educational context limited school budgets create greater pressure for reduced upfront capital costs, but as outlined by the USGBC's 2013 State of Our Schools Report, many if not all of the savings from lower quality buildings are lost quickly over time as such buildings have significantly larger maintenance and operating costs. This emphasis on speed and initial occupancy shifts focus from the long-term viability of these installations, and places future maintenance costs and up-keep of the structures on the responsibility of different budgets and groups than those purchasing the units.

Stigmas and Preconceptions

This category of building is rife with stigmas, some unfairly bestowed, but many quite deservingly earned from their consistently poor performance in regards to providing safe, comfortable shelter for their occupants. These buildings may be perceived to engender a sense of impermanence or transience by the owner or user groups who choose to, or are required to occupy them. Due to the typically poor quality of materials, space and level of comfort provided by standard relocatable buildings, there are also perceptions that relocatable buildings are merely a "make-shift" arrangement is very prevalent. These short-term investments, to install relocatable buildings by the company or organization commissioning them can communicate inadvertently that the owner or organization does not prioritize the health and well being of the occupants and is unwilling to invest in a more permanent facility for the long term. Such feelings might be inferred by the unreliable, and sometimes hazardous, conditions presented by relocatable buildings.

Existing Requirements

In North America, about the parameters, regulations, and review processes, for the design, manufacture and construction (or installation) of Relocatable Buildings are vast and divergent. These are overseen and enforced by different jurisdictions and vary substantially from one province to another and one state to another. Relative to the requirements placed on conventional construction, the requirements for Relocatable Buildings are very limited and in need of renewed interest and oversight. The perceived, limited lifespan of these buildings, make them too short to worry about. Relocatable Buildings as transient, ignored and neglected building types, symbolize and often house, the segments of our population at the margins, at risk of slipping through the cracks. Groups within society that are vulnerable, or placed in tenuous positions that to complain too much about said accommodations would lead to the loss or removal there of.

Due to their unplanned, but frequently lengthy stays, Relocatable Buildings cause a wide range of problems and issues for local municipal building and planning departments, as well as other Authorities Having Jurisdiction. Given that such installations were to be in place for "only a short time", municipalities have in many cases, been pressured to turn a blind-eye to installations of such relocatable buildings when owned by companies providing key employment to local constituents, or local school boards facing unplanned space shortages and tight timelines. The underlying fact that these relocatable buildings were commissioned to address a lack of available accommodations at a given facility means that while intended for short-term use, rarely are these agglomerations removed by their projected end date. In many cases, the client sees that they could potentially use a few more of "those cheap shelters", and so one or two modules, can in short-order expand to a village. Municipal planning and building departments are often forced to deal with quasi-temporary arrangements of modular structures. The approach to review and approval of 'temporary buildings' is very inconsistent from one jurisdiction to another even within close geographical proximity to one another. Given the lack of regulatory oversight of the industry and the continued perceived, and real, cost savings to consumers of relocatable buildings their specification and use continue to grow. Such cost savings are in some ways achieved because the buildings are not held to the same set of standards or quality of construction as conventional buildings, making them much cheaper to initially construct and deploy, but much more expensive over the long term to maintain and operate.

How can current concerns about Relocatable Buildings be addressed?

Voluntary Standards vs. Mandatory Regulations

There appear to be two primary approaches that can be taken to change the current trajectory of development and product quality of Relocatable Buildings in the North American context: Voluntary Standards and Mandatory Regulations.

The first approach, adoption of **Voluntary Standards,** is optional and can be implemented by any manufacturing company and/or design consultant, working with such manufacturers, to improve the quality of their base building stock. Manufacturers can pick and choose which features to include in different models on the basis of the proposed occupancy or create different levels of comfort or 'luxury'. These standards can work to set one product apart from a competitor's products. Implementation of voluntary standards has the potential to show customers examples of ideal Relocatable Building Designs, as well as provide key marketing opportunity for manufacturers who are early adopters of these techniques and strategies. This approach however, relies on the manufacturer's need and desire to differentiate their product from their competitors. As well, it relies on the potential client's level of understanding and appreciation of these differences between the standard and improved models in order to see and value the improvements that such design changes could make. This thesis investigates some examples of the specific Voluntary Standards currently available to relocatable building manufacturers to model their structures after in order to achieve improvements in each of the categories listed above: **quality, durability, safety, comfort and efficiency**.

The second approach is to change the **Mandatory Regulations** around how Relocatable Buildings are allowed to be designed, built (or manufactured) and installed in a given jurisdiction. Changes in the laws and codes around the design and construction of relocatable buildings will have the benefit of improving minimum standards across the board and benefitting a much greater number of users. While legislative changes to the base-line requirements would not likely produce some of the more exemplary, or innovative, structures achieved through the adoption of voluntary standards such as CHPS (Collaborative for High Performance Schools) or LEED (Leadership in Environment and Energy Design) they would serve to improve the minimum quality across the industry. Rather than production of 'one-off', innovative, demonstration models, this approach has the potential for much broader reaching for improvements of the quality, durability, safety, comfort and efficiency of relocatable buildings for their occupants. By illustrating the current gaps in the Ontario provincial regulations around relocatable buildings, an opportunity to clarify and improve such primary references documents emerges. These documents fundamentally inform the development and implementation of relocatable building installations and are relied upon by designers, architects, engineers, manufacturers, contractors, building officials, inspectors, clients and occupants. With the aim to both improve the level of safety and comfort of these buildings, these regulatory modifications also have the potential to improve the long-term durability and sustainability of relocatable buildings when they are used and significantly reduce the overall construction waste generated by this industry.

While voluntary standards encourage a drive for innovation for the 'best' solution, there will be limited uptake of this challenge by the relocatable building industry as a whole. Simultaneous to this push for cutting edge advancement, there needs to be formal mechanisms and processes implemented to address the mainstream building stock that is being produced, shipped, installed and inhabited at a significant pace. These low-end, mass produced, commodity-type buildings will not be improved through the encouragement to adopt voluntary measures alone. Emphasis on profit over service, by businesses operating under the following philosophy that compliance with **minimum requirements is equal to the maximum expenditure,** forces the regulators' hand to ensure that even the lowest price units provide compliant building solutions**.** Through the investigation of the context, history and contemporary concerns being dealt with in the Relocatable Buildings industry, it is shown that focus on the second approach of mandatory regulations in necessary to drive broad based change within the industry as a whole and by extension to provide improvements to as many occupants of these buildings as possible. Increasing the legal requirements of manufacturers is seen as the most effective method to achieve this goal. This thesis examines the potential, details and positive outcomes for revising the Ontario Building Code to reflect the addition of a new chapter, **Part Ten**, which would set forth new regulatory requirements for the installation of Relocatable Buildings in the Province of Ontario.

Figure 4:
Butler Building

Figure 5:
Portable Classrooms - ModSpace

Figure 6:
Workforce Housing – Industrial Accommodations – William Scotsman

1.1 KEY TYPOLOGIES AND ISSUES OF RELOCATABLE BUILDINGS IN THE INDUSTRIAL, COMMERCIAL & INSTITUTIONAL (ICI) SECTOR

What are ICI Relocatable Buildings?

ICI RBs specifically refers to that segment of the construction industry, which is developing relocatable buildings for Institutional, Commercial and Industrial Clients. There is a diverse spectrum of clients within the ICI construction market. Institutional clients are often, but not exclusively, public sector organizations and include schools serving different age groups from elementary public schools to University Campuses; they also include hospitals and community centres. Commercial buildings are typically geared to the private sector and include office buildings, retail businesses, banks, and restaurants. Industrial clients range from light industrial manufacturing buildings and petrochemical refining operations, to large-scale mining and resource development sites. This broad range of potential clients all fall within the umbrella of ICI construction and the relocatable buildings that serve this market sector are also quite diverse. For the purposes of this study, the focus will be limited to two key typologies under this umbrella:

Portable Classrooms and

Relocatable Industrial Accommodations

A Necessary Typology

What are the underlying needs, which have generated the demand for ICI Relocatable Buildings?

- Affordable & readily available space solutions to accommodate
  - Short-term fluctuations in student enrollment;
  - Remote accommodation of workers; and
  - Transient populations that move locations based on seasonal work.

Contemporary Use

There are many legitimate reasons for the continuing use of, and dependence on, Relocatable Buildings in contemporary society. From the unpredictable nature of determining move-in dates on large scale construction projects to the limited budgets of local school boards accommodating fluctuating student enrollment. From the increasing frequency and severity of natural disasters resulting in the call for quickly deployable structures that are flexible in nature to house groups of displaced persons, to providing shelter to residents of remote communities in the North. The accommodation of industrial workers for employment at remote energy and resource extraction projects demands building solutions, which can be deployed with minimal on-site construction due to cost of construction labour, access to materials, extreme climatic requirements and more. Each of these groups currently depends on relocatable buildings to provide a critical shelter function. The majority of these scenarios call for a quick shelter solution that is not intended to remain in-place forever, but often for an un-determined time frame, with the potential to stretch well beyond any preliminary estimates.

They also typically require a solution that has limited impact on the site where it is situated. Despite their intended limited duration of use, these structures still need to address and meet the needs of functionality, occupant comfort and safety along with responsible use of resources. Given the frequent extension of placement and inhabitation these considerations are even more important.

Budget Constraints

Many companies and organizations have limited funds readily available or budgeted for capital expenditures on buildings. While buildings are essential and critical to the business or organization's existence, emphasis for investment is primarily focused on the Human Resources in the form of wages and benefits, or direct expenditures on equipment or tools specific to a task. The building, which protects these and other investments, is quickly moved to a lower priority until the need for space becomes so dire that changes have to be made in a very short window or when other failures of the existing shelter occur. Due to limitations in time and budget constraints, individual organizations and companies looking to procure relocatable buildings are not generally interested in investing time at the individual project level to question or change the *systemic problems* of the relocatable building supply as a whole. The RB manufacturers, which cater to these clients, are equally not inclined to address long-term problems of quality or a range of code and life safety issues unless mandated to. Despite the fact that installation of the Relocatable Building projects in industrial settings are completed by the same manufacturers on a recurrent basis, problems continuously arise. Due to the budget constraints typically associated with projects using an RB solution, there are no 'extras' provided in these units. What is manufactured, marketed and sold to the consumer is a "lean", "fit-for-purpose", "economical" and quick solution to their spatial needs. Clients seldom realize at the outset that the product that they are leasing or acquiring maybe little more than a 'tinfoil' wrapped firetrap inadequately designed for its geographical location, local surroundings or specific occupancy needs. The modules may or may not meet basic structural and code requirements of the local jurisdiction's conventional buildings with similar occupancies. Other frequent substantial non-compliance issues found with RB installations include improper fire safety are frequent infractions.

Time Constraints

Directly related to the limitations of budget constraints are time constraints. As previously stated, investment in buildings is minimized or avoided by many organizations looking to operate on limited budgets. Routine maintenance can sometimes be ignored, and when additional space is needed, there is very little flexibility in timelines to accommodate the rounds of design and planning essential to addressing systemic issues. Instead, Relocatable Buildings are perceived as a quick fix - in the moment, which can solve space issues that the organization is struggling with while minimizing budgetary expenditures. In the industrial context, owners look to sell or lease buildings with limited budgets, and constrained timelines because project planning is behind schedule, or more workers are needed on the fly. In the educational context, emphasis on providing a turn-key solution to the approaching academic school year's enrollment crunch, is desired to occur with minimal disruption to the class schedule and installations are typically confined to the two month window of the summer school break.

Disposable Buildings

Leased, used buildings, which are often of substandard construction quality, are typically not in good shape when they arrive on site. They are often not respected by occupants or workers and are subject to increased levels of abuse. The materials they are constructed from are typically flimsy and cheap, and deteriorate quickly from light use, and exposure to basic weather events. After as little as five years[32], there are significant issues such as mold, rodents, roof leaks, and differential settlement. By ten years[33], depending on their occupant load and use, they have completed their lifespan and are ready to be sent to landfill. In industrial settings buildings and accommodations for employees are considered by the corporation to be a costly but necessary aggravation – one not perceived to have the same value in long-term investment as a critical piece of process equipment. Despite the intended temporary nature of these buildings and a designed lifespan of a maximum 10 years, many of these buildings are still in service (and significant disrepair) after 20 years, and sometimes as long as 40 years.[34]

The Role of Building Codes

> "The Code is essentially a set of minimum provisions respecting the safety of buildings with reference to public health, fire protection, accessibility and structural sufficiency.... Its primary purpose is the promotion of public safety through the application of appropriate uniform building standards."[35]

When fundamental requirements of shelter and human health are overlooked, the larger community is affected both directly and indirectly. With regards to Relocatable Buildings, it is critical that increased standards be developed, in order to mandate manufacturers to provide suitable buildings. These buildings should be designed and constructed so that all members of our communities are afforded the same level of protection that is expected from permanent conventionally constructed buildings. In his book Prefab Architecture, the author, Ryan Smith, discusses the 'design innovations' that a project called 'Cargotecture' incorporated into its realization:

> "Cargotecture did not reduce design and construction costs. However, the project was brought within the desired budget by design innovations by careful **sub-threshold code**, which removed the need for an elevator, sprinkler and more than one stair; and eliminated exterior fireproofing. Also measures were taken to remove the need for structured parking and underground water retention systems."[36]

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32 Authors' first hand observations from industrial site review. Company not disclosed.

33 www.earthfix.info "They Have to Go: The Environmental Cost of Portable Classrooms.

34 NPR – Here and Now. "Portable Classrooms – No Place to Learn: Interview with Tony Schick – Earth Fix

35 Ontario Building Code Compendium 2012 Vol.1. Pg. i.

36 Ryan Smith, Pre Fab Architecture: A Guide to Modular Design and Construction. Pg. 276.

'Sub-threshold Code' Design is murky ethical territory and should be avoided as a general design strategy. Circumnavigation of codes and regulatory requirements do not qualify as true innovation. By avoiding the issues, that are to be addressed through such codes, the designer abdicates responsibility to produce a safe shelter. They should not be trying to get around minimum rules. The role of the building code in permanent construction is held to a different level of accountability, regulation and expectation. In contrast to this approach to "code compliance" or rather code avoidance, the production of a prefabricated home - Chameleon House in Rural Michigan by Anderson and Anderson Architecture took a different approach:

> "Although built in an assembly line with other portable classrooms, the project **exceeds on-site construction code standards** and minimizes waste."[37]

By embracing the role that codes and governing policies have in shaping our structures and ensuring minimum levels of quality are provided for all inhabitants we can greatly improve the built environment, and the quality of space that they envelope.

Improvement of Minimum Standards

> "Construction of sound, safe buildings and structures is fundamental. Building codes and regulations provide these minimum safety standards."[38]

Relocatable buildings serve a crucial role in the existing built environment. Though their intended duration of occupancy is to be limited to short-term stays, in reality, they regularly remain in place at their "temporary" sites for much longer periods than initially estimated. By improving the minimum expectations and requirements of these structures, there is the potential to impact a large number of people in a positive way by providing an improved level of construction quality and durability. Better quality results in the design and construction of these units has the added benefit of improving sustainability of the structures and reducing raw material and energy use through increased durability. Improved occupant comfort, more responsible and efficient use of energy and reduced operational costs, can all result from increased insulative values, better sealed assemblies and more efficient fixtures and equipment specifications. Modifications to existing regulations would mandate that even the most basic models would be safer structures, legislated to be constructed and sited in a way that addresses the changing external site conditions typical with the use of these types of buildings and would mitigate and anticipate risks from without as well as within.

[37] Anderson & Anderson. Prefab Prototypes. Pg. 286.
[38] C.H.O.P. – Chapter 1.2.4 Volume 1, Pg. 1.

Minimum Standards are not the Ideal

> "People on the fringes of society as well as those living in trailer parks are not traditionally embraced when discussing the merit or impetus for introducing design or technological innovation."[39]

The thesis proposal is composed of suggested modifications to a series of current construction standards and building codes, with annotations to discuss how underlying issues of quality and occupant life safety can be addressed. By focusing on regulation, as opposed to voluntary industry measures, the intent is to ensure that all relocatable buildings constructed within or imported to the Province of Ontario meet a higher minimum standard. While improved minimum standards still do not represent an ideal construction quality, (such might better be demonstrated by voluntary rating systems geared towards delivering the 'best' solution) these regulatory modifications have the potential to make broad improvements to the RB stock to better protect the health, life-safety and occupant comfort of all user groups, not just a select few.

Proposed Amendments to the Ontario Building Code Compendium.

The proposal suggests that such updated minimum technical requirements and changes to the legislative framework will help to shape the future design for these building typologies. Recognizing that in the 2012 edition of the OBC 'Part Ten - Change of Use' has been recently added[40], this proposal suggests that the 'Change of Use' part be re-numbered Part Thirteen. Subsequently, that the Part Ten title be changed to "Relocatable Buildings" in order to serve Temporary Accommodations following the example of the Alberta Building Code model, as a means of generating national consistency, and might subsequently inform changes to be adopted by the National Building Code of Canada (NBCC).

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[39] Dean Goodman, LGA, Transportable Environments 3, Robert Kronenburg Ed.
[40] Ontario Building Code Compendium 2012 Edition Vol. 1.

Figure 7: Typical Portable Classroom Example

1.2 PORTABLE CLASSROOMS

What are Portable Classrooms?

Portable Classroom – a transportable, single- or multiple-section, one-storey classroom spaces ready for occupancy on completion of set-up in accordance with the manufacturer's instructions.[41]

The most visible and common example of the use of relocatable structures within the context of educational facilities is the infamous "Portable Classroom". Adopted in the 1960's and 1970's as a way of quickly enlarging the capacity of a school's building to accommodate the constant fluctuation of student enrollment at relatively low costs to the school board[42], these structures have continued to persist in the educational landscape of North American schools. In the province of Ontario, as of 2004, almost ten percent of students in the Public and Catholic education systems were receiving instruction from within the walls of a Portable Classroom. In the U.S., that number is even higher with thirty-one percent of schools using portable classrooms.[43] There is aggressive pricing competition between companies in the business of creating manufactured housing and modular classrooms. This competition constitutes a race to the bottom and as a result affects the quality of learning environments of approximately three million students each year in the United States alone, impacting students from all age groups: Day Care, Kindergarten- Grade 12 (K-12), Community College and University Levels[44].

The Promise of Flexible, Affordable Accommodations

> "Rapid growth in various areas of the United States has led to the increased use of portable classrooms as a solution to overcrowding… Often they are introduced as a stop-gap measure but construction of permanent classrooms often ends up being delayed for decades thanks to tight educational budgets."[45]

The need for Relocatable Classroom (RC) solutions at schools is typically dictated by swings in student enrollment, or removal of regular classrooms from service during renovation work. When RCs are initially installed at a school location, the duration of their stay is frequently unclear and a projection of the maximum number of relocatable units is often unknown. With the underlying assumption that the units "will not be in place for long", many of the design considerations, routinely incorporated in to the design and siting of a permanent school building, are ignored when planning the layout of relocatables.

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[41] CHPS, Inc. – The CHPS High Performance Relocatable Classroom – Best Practices Manual. 2009. Pg 5.
[42] Joann Gonchar. Modular Classroom Makeover – Architectural Record. January 2014 http://archrecord.construction.com/tech/techfeatures/2014/1401-Modular-Classroom-Makeover.asp .
[43] Lewis, L & Debbie Alexander. Condition of America's Public School Facilities 2012-2013, Page 6.
[44] Modular Learning Environments – Beyond the 'Classroom in a Can'
[45] "Learning the hard way – the poor environment of America's Schools" Vol.110, No.6, June 2002 – Environmental Health Perspectives, Page A302.

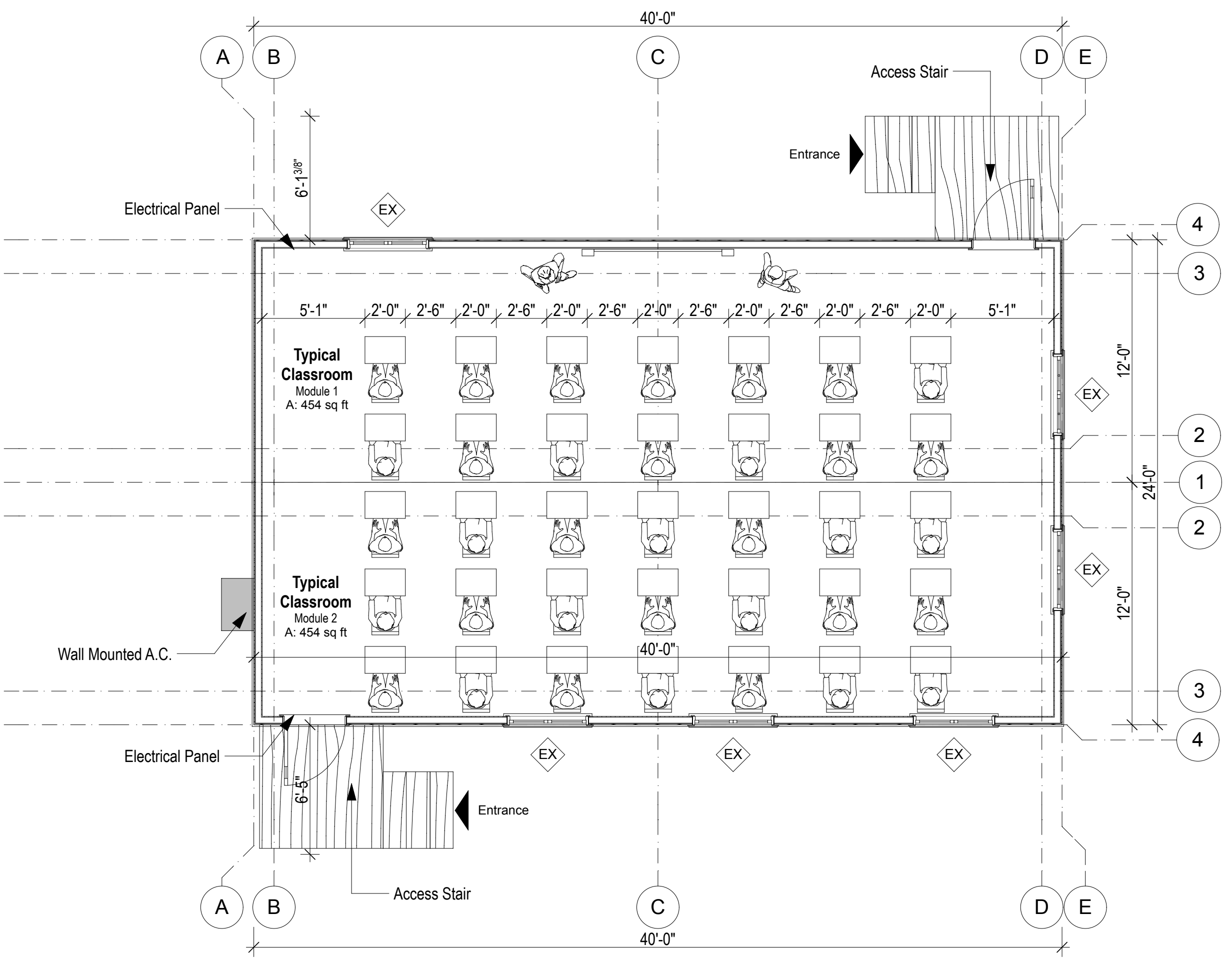

Figure 8: Typical Portable Classroom Floor Plan

In the rush to procure, and acquire relocatable classrooms under tight time frames the key issues of **quality, durability, safety, comfort and efficiency**, are neglected and what arrives onsite does not live up to the initial promises.

Delivery of Dark, Cramped Noisy Sick Buildings.

While these modules do suffice to fill some basic need of cheap and flexible accommodations, quality does not appear to be a primary concern for the average manufacturer. As previously described, standard quality, Relocatable Buildings have many issues to be addressed. These buildings barely meet minimum requirements for fresh air ventilation, air conditioning is poor functioning in summer while heating is inadequate in winter, they have poor or non-existent air distribution systems, mechanical units are inefficient energy hogs, and are noisy and disruptive to the classroom setting.

What are the Problems with Portable Classrooms?

The United States Environmental Protection Agency (US EPA) highlights the typical problems encountered with portable classrooms:[46]

1. **Poorly functioning HVAC systems**
2. **Poor Acoustics & Low Sound Transmission Coefficient (STC)**
3. **Chemical off gassing from pressed wood and other high emission materials, high volume of Volatile Organic Compounds (VOCs) and other toxins being released**
4. **Water entry and mould growth from poor quality of construction, air infiltration and inadequate sealing of the building envelope.**

Quality

There is a noticeable disparity in quality of construction between permanent schools and relocatable classrooms. Many relocatable classrooms have been used and moved around from one location to another several times, and have suffered from the stress and strain of install, transportation, dismantle and re-installation processes. Maintenance on these used units is minimal at best, as they are frequently leased from the manufacturers, and school boards are not looking to spend additional money on assets that they do not own. Manufacturers get away with not maintaining the units, as there is limited push back, and many students and teachers are not provided an adequate method to voice their concerns and issues.

The initial poor quality of construction of a classroom module directly affects the other four considerations.

Quality of Space: Access to natural lighting is limited to a few windows placed for ease of construction and transportation, not for optimizing views, natural light, or cross ventilation of natural breezes.

Quality of Materials: Material Selection is generally based on cheapest available solution, and does not address off gassing of harmful toxins, or long-term durability. Vinyl-faced Gypsum Wall Board and Vinyl

46 www.epa.gov US EPA Study on Portable Classrooms

Composite Tile used for flooring expose occupants to PVC. Many of the wood composite products used in the wall assemblies contain formaldehyde – a known carcinogen. Additionally due to poor quality of the assembly, once exposed to moisture many of these buildings become subject to mould growth.

Durability

Limited durability is provided by the type of materials specified in the construction of Relocatable Classrooms. Materials are selected based on being lightweight for transit, readily available, for ease of replacement once damaged, and inexpensive in order to maximize profits while providing bare minimum durability. The flooring materials typically installed are not well suited for standing up to any moisture and do not adequately protect the subfloor sheathing's structural integrity.

Durability of Interior Materials: Interior Materials typically consist of Vinyl composite floor tile; Vinyl faced GWB or Wood Composite Paneling Wall Finishes and Vinyl Faced Acoustic Ceiling Tiles.

Durability of Exterior Materials: Exterior materials typically consist of Painted Metal Liner Panel for underside of Floor Assembly, Untreated and unfinished Plywood Skirting, Painted Wood Composite Wall Panels and Single Ply PVC or EPDM Roof Membranes.

Safety

Often the health of the students or teachers is compromised by the specification of inexpensive, building materials and low quality design and execution.[47] These issues lead to poor attendance, poor productivity, poor performance, increased employee absenteeism, and increased illness and complaints

Fire and Life Safety: Building Assemblies are not expected to provide the same level of fire separation as permanent school buildings.

Exposure to Toxic Substances: Installation of poor quality materials can lead to the potential exposure of students and teacher to harmful substances such as VOCs (Volatile Organic Compounds) off gassing from building materials, and potential exposure to other designated substances including lead and asbestos in older re-used modules.

Exposure to Mould: This is an issue of concern, which reaches beyond the academic and professional world. The number of school district dealing with issues around indoor air quality and mould as relates to Portable Classrooms is also covered by news media and is of concern to the daily lives of many individuals. According to the EWG (the Environmental Working Group), in their study of portable classrooms – These existing structures expose their occupants to a host of carcinogenic substances including exposure to formaldehyde (both urea and phenol), benzene and other toxic substances.[48]

Comfort

Beyond providing a basic shelter in which students or workers are sheltered from the exterior elements and are provided safety, the comfort of the occupant is critical in providing a space that serves its function and purpose well. Students in a portable classroom need to be physically comfortable in order to be able to learn at their

[48] Environmental Working Group – Portable Classroom Study.

best. If the space is too hot, too cold or too noisy, this will distract from their ability to absorb their lessons and fully engage with and participate in their school curriculum.

Thermal Comfort: Inadequate levels of insulation are provided in standard modules.

Student Inclusivity: Barrier Free Provisions are not adequately addressed by the current requirements for Relocatable Classrooms.

Acoustic Comfort: Noise/Privacy – Vinyl faced materials provide minimal absorptive qualities for acoustics, and minimal insulation levels are provided in the units. When classrooms are paired together, noise travels from one classroom to the next. When standing in isolation noises from the exterior are easily distracting to students. Additionally excessive noise from HVAC systems and poor distribution systems are extremely disruptive. So much so that many teachers shut down mechanical units during lessons or lectures to reduce noise levels and in doing so, compromise the fresh air ventilation and oxygen levels of the space.

Efficiency

Energy and Water Efficiency of the Relocatable Portable Classroom needs a much higher prioritization.

General Energy and Water Efficiency: Energy Efficiency is not prioritized

HVAC Systems: Energy Efficiency is not prioritized

Artificial Lighting Systems: Energy Efficiency is not prioritized

Siting of Portable Classrooms

Issues arising directly from the ill-considered placement of Relocatable Classrooms compromise fundamental principles of building design and site planning, resulting in problems related to spatial separation, limiting distance and life safety requirements. One approach to addressing the piece-meal nature of this type of planning and implementation is to increase the required fire resistance rating of all these structures' exterior construction assemblies to alleviate issues with exposure to future buildings not evaluated at the time of initial construction.

Part 3.9 "Portable Classrooms" within the Ontario building Code (OBC) indicates that by providing either a six metre (6m) separation distance or a forty-five min interior fire separation, these structures can be clustered together in groups of six buildings.[49] The currently accepted standards for locating portable classrooms on a school site in proximity to the main school building and in proximity to one another is in need of review and modification. Under the current Ontario Building Code, occupants of these portable classroom structures do not receive the same level of provision of basic required components for occupant health and life safety when compared to 'real' permanent school structures. The threshold for the requirement for installation of a fire alarm system needs to be significantly reduced. In its current iteration – the average portable classroom contains thirty (30) students, one (1) teacher and one (1) educational assistant. The requirement for fire alarm coverage is only mandated once the collection of portable classrooms reaches twelve (12) units – meaning that

[49] Ontario Building Code Compendium 2012 edition. Vol 2. Appendix. A-3.9.3

a collection of 372 occupants of these buildings can be legally in place with no fire alarm coverage on the portable buildings themselves.

While the size of the classrooms are such that the distance to exiting is relatively small there is no differentiation between classrooms for different age groups of children or for children with special needs who are equally apt to spend some portion of their educational careers within these ubiquitous structures. Such occupant groups - young children or special needs students may require additional assistance in egress during emergency scenarios. The resultant insinuation is that the value of a child's life is less than an adult based on the reduced protection and provision of life safety systems for these young students.

In other occupancies, there is a requirement for the spatial separation of tenants. Increase to a minimum of 1HR fire resistance rating of the fire separation in accordance with other parts of the Ontario Building Code. Especially with young children, while it is a school setting, there is a high probability for children to be sleeping during quiet / nap time, which will only serve to further reduce the reaction time of these students if no alarm system is required and a true emergency occurs.

Understanding Occupancy

Assuming an average occupancy of thirty to thirty-five people (majority children) per structure, these clusters would house 210 people. These collections of classrooms are typically installed without additional adequate washroom facilities connected to the cluster, and many times the groups of modules are connected together by raised wooden platforms. To allow for Barrier Free (BF) accessibility between the units walkway systems along with exterior ramps must be built and incorporated within the site design of the units. Accessibility is seldom adequately accommodated in the design of relocatable buildings and portable classrooms, which under the present code is not required if the main permanent school building is accessible. While the code does provide some limited guidance on the subject of portable classrooms, other building occupancies that make use of RB solutions are not specifically addressed. The current typical lifespan of standard issue portable classroom is roughly five to ten years, based on typical levels of use and occupancy.[50]

> "…the green portable classroom has instigated discussion for other school boards and universities needing space quickly, but not wanting to sacrifice energy performance and interior air quality."[51]

Portable Classroom Evaluation Precedents

Past studies and evaluations of portable classrooms serve to highlight many of the common complaints of the contemporary users. While highlighting the typical problems encountered with RBs, several of these studies demonstrate that implementing economically feasible upgrades to improve these simple structures, with tangible results *is* possible. In their 2004 document "Preliminary Evaluation of Performance Enhanced

50 Typical Lifespan Reference

51 Anderson & Anderson. Prefab Prototypes. Pg. 287.

Relocatable Classrooms in Three Climates"[52] the principal investigators: Stephanie Thomas-Rees, Danny Parker and John Sherwin of the Florida Solar Learning Centre demonstrated the comparatively poor performance of standard relocatable classrooms against their 'Performance Enhanced Relocatable Classroom (PERC) twin. One of each of these existing and enhance modules were located in New York, North Carolina and Florida and monitored for their use of energy, provision of occupant comfort as well as other key metrics, and then following an eighteen month monitoring period, evaluations were made of their effectiveness. This particular study was modeled after a similar study of portable classrooms completed in 1996 entitled "Design and Evaluation of Energy Efficient Modular Classroom Structures"[53]. The 1996 study completed by a research group, at the University of Oregon included: Sarah Bernhard and G.Z. Brown. This team compared a series of portable classrooms located in divergent parts of the United States including: Honolulu, Hawaii; Astoria, Oregon; Bakersfield, California; Fairbanks, Alaska; and Spokane, Washington. Both of these studies highlight the poor quality of existing stock of relocatable buildings and the opportunity to improve occupant comfort while reducing energy use and operating costs, by adopting simple improvements to the building envelope. These studies also demonstrated that, while varied, a discernable payback for such upfront capital investments in the improved quality of portable classroom was achieve in all of the different climate zones.

Opportunities for Architects in Educational & Institutional Settings

Relocatable Buildings used in the Educational context provide much needed flexibility and quick delivery of space solutions being created by architects to address for school facilities throughout North America. By having, a more active and engaged process for review of these products, improvements can be made on a much broader basis. As can be seen by the Architecture for Humanity (AFH) Challenge to improve the basic classroom, there are many creative and viable ideas and solutions to this problem. The range of possible solutions available to us is not the limiting factor to this issue. Problems stem from limited resources and meager political will to pursue different solutions to the same old problem. Rather than encouraging more innovative designs to be created and then subsequently shelved, we need to change the underlying requirements of this 'product', and then see manufacturers work to deliver new and innovative buildings to the market, based on regulatory and legislative changes that ensure quality and compliant building solutions are received by the consumer regardless of sector.

The adjoining page illustrates a recreation of the existing diagrams from the Ontario Building Code– See Figures (9-14) based on current acceptable standard from the Ontario Building Code (OBC) Part 3, Appendix A Section 3.9.3[54]

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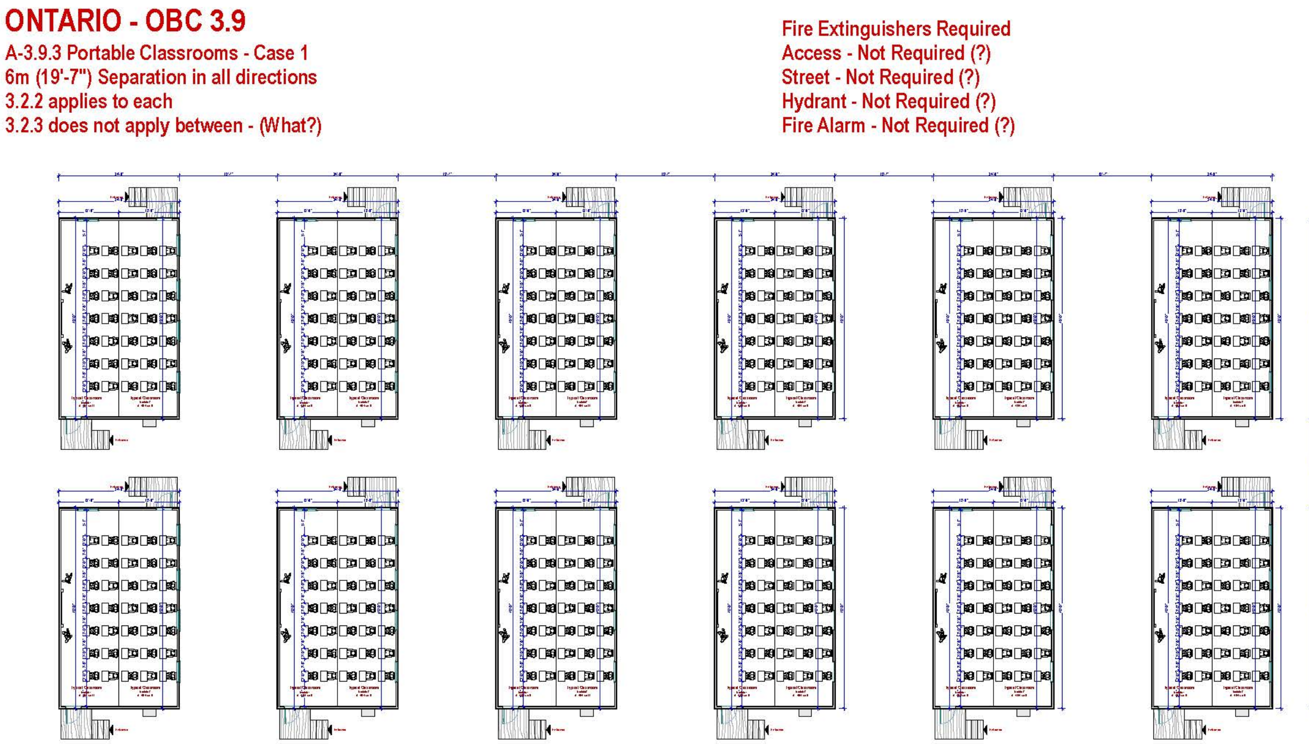
52 Stephanie Thomas-Rees et. al. FSEC-PF-382-04, "Preliminary Evaluation of Performance Enhanced Relocatable Classrooms in Three Climates". Washington, D.C. August 2004.

53 Sarah Bernhard, G.Z. Brown, et. al. "Design and evaluation of Energy Efficient Modular Classroom Structures" University of Oregon, Eugene Oregon. 1996.

54 Ontario Building Code Compendium 2012. Appendix A, 3.9.3. Pg. 56.



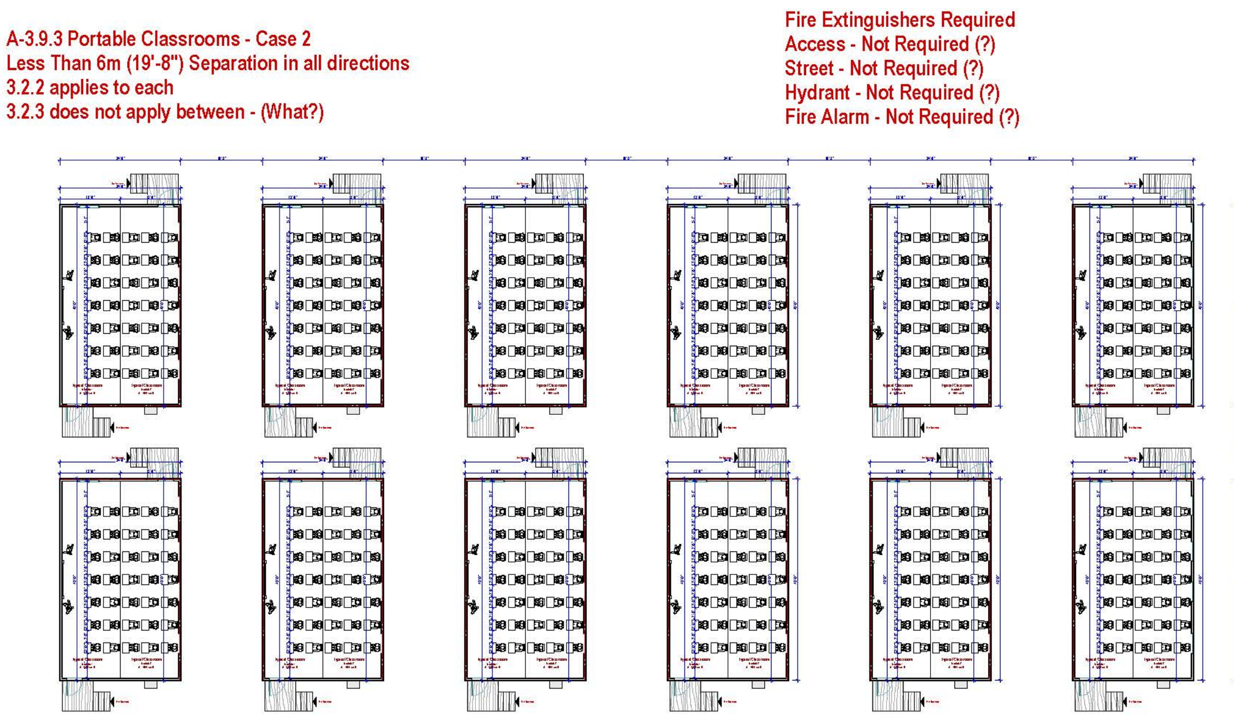
Portable Classrooms Case 1

When the individual modules are located more than 6m from one another
– fire separations are required only between those modules which are less than 6m apart

- No fire route access is required
- No Hydrants required
- No Fire Alarm Connection is required

Extinguishers are required

Figure 9: Portable Classroom Siting Diagram #1

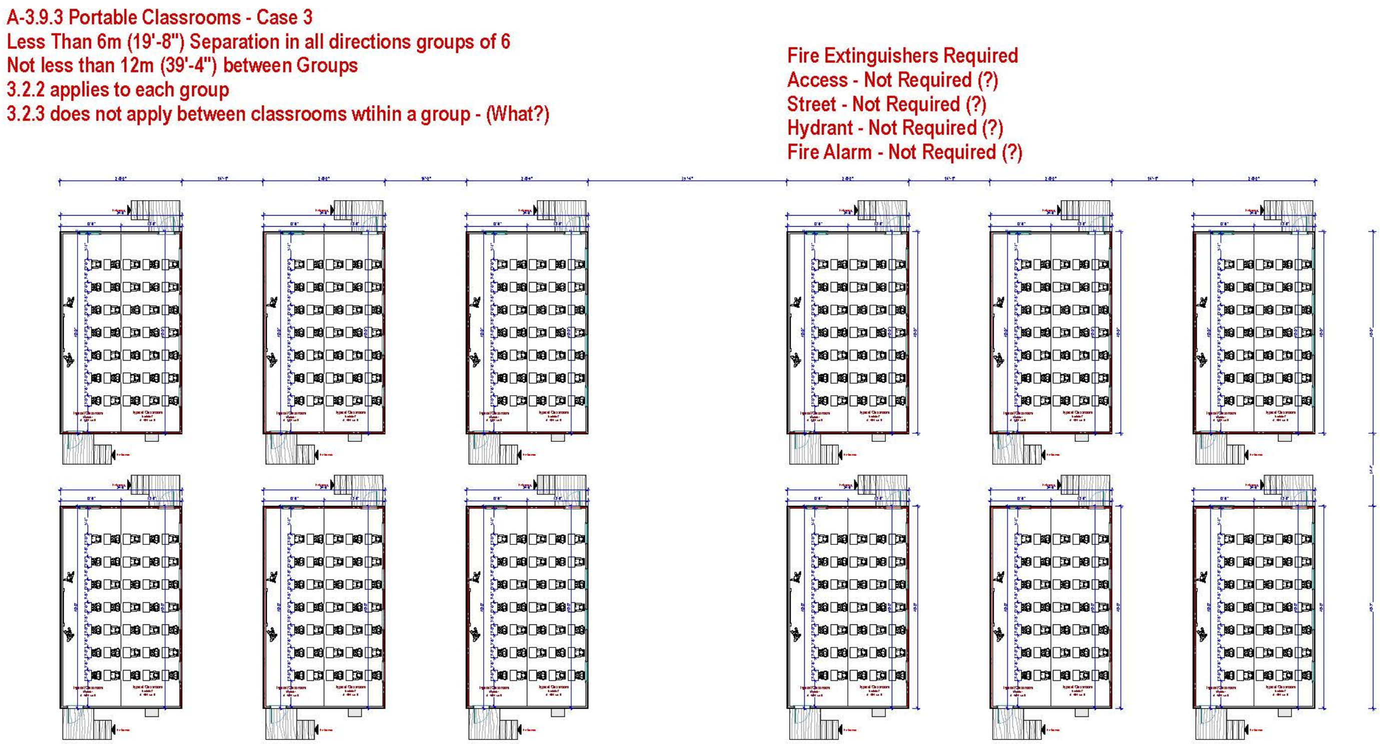


Portable Classrooms Case 2

When the individual modules are located less than 6m from one another
– fire separations are required only between those modules which are less than 6m apart

- No fire route access is required
- No Hydrants required
- No Fire Alarm Connection is required
- Extinguishers are to be provided,

Figure 10: Portable Classroom Siting Diagram #2

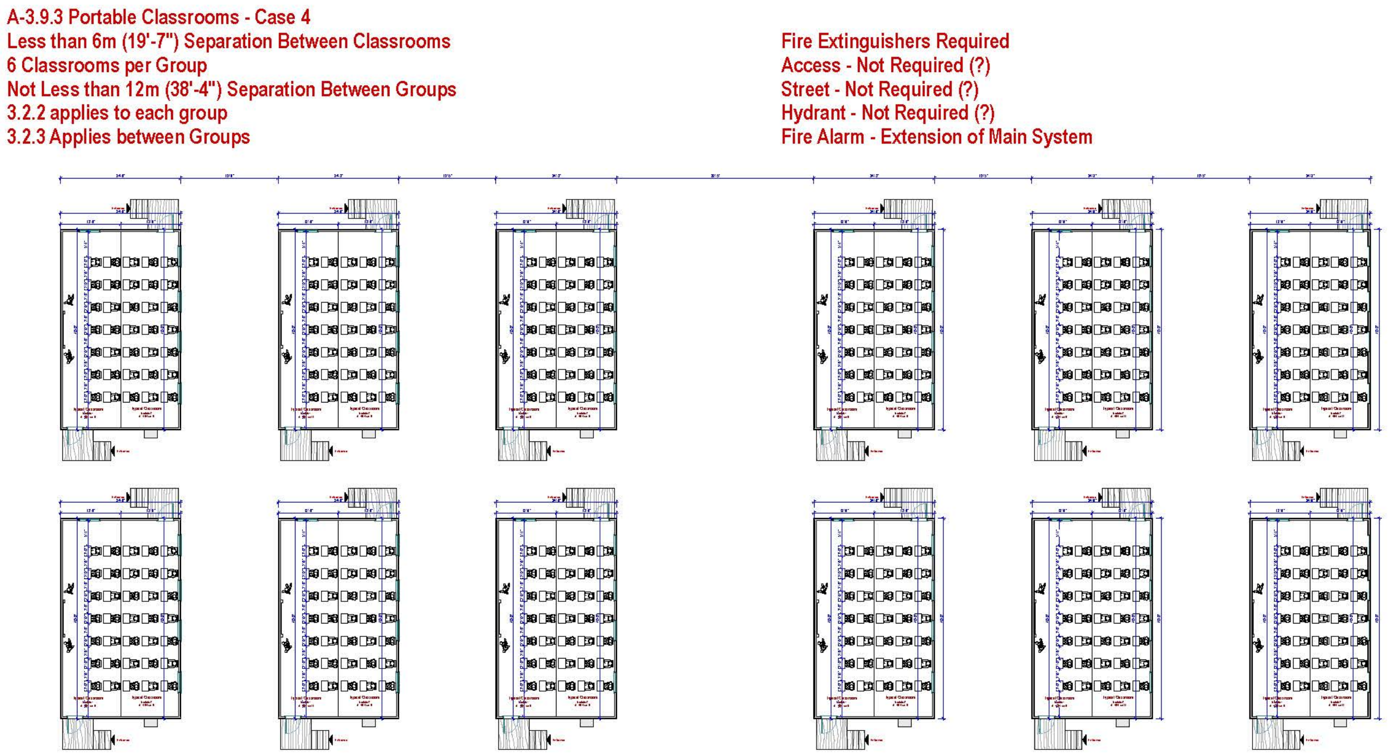


Portable Classrooms Case 3

When the individual modules within a cluster of six classrooms is located not less than 12 m from another cluster of six classrooms
– fire separations are required only between those modules which are less than 6m apart.

- No fire route access is required
- No Fire Alarm Connection is required
- Extinguishers are to be provided,

Figure 11: Portable Classroom Siting Diagram #3

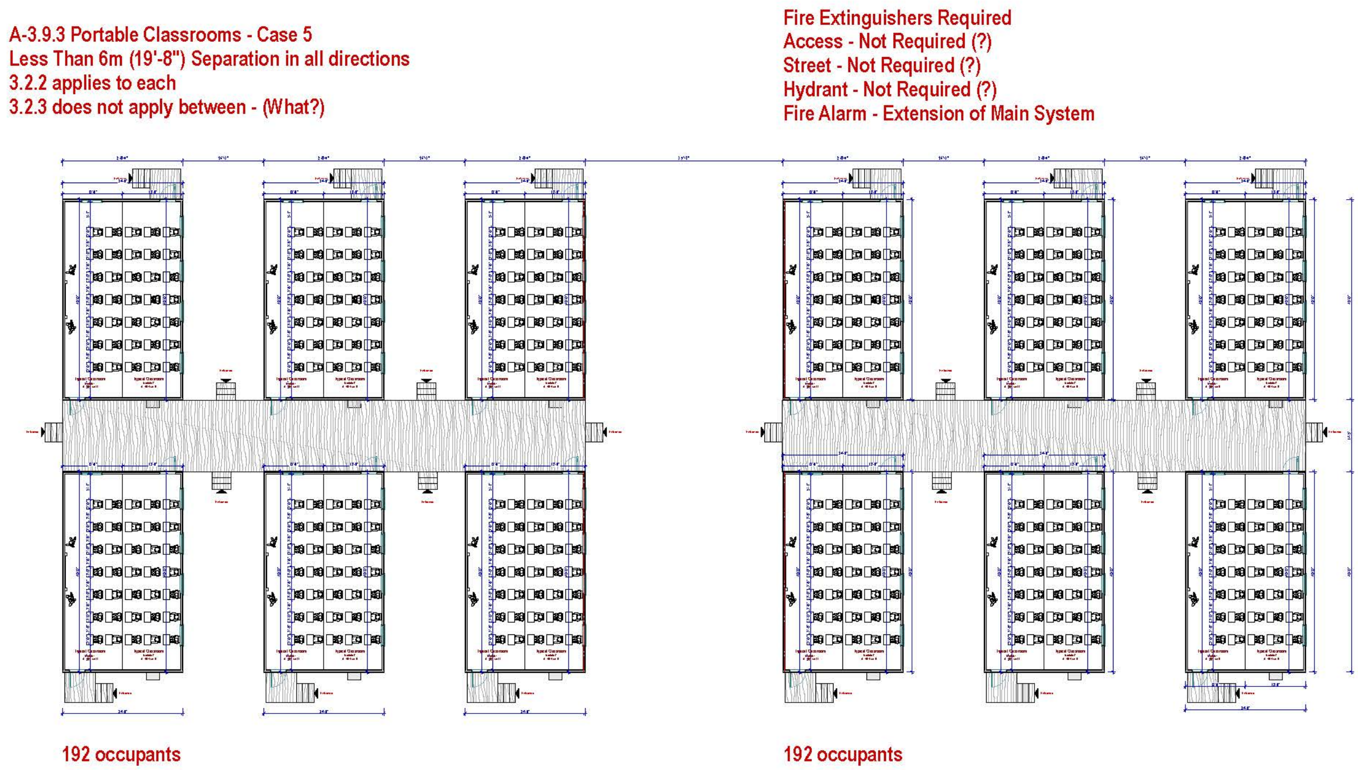


Portable Classrooms Case 4

When one cluster of six classrooms is located not less than 12 m from another cluster of six classrooms – no fire separations are required

- No fire route access is required
- Extinguishers are to be provided,
- As is an extension of the fire alarm from the main school building.

Figure 12: Portable Classroom Siting Diagram #4



Portable Classrooms Case 5

Linked by Exterior Walkways – the two clusters are each considered their own separate building.
Up to 210 occupants could be within each of these 6 module clusters.
Fire separations are required between the two clusters, but **not** between the individual modules within the clusters.

- No Fire Route Access or Hydrants are required
- Extinguishers are to be provided
- And an extension of the Fire Alarm system from the main building is to be provided

Figure 13: Portable Classroom Siting Diagram #5

Figure 14:
Industrial Accommodation by Modspace at Husky Refinery

1.3 RELOCATABLE INDUSTRIAL ACCOMMODATIONS

What are Relocatable Industrial Accommodations?

Relocatable Industrial Accommodation – factory-built structures that provide accommodation for an industrial work force living and working in a temporary location, but does not apply to manufactured homes, prefabricated single-family dwelling units, or other types of prefabricated or manufactured buildings. These structures are also used for Group D (business and personal service) and Group F Division 3 (low hazard industrial) occupancies for a work force working in a temporary location.[55]

Typologies Of Industrial Accommodation

A few examples of the range of industrial accommodations created from modular "relocatable buildings" to fill the demand for office, washroom, lunchroom and meeting facilities at industrial plants throughout North America:

- Washrooms
- Locker Rooms
- Equipment Storage (Tools, PPE, Materials, Equipment)
- Shower Trailers
- Asbestos Decontamination Facilities (Mobile Units to support workers doing asbestos removal)
- Lunchrooms (Small office lunchrooms to full sized cafeterias for hundreds of people.)
- Office Space (open and closed office space arrangements
- Meeting Space (Conference Rooms, Break-out Space, Project Planning & Coordination)
- Multi-Use Complexes (Recreational Space, Lounges, Gym facilities)
- Residential Accommodation in Remote Locations
- Blast Resistant Modules (BRMs) will all of the same above uses, however different construction to allow for location within high-risk contours and process areas.

See Appendix A for sample plans of a wide variety of typical industrial relocatable building typologies

[55] Adapted from the Alberta Building Code 2007 – Part Ten

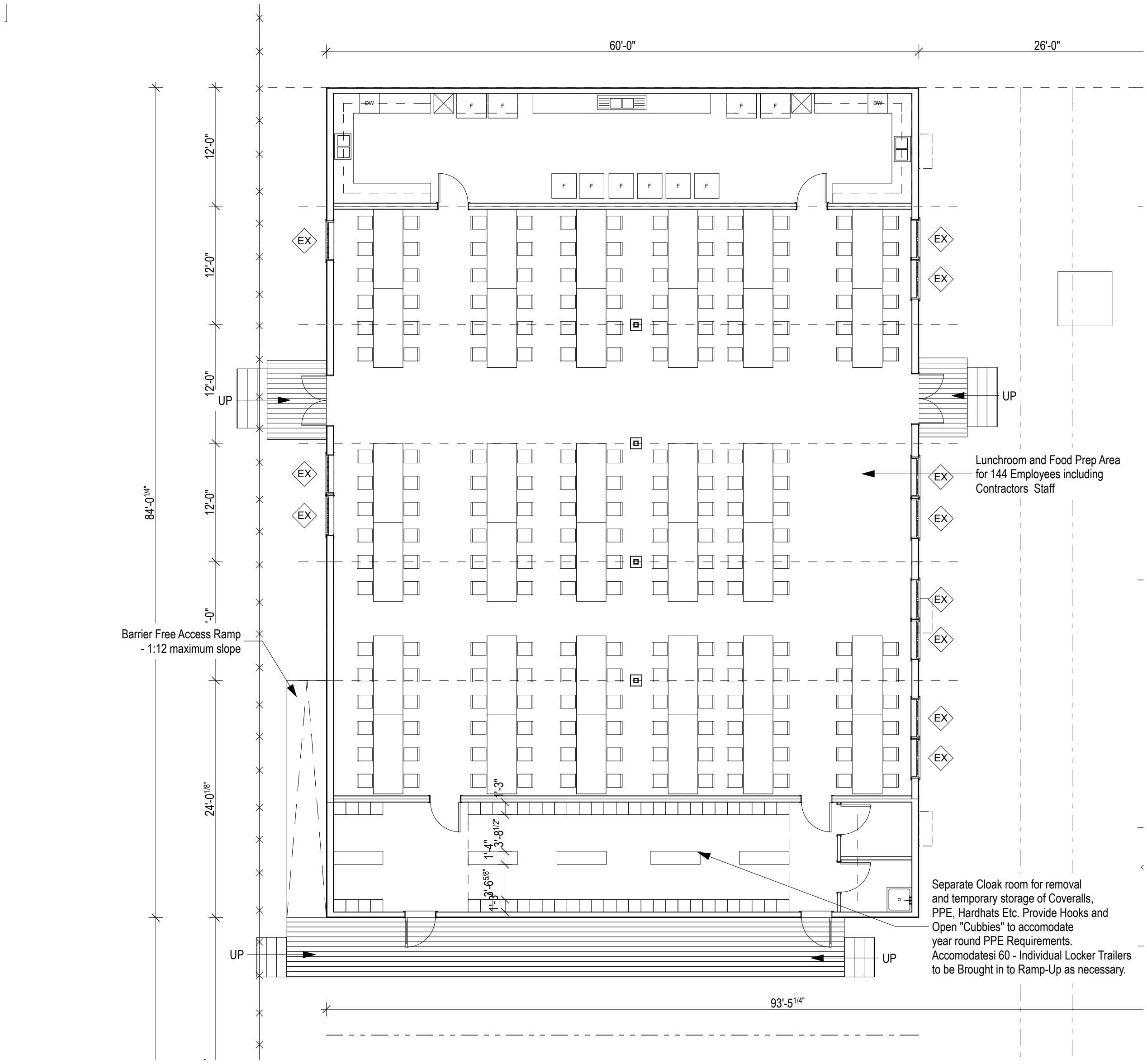


Figure 15:
Sample Floor Plan Industrial Accommodation – Lunchroom Complex

Application of Relocatable Buildings in Industry

Relocatable Buildings, used under the umbrella of Industrial Accommodations or "Workforce Housing", are among the most varied and diverse RBs being manufactured and installed. These agglomerations of modular units are required to function as homes, offices, and recreational facilities for the thousands of employees who work in industries including remote resource extraction and large-scale construction sites. Due to the volume of these relocatable building complexes being erected at sites throughout the Province of Alberta, the Government of Alberta was urged to take steps to ensure that minimum standards of construction quality was being specified, produced achieved and delivered for the RBs in their province. Though the number and size of such types of installations in the Ontario context do not rival those of Northern Alberta's oil sands developments, there are still significant industrial developments in this province requiring more clear standards and increased level of oversight.

Problems with Industrial Relocatable Buildings

Issues of transportation, weight, speed of assembly and cost of materials are all relevant and contributing factors to the design and production of buildings by RB manufacturers, however the issue of quality is not addressed in a substantive manner, because the manufacturers are not required to do so. Simultaneously, much of the time, the client (purchasing department / end user) is not fully aware of the sub-standard quality of product that they are about to receive. While the client is under the assumption that minimum codes are being met, by these relocatable buildings, many units delivered to site are designed and built for other jurisdictions, having different climates or construction codes or have been relocated multiple times and have not been brought up to date. Additionally, clients are not fully aware of the discrepancy between the requirements for "factory made buildings" vs. standard permanent construction. If the playing field was leveled, there is the potential for advancement in production quality to take hold in this sector. The same concerns and issues that apply to portable classrooms are equally relevant for relocatable industrial accommodations: **quality, durability, safety, comfort and efficiency.**[56]

Quality – The totality of features and characteristics of products or services that bear on their ability to meet specified requirements.

Durability – the ability of a building or any of its components to perform its required function in its service environment, over a period, without unforeseen cost for maintenance or repair.[1]

Safety – the condition of being safe; free from danger or risks.

Comfort – a state of physical well being; being comfortable | things that make life easy or pleasant.

Efficiency – effectiveness, competence, or the ability to accomplish or fulfill what is intended. / The ratio of useful work performed to the total energy expended or heat taken in.

[56] Oxford English Dictionary.

Part 10: Relocatable Industrial Accommodations, within the Alberta Building Code 2007, serves to clarify requirements for both the finished RB product as well as standards to be met within the production facility for companies doing business in Alberta. It also lists stringent certification requirements in order for final products to be acceptable for installation on Alberta Sites. This standard while raising the minimum requirements of RBs (increased cost of construction) has also served to provide consistent industry-wide expectations in that province and improved products for those required for inhabiting these spaces.

Workers In Industry

Industrial, construction and manufacturing settings have many inherent health and safety risks presented to workers on a daily basis. One such risk should not be their buildings. It is essential for the 'safe space' that they inhabit for meetings, office work, lunch and breaks to function in a manner that does not increase the level of hazards and risks that they are required to mitigate. Relocatable buildings of poor quality construction have direct and indirect impacts on employees' health and safety and productivity. The individuals and groups most directly affected by the quality of these structures are the occupants themselves, while owners and operators of these buildings deal with indirect repercussions such as post-incident litigation and diminished employee morale. Relocatable buildings are typically situated in rural, remote, industrial or low-income institutional settings and therefore are not necessarily directly visible to passing community members. Even though they may not directly impact the visual landscape of a city, in the same way that a new skyscraper or museum would, they still have an impact on the community at large. These spaces, which constitute the daily work environment of a large number of people, are required to occupy day in and day out shape the experience and perceptions that these individuals have about buildings, design and the space around them. Poor quality spaces can also affect the occupant's health and well being which can affect the community at large through many indirect cost associated with inadequately investment in buildings. The current model for manufacturing of these units is based on assembly in large factories mostly in the United States in states with few, or more lax labour laws and low wages, and then assembled units are subsequently shipped out to the desired location via transport truck and escorted caravan in cases of oversized or multi-module clusters.

Safety of the Worker

There is the potential for improvement in quality control by virtue of moving processes indoors in controlled environments, however the labour (skilled laborers) hired to work in these factories may or may not receive the training to members of the various skilled trades within the Ontario trade union system. By moving outside of the 'brotherhoods' this type of construction can become more akin to the assembly line manufacturing processes of automobiles and other large ticket consumer products, but not without substantial rethinking of the end product that is being produced in these environments.

There has been a substantial cultural shift around topics of safety (especially in the Oil and Gas industry). The impetus for modified site approaches to trailers and "removable Buildings" at refineries and other industrial sites. Beyond the issues of quality control of the product, is the variable and fluctuating site conditions into which such buildings are to be inserted. This increased awareness and adjusted approach to safety which falls on the heals of large industrial disasters including that of the Texas City Refinery Explosion - March 23, 2005[57]

The Ontario Building code does recognize the relocatable industrial accommodations as a special occupancy type within Part 9 that addresses the construction of Small Buildings and Housing specifically under Section 9.10.21 – Fire Protection of Construction Camps[58]. This section is very limited in scope. It does not recognize the breadth and diversity of relocatable industrial accommodations nor the scale of many of their installations. This section does not afford those individuals required to live in relocatable accommodations the same levels of fire protection, privacy or quality of space afforded to residential occupancies in other parts of the code, nor does it meet the level of detailed offered by the Alberta Part Ten – Relocatable Industrial Accommodations. It is imperative that, as part of the modifications to the regulatory documents proposed at the end of this thesis, the OBC Section 9.10.21 be reworded to address the contemporary issues that these types of occupancies are encountering today.

Limitation of Manufacturer Liability

There is an expressed limitation of responsibility (liability) around the manufacturer of the modular building units in so far as it pertains to the placement of units on a site. Manufacturers intentionally limit involvement with the placement and siting of buildings, there-by reducing their exposure once the units are delivered. All permitting of the relocatable building project and "compliance with local codes" are pushed back on to the responsibility of the customer who may or may not have the proper consultants and team in place to address these needs. Additionally, given the wide array of regulations from one jurisdiction to another, large RB manufacturers operating in multiple markets typically seek to fulfill minimum standards of the least stringent local authority and address non-compliance issues in other jurisdictions only when pressed or forced to. The manufacturers seldom meet the local code requirements but even though they recognize this as an issue, changes to the assemblies from any standard 'in-house' system that they are not use to providing is an onerous process, adding cost and time to the overall schedule of the project delivery and installation.

Siting Issues of Relocatable Buildings

Problems frequently arise due to the fact that many of these "modular units' are actually constructed in districts outside of the location for which they are to be ultimately erected.

[57] CCPS: Guidelines for Evaluating Process Plant Buildings for External Explosions Fires and Toxic Releases. Wiley 2012, Pg. 15.

[58] Ontario Building Code Compendium 2012, Pg.

While manufacturers include reference code standards in their production or construction documents, such references are often out of date or not applicable for the specific jurisdiction different than the intended installation site. Construction Documents for Relocatable Buildings at sites in Ontario in the last five years call out references to the 1995 National Building Code of Canada, which is both out of date (wrong edition) and not the governing document foe construction in the province of Ontario. Complexes are designed en masse in American jurisdictions and are subsequently rubberstamped by Ontario architecture and engineering consultants, with questionable levels of experience. Many such firms never step foot on the job site or see the building in person for review or inspections.

In the same manner that Portable classrooms often do not meet the needs of their students, relocatable buildings in industrial settings are often not adequately designed for the climatic or the environmental conditions in which they are to be sited. Blanket approvals and stock designs issued by manufactures, do not respond to the specific issues encountered at many sites because the units are constructed, without knowing the end location. This is one of the many issued that is addressed by the Alberta Part 10, in a way that properly acknowledges the particularities of installing and operating relocatable structures in a cold, northern climate.

Blast, Toxicity, Fire Exposure

There is a lack of communication and transparency between these high hazard industries and the risks / that they pose to the immediate and regional surrounding areas. The Sunrise Natural Gas Explosion in Toronto 2008, is a recent more local illustration of the devastation that can be caused by an accident on an industrial site.[59] Use of Blast Resistant Modules (BRMs) another form of Relocatable Building in the context of Heavy Industry and High Risk Sites. Blast information is not publically disclosed nor is it communicated with the local municipality or the local building officials. Local municipalities have no jurisdiction on issues of Explosion or Blast Risk. There is a need for building codes to acknowledge potential risks these buildings could be exposed to and outline a path for review, assessment and compliance if such risk factors are present. Presently, it is mute on these issues. As there are inherent exposures to potential dangers given the nature of the industries typically making use of RBs. There is a need to recognize the potential risks of these types of industries in developing a siting arrangement for temporary and portable structures of standard construction.

Specialized Relocatable Buildings – Blast Resistant Modules (BRMs)

On manufacturing sites in the petrochemical and other heavy industry throughout North America, there is a shift towards implementing and using Blast Resistant Modules (BRMs), rather than standard stick-framed RBs, in areas that are considered high risk to outside hazards[60]. However, these are voluntary measures, which are implemented in an ad-hoc manner, without consistent review and oversight across the industry. This trend is

59 http://www.thestar.com/news/gta/2014/08/07/class_action_lawsuit_against_sunrise_propane_approved.html
60 CCPS - Guidelines for Evaluating Process Plant Buildings for External Explosions, Fires and Toxic Releases. Pg 48.

based on the American Petroleum Institute's (API) published Recommended Practice Guidelines[61], which advises companies in this industry through development of best practice standards. While these are recommended best practices, they are voluntarily adopted on site, and much of the time these apply to only new construction or new facilities, and the grandfathering of existing precarious facilities continue to occur at the expense of the local workforce. Implementation of the API RP standards is still left up to the discretion of the individual companies and the company's management as there is no specific enforcement agency. Refineries and large industrial facilities which are major sources of employment to their home communities are often granted reduced compliance requirements when in comes to installations such as relocatable buildings. RB complexes are viewed as temporary, but might remain in place and in use for upwards of ten years depending on the site-specific needs. Rather than investing in proper infrastructure for their human resources these temporary structures are used in applications which would be much better, safer and more efficiently served by the construction of a conventional building which properly conforms to the requirements of the provincial building code and the local municipal zoning and site control requirements. At the time of writing this, the Province of Ontario was in the midst of updating and releasing a re-written version of the Ontario Fire Code 2015. Such changes were not available to the Author for consideration in the completion of this thesis work.

[61] CCPS - Guidelines for Evaluating Process Plant Buildings for External Explosions, Fires and Toxic Releases. Pg. 27.

Figure 16 – Selection of Company Logos For Modular Building Manufacturers

CHAPTER 2

THE CURRENT STATE OF RELOCATABLE BUILDINGS:

2.1 The Manufacturing Industry

2.2 Case Study of Existing Relocatable Industrial Accommodations

What are the Major Issues?

2.3 Functionality
Quality of Space

2.4 Durability
Quality of Materials

2.5 Safety
Inadequate Fire and Life Safety Precautions

2.6 Comfort
Inadequate Thermal Performance & Space Conditioning

2.7 Efficiency
Excessive Energy Demands

2.8 Require Modifications
Building Assemblies

2.1 THE MANUFACTURING INDUSTRY

Relocatable Buildings are constructed by a number of different modular construction firms, located throughout North America and globally, which pride themselves on providing full turnkey operations and speedy – efficient results.[62] While the promise of a one-stop-shop solution is emphasized by marketing literature, few of these companies truly outline all aspects of the construction costs, permitting requirements, site preparation or local design implications that are essential parts of the installation of these modular units for various client needs. As a result, many projects implementing RBs require additional local architectural and engineering consultants to participate in the process to facilitate permitting processes, zoning amendments and other requirements such as site plan approval processes for the building installation. These factors are frequently glossed over by the manufacturer when 'selling' this approach to the consumer.

Relocatable Buildings are being commissioned and bought by purchasing departments from a wide range of sectors looking for expedient and economical shelters for use over 'limited' periods. The projected length of time that these structures are to be occupied is often grossly underestimated as is the overall long term costs of erecting and deconstructing substandard shelters on a routine basis rather than investing in a permanent structure that is actually designed to be durable and meet the needs of the occupant user group.

The Modular Building Institute, an industry lobby group and trade association for modular construction companies in North America, promotes the adoption of RB solutions as well as a wide range of modular construction applications Buildings. While the organization shows potential voluntary best practices, it does not regulate or enforce any specific level of quality of the product. This association provides a centralized repository of knowledge and industry expertise. Included among the Modular Building Institute reference documents is a comparison chart of different regional jurisdictions and the required codes and standards that need to be met for the installation of modular buildings in each region. This tool further highlights the discrepancies and inconsistencies between regulations, expectations, and levels of quality from one state to another and from one country to another.

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[62] Modular Building Institute. www.modular.org. Accessed April 2015.

2.2 CASE STUDY OF EXISTING RELOCATABLE BUILDING COMPLEX

To further illustrate some of the many issues facing occupants of typical Relocatable Buildings the following is an example of a typical multi-unit relocatable building that is commonly erected on industrial, commercial and institution sites around Ontario. This example would be considered the "Premium Model" according to the manufacturer[63], relative to the models available for lease on short-term notice. While this particular case is exemplary of typical construction materials and methodologies used in relocatable buildings, it is not "Premium" by other building industry standards in terms of finishes, performance or quality of space. There are significant problems with the level of thermal comfort, air-tightness, indoor air quality, access to natural daylighting, barrier free accessibility and provision of fire resistance ratings of construction assemblies. Issues of durability and long-term costs associated with maintenance and operation are also a significant issue. This typical case would be considered 'middle-of-the-road' in terms of available quality of construction for mainstream industrial relocatable accommodations. In older models or used units relocated from other jurisdictions some cases, insulation is essentially non-existent, wall assemblies are paper thin, and air conditioning is optional, among other problems.

What are the Major Issues?

Functionality:

Quality of Spaces:

- Low Ceilings, Dark, Drab colour, Labyrinth of make shift furniture and cubicles, no clear hierarchy of spaces, Poor Layout, Poor Circulation Patterns, Inadequate Signage.

Durability:

Ability to withstand level of use and appropriateness of material specifications:

Quality of Materials:

- Significant material quality and durability issues: Underside of Flooring is not moisture resistant, and has experienced problems with raccoons, possums and other rodents chewing through and inhabiting the floor assembly.
- Unhealthy interior finish materials including Vinyl Composite Tile and Vinyl Faced Gypsum Wall Board used throughout

Safety:

Fire and Life Safety

- Structural Stability of Building
    - Unstable foundation – stacked concrete block with inadequate tie downs – rusted through – meant for short duration, been in place for 10 years
- Emergency and Egress Lighting – often missing, broken or in disrepair.

[63] Modspace www.modspace.ca

- Appropriate and Adequate Fire Resistance Rating of Fire Separations

Exposure to Indoor Air Quality Issues

- Off-gassing of Toxins
- Mould & Excessive Moisture
    - Issues with moisture and mold growth In building materials due to improper moisture and vapour barrier installation

Exposure to Outdoor Air Quality Issues

- Lack of Automatic HVAC Mechanical Shut-down
- HVAC units are located within close proximity to operable windows with issues of noise, emissions

Comfort:

Thermal Comfort

- Insulation Levels not adequate
- No continuous layer of insulation on any construction assemblies to reduce or eliminate thermal bridging
- Problems with air tightness

Access to Natural Daylight and Views, and Natural Ventilation

- While private offices have windows, the central workspace does not have access to exterior windows or any type of natural day light

Barrier Free Access and Inclusivity

- No Barrier Free Access – No Ramps or Lifts
- Exterior Doors do not provide adequate space adjacent to door handles to facilitate accessibility even if ramps were provided.
- Washrooms are not Barrier-Free

Energy Efficiency:

Air Tightness and Quality of Construction

Significant Heat Loss due to low insulative Values of Building Assemblies

Poor Quality, Single Pane Window Assemblies

Noisy and poor HVAC Efficiency

Older inefficient Ballasts, and oversized fixtures relative to products available today make for poorly performing artificial lighting efficiency

Water Efficiency

Many of these buildings are not even connected to running potable water or sewer systems, but where these amenities are provided; they seldom meet current levels of water conservation technology.

No Barrier-Free Ramps or Accessibility Provisions for Occupants.

Exterior Doors do not provide adequate space adjacent to handle side of door to facilitate accessibility. Washrooms provided do not have BF fixtures or access.

Central Workspace has no access to exterior windows or natural daylight either directly or indirectly through sidelights in private offices.

HVAC units are located in close proximity to windows contributing to issues of noise, exposure to emissions from fuel exhaust.

Insulative value of walls, roof and floor is not adequate to provide necessary human comfort or energy efficiency of the building envelope

No continuous layer of insulation to prevent thermal bridging.

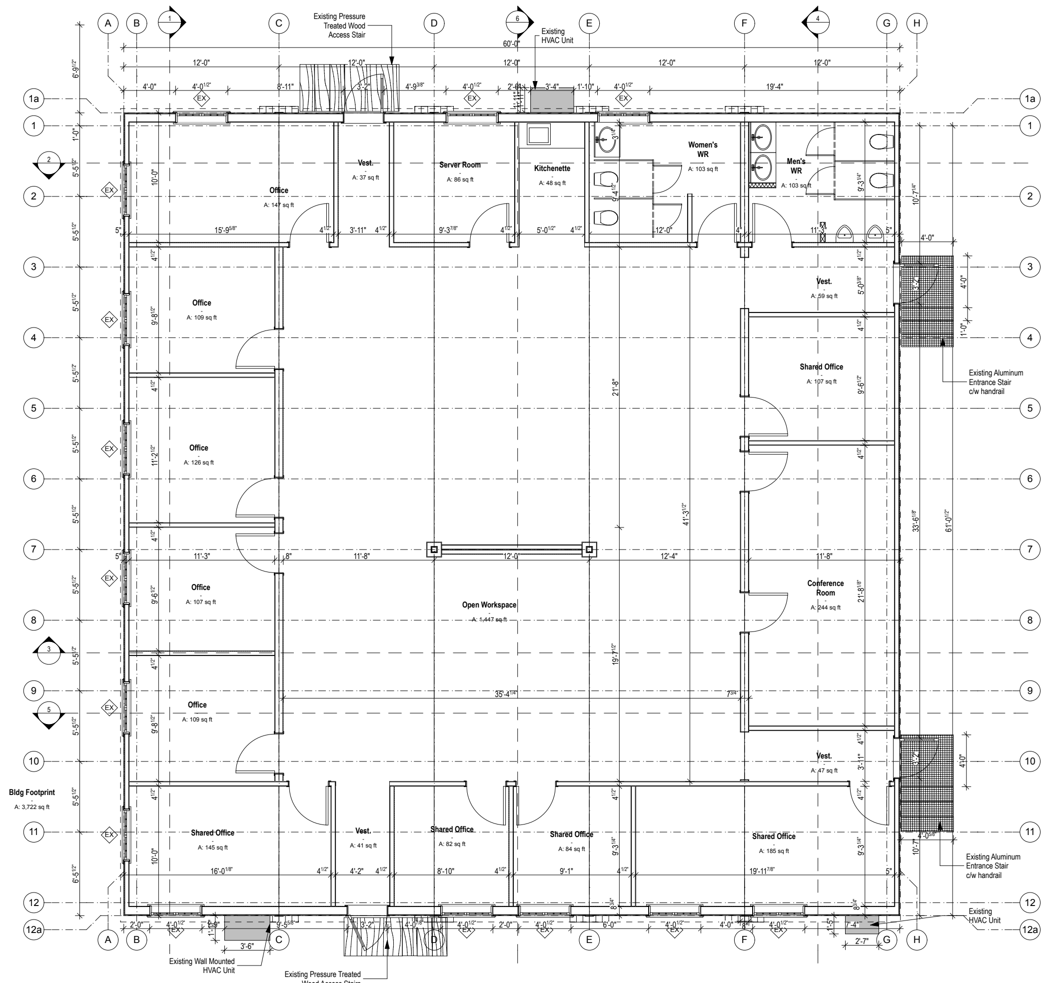

Figure 17 – Case Study of Typical Five Module, Multi-Unit Relocatable Building

No continuous insulation to provide thermal breaks in wall, roof or floor construction assemblies.

No seismic stability

Questionable Base – potential for differential settlement over short period of time.

Inadequate specification for exterior skirting materials – contributing to rotten / deterioration of wood in direct contact with the ground leading to wicking of water and further deterioration of other building elements.

Deterioration leading to access by rodents and other pests into the building area.

Vapour Barrier, where used is improperly installed on the wrong side of the existing insulation.

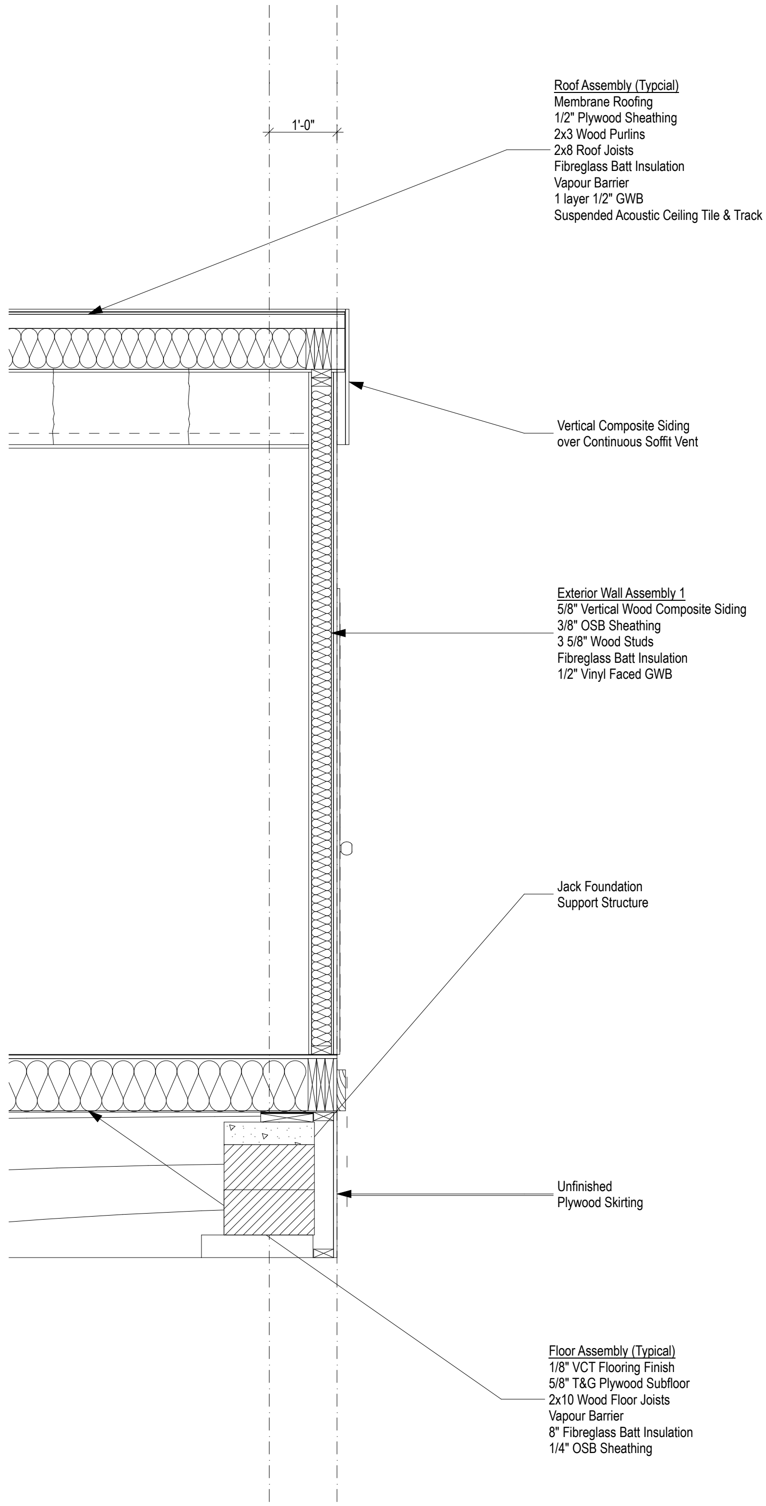

Figure 18 – Wall Section #1 - Case Study Relocatable Building

No continuous insulation to provide thermal breaks in wall, roof or floor construction assemblies.

No seismic stability

Questionable Base – potential for differential settlement over short period of time.

Inadequate specification for exterior skirting materials – contributing to rotten / deterioration of wood in direct contact with the ground leading to wicking of water and further deterioration of other building elements.

Deterioration leading to access by rodents and other pests into the building area.

Vapour Barrier, where used is improperly installed on the wrong side of the existing insulation.

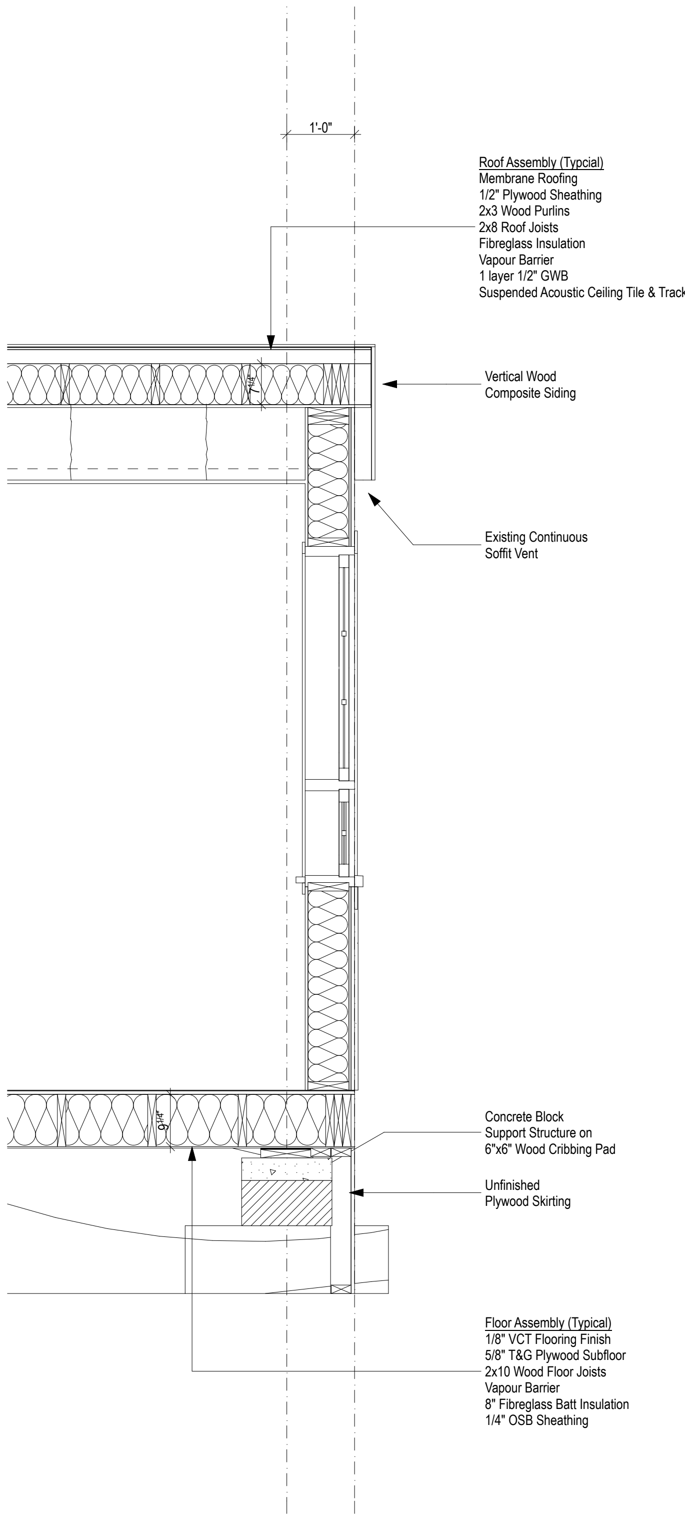

Figure 19: Wall Section #2 - Case Study Relocatable Building

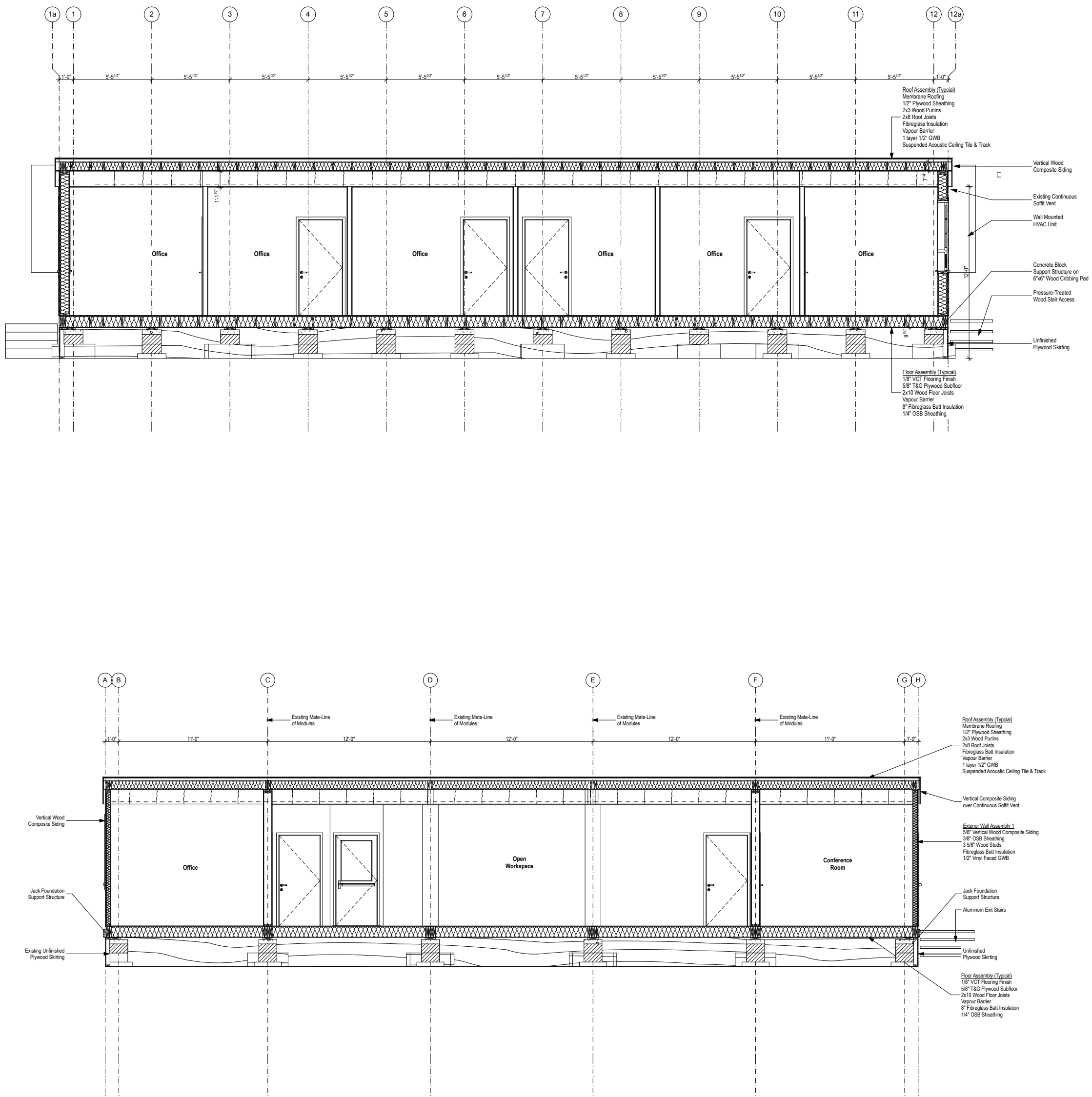

Figure 20 & 21: Building Sections - Case Study Relocatable Building

2.3 FUNCTIONALITY

QUALITY OF SPACE

The inadequate quality of construction leads to many issues outlined above including problems of occupant comfort, energy use, operational costs and life safety issues to reiterate a few. In addition to these problems, the overall capital costs that an organization must incur to upgrade and replace these poor quality structures if they are to maintain any level of decency for the user, is a huge additional investment after the fact.

Low Ceiling Heights

Few Windows – Limited access to:

Views to surrounding environment,
Natural Daylighting,
Natural Ventilation

Disorienting

No Clear Hierarchy of Spaces

Bland, Drab, Mundane, Ugly - Uninspiring

2.4 DURABILITY

QUALITY OF MATERIALS

This means while the initial investment in the first structure may have been inexpensive; those costs are repeated over and over (possibly every 5 years) based on a typical life span as seen by standard use of these structures). Those costs continue to climb, as not only are the building materials that need to be replaced (with lots of impacts to landfill use, and environmental issues of wasted materials) but transportation, and installation costs are repeated every five years as well.

As is seen in this case study, issues of durability as they relate to the building envelope are a critical part of the problems associated with relocatable buildings. Failure related to the ingress of air and moisture occurs quickly wherever weak or vulnerable joints are located. Frequently this is found at the mate-lines where modules are tied together on site. This connection point can become the source of continuous aggravation and problems if not installed properly from the beginning. The mate-line issue is a factor in a three of the major building assemblies: the exterior load bearing wall assemblies, the above-grade floor assemblies, and the roof assemblies.

Typical Roof Assembly:	Single Ply Roof Membrane
U-Factor = 0.284	1/2" Plywood Exterior Sheathing
FRR = 0	2"x3" Wood Purlins
	2"x8" Wood Roof Joists
	Fibreglass Batt Insulation between the Joists
	6mil Poly Vapour Barrier
	½" Gypsum Board Ceiling Membrane
	Suspended Acoustic Tile and Track
Typical Exterior Wall Assembly:	5/8" Painted Grooved, Wood Composite Siding Panels
U-Factor = 0.397	3/8" OSB Sheathing
FRR = 0	2"x4" Wood Stud Wall Construction
	Fibreglass Batt Insulation between the studs
	6mil Poly Vapour Barrier (Sometimes Installed)
	½" Vinyl Faced Gypsum Wall Board with Battened Joints
Typical Floor Assembly:	12"x12" Vinyl Composite Tile Flooring w/ adhesive
U-Factor = 0.227	5/8" T&G Plywood Subfloor
FRR = 0	2"x10" Wood Floor Joists
	Fibreglass Batt Insulation between the Joists
	6mil Poly Vapour Barrier (On the Wrong Side of the Insulation)
	¼" Unfinished Oriented Strand Board – Bottom Board

2.5 SAFETY

INADEQUATE FIRE & LIFE SAFETY PRECAUTIONS

The Fire Resistance Rating (FRR) of the floor, wall and roof assemblies of a typical Relocatable Building, as is demonstrated by this example in Section 2.4 is very poor. The each of the building envelope assemblies provide a fire separation Fire Resistance Rating of zero. The selection of construction materials has not, in the past, been based upon their quality and performance, but rather on lightness (for transportation requirements) and economic feasibility (cheapness). Emphasis on the specific fire resistance ratings, and tested fire separations has been low or non-existent. Where incorporated, often the fire separation will be inadequately constructed, will not meet the testing requirements of the claimed fire resistance rating, or not take into design consideration how to address the realistic potential sources of the fire hazard.

In an educational setting, as has been permitted by the current Ontario Building Code, up to eleven portable classrooms are permitted to be installed on the grounds of a permanent school without providing full and proper connection of those buildings to a integrated fire alarm system with an annunciator panel.[64] It is only when a twelfth classroom is installed, that that threshold is met, and an alarm system is required. Recognizing that the average portable classroom houses approximately thirty students along with a teacher, and an educational assistant – the population of individuals who could be housed in a complex of portable classrooms could realistically approach 352 people before that threshold is met. As such, those same complexes operate without proper fire resistance ratings of the building envelope, proper hydrant coverage; integrate fire alarm systems and the other mandatory fire safety features of a permanent school. Fire Hazard investigations in the U.S. have shown that there is not a huge difference in the proportion of fires occurring in regular school buildings versus portable classrooms. However, when fire does occur within a portable classroom, there is a higher risk of fatality.[65] This increased risk is attributed in part, to the size of these buildings and the speed at which the fire can 'flash over'.[66]

Where relocatable buildings are used in an industrial setting, occupants are at much greater risk for exposure to fire by virtue of potential risks within their surrounding work environment as oppose to any inherent fire hazards within the structure itself. Whereas the building code is intended to protect occupants from building collapse by rating building components from inside to afford occupants a chance to escape. Occupants of buildings in industrial settings may be looking to the buildings on site as a potential safe haven, but based on their current quality and type of construction, relocatable buildings do not provide this function. In fact, the 'trailers' as they are commonly referred to, often become a greater hazard to the occupants, than if they were not in a building at all.

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[64] Ontario Building Code 2012. Part 3.9 Appendix A. Pg. 56.
[65] John R. Hall. *Manufactured Homes Fire*s – NFPA September 2013.
[66] John R. Hall. *Manufactured Homes Fire*s – NFPA September 2013

While the building code approaches the issues of fire safety from the perspective of maintaining structural integrity of the building long enough to provide an opportunity for escape from within, this does not address the need to protect structures from hazards that lie without the building. Fire Resistance Rating requirements for all of these structures should be required to address both potential hazards inside as well as outside of the building envelope, which means that the construction assemblies shall be designed accordingly.

2.6 COMFORT

INADEQUATE THERMAL INSULATION

One key factor in the poor quality of construction of Relocatable Buildings and design requirements is the low level of insulation provided in their typical construction assemblies. Many of these buildings are leased to the end users, sometimes for protracted periods, and limited maintenance and/or upgrades are completed on the units. The company or organization leasing the unit is not inclined to invest additional money in a structure that they do not own. The modular building supplier is happy to continue collecting rent on the unit despite the continuing deterioration as the base unit values is very low, and they are geared to gather as much profit as possible from them with minimal expenditures. The individuals negotiating these contracts to get the lowest costs for the renter and the highest profits for the lessor are rarely if ever the end user or occupant of these same structures, and so have minimal vested interest in the human comfort of the occupants.

Due to the extremely low levels of insulation and poor quality of air/vapour barrier installation, on typical existing modules, these units provide inadequate thermal temperature control. They are typically scorching hot and humid through the summer months and cold and drafty throughout the winter months, mimicking the climatic conditions routinely experience in the Province of Ontario due to significant climatic swings from one season to the next.

Standard Relocatable Construction[67] (As Described in Section 2.4)
(Climate Zone 6)
Typical Roof Assembly

U-Factor = 0.284 W/m2*°C
RSI (Metric) = 3.52
R-Value (Imperial) = R-20

Typical RC Wall Assembly (Type 1 – 2x4)

U-Factor = 0.397 W/m2*°C
RSI (Metric) = 2.52
R-Value (Imperial) = R-14

Typical RC Wall Assembly (Type 2– 2x6)

U-Factor = 0.341 W/m2*°C
RSI (Metric) = 2.93
R-Value (Imperial) = R-16

Typical Floor Assembly

U-Factor = 0.227 W/m2*°C
RSI (Metric)= 4.41
R-Value (Imperial)= R-25

[67] Modspace Premium Relocatable Modular Office Complex. www.modspace.ca Accessed February 2015.

In order to achieve improved energy efficiency through redesign of the building envelope, increase resistance to thermal heat transfer is essential. While the previous tables show the existing U-factors and R-Values for the typical Relocatable Building Envelope, the below chart shows the increases in insulation necessary to start to bring this building into compliance with the new Supplemental Building Standard – SB-10 in the Ontario Building Code. At the present time, compliance with this section is not required for relocatable industrial accommodations, or portable classrooms, but that should be reconsidered, given the inherent problems with these building types and the marked improvements that compliance would bring to the occupants.

Proposed Relocatable Standards to meet SB-10[68] (U-factors listed are maximum values)
(Climate Zone 6)

Proposed Roof Assembly

U-Factor = 0.119 W/m2*°C

RSI (Metric) = 8.4

R-Value (Imperial) = R-48

Proposed Wall Assembly (All Exterior Walls to be the same)

U-Factor = 0.247 W/m2*°C

RSI (Metric) = 4.05

R-Value (Imperial) = R-22

Proposed Floor Assembly

U-Factor = 0.147 W/m2*°C

RSI (Metric) = 6.8

R-Value (Imperial) = R-39

[68] Ontario Building Code Compendium 2013. Vol. 2 SB-10. Pg. 45.

2.7 EFFICIENCY

EXCESSIVE ENERGY DEMANDS

The minimal insulative values in the floor, wall and roof assemblies of these units is the issue of excessive energy costs required to operate these 'shelters' in a way to maintain an acceptable level of human comfort. These become costly units to operate as prices for natural gas, electricity and other forms of energy continue to rise. Ultimately, these units still do not provide an adequate level of human comfort for the occupants. This same factor also tends to lead to individual occupants taking comfort and temperature matters into their own hands by bringing in to their work environment or classroom setting within the modular unit, electric space heater which may or may not pose other fire and safety hazards within the space.

To establish the difference in energy use on the basis of the building envelope alone, we use the Typical Dimensions of a Portable Classroom (24'x36'x12'), the Average Change in Temperature for Southern Ontario from the Interior desire temperature to the average winter exterior temperature and the Heat Transfer Values established in Section 2.6. We are able to compare Building Envelope Insulative Values between a standard Relocatable Building on the market, and one that would be designed to meet the criteria of SB-10 and determine a Heat Transfer Calculation to understand the significance of these changes.

Using the formula $Q_t = A \times U \times \Delta T$

With the Standard Model the Total Calculated Heat Loss **Q = 2278.7**

With the SB-10 Compliant Model the Total Calculated Heat Loss **Q = 1360.2**

Reduction of Q = 918.5

Therefore, the building is able to achieve a 40% reduction in Heat Loss (without accounting for the improvement in continuous insulation, or reduction of thermal bridging)

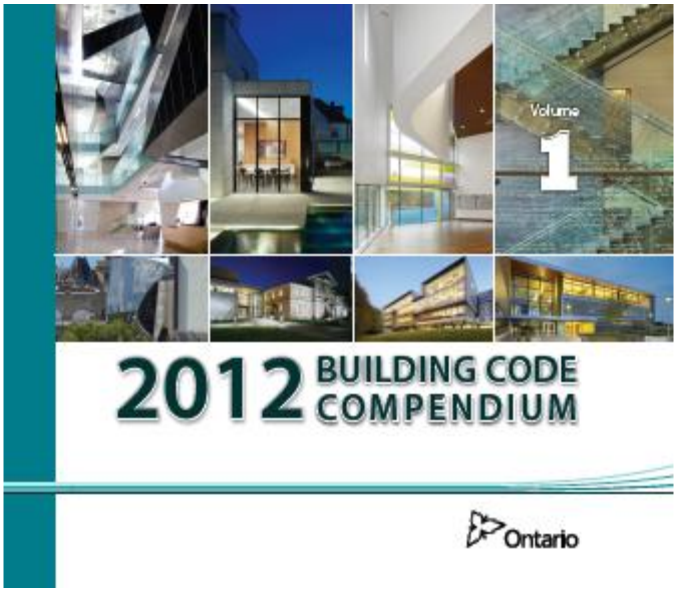
In addition to improvement of the building envelope performance, key areas of energy reduction to be incorporated in the design and specification of portable classrooms and relocatable industrial accommodations should include:

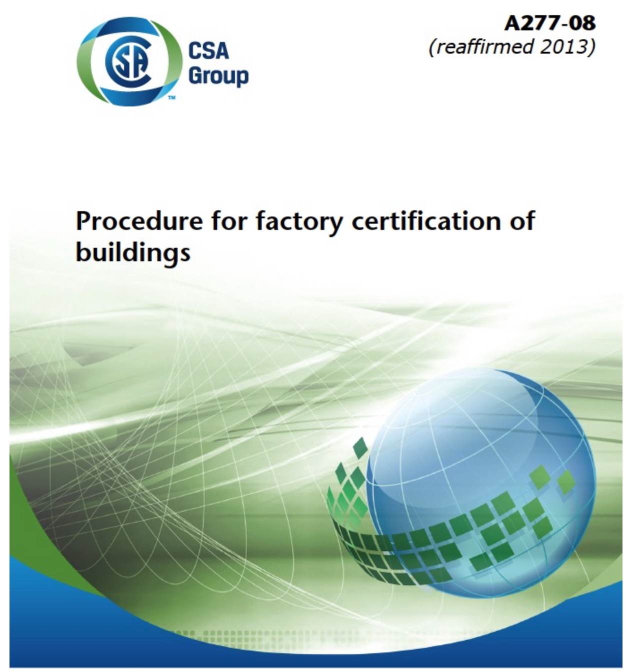
- Energy Star Rated Appliances & Equipment.
- Specification of Energy efficient Lighting Fixtures and Lamps.
- Specification of Energy Efficient HVAC Units including HRVs and ERVs.
- Specification of Water Efficient Plumbing fixtures including low-flow faucets and dual flush toilets.

2.8 REQUIRED MODIFICATIONS: BUILDING ASSEMBLIES

There needs to be more than voluntary measures and good will to make a true change in the nature and culture of this industry, and the resultant building products emerging from current manufacturers. In jurisdictions where required codes and standards have been implemented there is a notable improvement in the quality of products being delivered to the site. Regions that lag behind the groundswell of regulatory change, risk inheriting the leftover second hand models of units that wouldn't be accepted in other more scrutinizing locales. This proposal would remove construction trailers and other relocatable buildings from the list of buildings exempt from the ASHRAE 90.1 standard. See OBC SB-10 Section 1.2 (1.2.1.1 (c)

Proposed Roof Assembly:	Single Ply Roof Membrane **(High Reflectivity – White membrane)**
FRR = 45 min	**2 layers Continuous Rigid Poly-isocyanurate Insulation**
	5/8" Exterior Fire Rated Plywood Sheathing
	2"x3" Wood Purlins
	2"x8" Wood Roof Joists
	Mineral Wool Batt Insulation between the Joists
	6mil Poly Vapour Barrier
	2 layers 5/8" Type X Gypsum Board Ceiling Membrane
	Suspended Acoustic Tile and Track **(HRC Tiles)**
Proposed Ext. Wall Assembly:	5/8" Painted Grooved, Wood Composite Siding Panels
FRR = 1 hr	**Continuous Rigid Insulation**
	5/8" Dens Glas Gold Exterior Type X Sheathing
	2"x4" Wood Stud Wall Construction
	Mineral Wool Batt Insulation between the studs
	6mil Poly Vapour Barrier **continuously sealed**
	5/8" Gypsum Wall Board Taped, Mudded & Sealed
	½" Vinyl Faced Gypsum Wall Board with Battened Joints
	(staggered to sheathing joints below)
Proposed Floor Assembly:	12"x12" Vinyl Composite Tile Flooring w/ adhesive (Low VOC)
FRR = 30 min	5/8" T&G Plywood Subfloor
	2"x10" Wood Floor Joists
	Mineral Wool Batt Insulation between the Joists
	Steel Furring Chanel
	5/8" Exterior Fire Rated Dens Glas Sheathing
	Peel and Stick Vapour Permeable Air Barrier
	Prefinished Steel Siding Bottom Board w/ continuous flashing at all joints





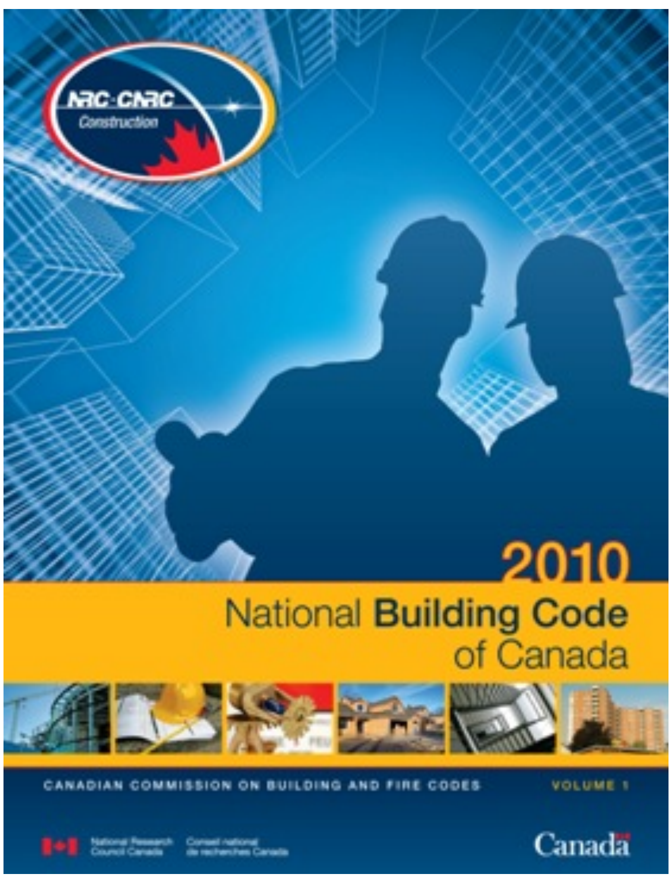


Figure 22, 23 & 24 – Current Standards: Cover Images

CHAPTER 3

REVIEW OF CURRENT CANADIAN REGULATIONS

Current Regulatory Bodies

Other Authorities Having Jurisdiction

3.1 PRECEDENTS TO INFORM THE CONTENT AND STRUCTURE OF PART TEN

Alberta Building Code Part 10, Division B – Relocatable Industrial Accommodations

3.2 CSA A-277 PROCEDURE FOR FACTORY CERTIFICATION OF BUILDINGS

3.3 CSA Z-240 MANUFACTURED HOMES STANDARD

3.4 ONTARIO BUILDING CODE (OBC) COMPENDIUM 2012

3.5 NATIONAL BUILDING CODE OF CANADA (NBCC) 2010

CHAPTER 3
REVIEW OF CURRENT CANADIAN REGULATIONS

Current Regulatory Bodies

Following are the current required regulations governing construction of these units within Canada and specifically the Province of Ontario. Through the review and analysis of existing applicable building codes including the Ontario Building Code (OBC) 2012[69], the National Building Code of Canada (NBCC) 2010[70], as well as the CSA Standards related to manufactured homes (CSA-Z240)[71] and the Process for Factory Certification of Buildings (CSA A277)[72] it will identify areas of potential improvement in the current standards. In addition to regulatory requirements, the research will look to existing voluntary standards and design guidelines, which have been adopted in some U.S. jurisdictions to fill the current void related to this type of construction. Among such voluntary standards in the educational sector are the Collaborative for High Performance Schools (CHPS) Design Guideline For Portable Classrooms[73], and the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Advanced Energy Design Guidelines for K-12 Educational Facilities[74], and in the industrial sector the American Petroleum Institute (API) Recommended Practice 753 for Portable Buildings[75].

Other Authorities Having Jurisdiction

Outside of the direct regulations of the construction itself are a number of other standards, which have the potential to impact the outcome of these manufactured buildings. Within the province of Ontario other Authorities Having Jurisdiction (AHJ) include: the: Ministry of Labour (MOL)[76] ; Occupational Health and Safety Act; the Ministry of Environment and Climate Change (MOECC)[77]; the Ministry of Health and Long Term Care (MOHLTC)[78]; the Ministry of Infrastructure (MOI)[79]; the Ministry of Education as well as regional

69 www.mah.gov.on.ca/Page7393.aspx Ontario Ministry of Municipal Affairs & Housing – Ontario Building Code. Accessed April 2015.

70 www.nrc-cnrc.gc.ca/eng/solutions/advisory/**code**s_centre_index.html National Research Council - National Building Code of Canada 2010. Accessed April 2015.

71 www.csagroup.org/en/industries/construction-buildings-infrastructure/factory-manufactured-buildings Canadian Standards Association – overview of factory manufactured buildings. Accessed April 2015.

72 http://shop.csa.ca/en/canada/factory-built-buildings-including-mobile-homes/a277-08-r2013/invt/27011982008 Canadian Standards Association - Procedure for factory certification of buildings. Accessed April 2015.

73 www.chps.net Collaborative for High Performance Schools. Accessed April 2015.

74 www.ashrae.org ASHRAE Advanced Energy Design Guidelines. Accessed April 2015.

75 www.api.com American Petroleum Institute Recommended Practice 753. Accessed April 2015.

76 www.**labour**.gov.on.ca/english/ Ontario Ministry of Labour. Accessed April 2015.

77 https://www.ontario.ca/ministry-environment Ontario Ministry of the Environment and Climate Change. Accessed April 2015.

78 www.**health**.gov.on.ca/en/ Ontario Ministry of Health and Long Term Care. Accessed April 2015.

79 www.moi.gov.on.ca/en/ Ontario Ministry of Infrastructure. Accessed April 2015.

organizations such as the Local Health Units and Local Health Integration Networks (LHINs). This research does not address all of these other potential regulatory body's influences on construction requirements of Relocatable Buildings but recognizes their potential importance in the development of best practice standards for these and other types of buildings.

Although Ontario is regarded as having amongst the best regulations and safety precautions in the world regarding the design of buildings and our building code, however there seems to be a gaping hole in the requirements when looking a the specific nature of relocatable buildings, construction trailers and portable classrooms. There are many issues and problems with Relocatable Buildings at the local municipal level due to unclear construction regulations and standards pertaining to these types of buildings.

3.1 PRECEDENTS TO INFORM THE CONTENT AND STRUCTURE OF "PART TEN"

Alberta Building Code Part 10, Division B – Relocatable Industrial Accommodations

This addition to the Alberta Building Code (ABC) was adopted by provincial regulation, September 2, 2007. Its creation was in direct response to the growing proliferation of relocatable industrial accommodations being erected at jobsites and remote communities and construction camps across the province of Alberta, the provincial government enacted specific legislation to amend the Alberta building code in order to more implement requirements and expectations around the installation of these types of relocatable units. While not without its flaws, it stands presently as the best Canadian example of improved regulatory clarity around the topic of Relocatable Buildings, especially in the context of industrial development.

3.2 CSA A-277 PROCEDURE FOR FACTORY CERTIFICATION OF BUILDINGS

This standard outlines the requirements manufacturers of prefabricated and relocatable buildings are required to follow to achieve factory certification of their buildings in order to be acceptable for installation in the Canadian Context. The standard sets for the inspection processes and approval procedure applicable to manufactured buildings, modular buildings and components for panelized buildings, that complements required on-site inspection and construction.[80] This document does not identify the specifics of the building components or the standards to which they are to be built, but rather outlines the specific quality assurance programs that are required to be in place at such manufacturing facilities.

While it is not the intent of this proposal to directly modify this specific document, its identification as it pertains to the complementary CSA Z240 Manufactured Homes Standards is important and relevant to the issue of improving the overarching quality standard requirements for manufactured buildings.

[80] Procedure for Factory Certification of buildings, CSA A277-08, Pg. 1.

3.3 CSA Z-240 MANUFACTURED HOMES STANDARD

This CSA Z-240 Standard specifically addresses the construction requirements of manufactured homes. Due to the fact that there is not a specific standard to address the manufacturing of similar type of structures used for alternative occupancies, this reference document is used universally, although, its ability to address the many conditions affiliated with other occupancies is in question. The standard does not adequately address the occupant health and safety issues, when used to evaluated buildings of a non-residential occupancy. The diversity of use and range of building typologies being installed and commissioned under the guise of compliance with this standard is concerning as in addition to the lack of specifics related to non-residential uses the standard also lacks specific guidance and requirements for development of installations with a higher density of modules of any occupancy.

Issues with the current edition of CSA Z-240:

- Frequent use of vague terminology with regards to expectation of the product.
- Too much reliance on "acceptable engineering practice" -this phrase is not clearly defined when it comes to certain topics. The standard is intended to address single-family homes of one or two modules, in isolation.
- This standard does not currently address the other primary occupancy types of relocatable buildings which are often "certified" or approved under this standard – but which the standard does not directly address or deal with. Specifically the vast array of industrial accommodations being manufactured including large interconnected complexes – easily approaching the area limit of a building necessitating the involvement of an architect (6000 sf.). These often house a range of functions including office space, larger cafeteria and lunchrooms, locker change spaces for larger numbers of employees, and even dormitory style accommodations for workers in truly remote areas. Employees are required to work and/or reside in these structures on a continual basis.
- The standard does not address the relationship of one cluster of modules to another, or the potential for fire exposure from outside of the structure.

3.4 ONTARIO BUILDING CODE (OBC) COMPENDIUM 2012

> "Since 1976, the Ontario Building Code has set the minimum standard for the design and construction of all new buildings and for additions, alterations and change of use of existing buildings in the Province of Ontario. The Code is a mandatory document used by architects, engineers, designers, builders, suppliers and manufacturers with regard to construction projects, which are regulated by the Code. The purpose of the Code is to set minimum standards for construction to minimize the risk to the health and safety of the occupants of a building and to provide for the barrier-free accessibility into a building and the energy efficiency of that building."[81]

With the goal of improving the health and safety of building occupants in the province of Ontario after a rash of urban fires and tragedies related the close proximity of combustible structures to one another and the increasing density of Ontario towns and cities. The provincial building code was developed and adopted for use. This code has undergone many alterations and modifications to incorporate the learnings, and developments within the design and construction industry. The Ontario Building Code 2012 Compendium as issued in 2014 addresses some limited aspects of the category of buildings that is being reviewed here, but it is very limited in is specific measures that address this range of building typologies, relying instead on outside CSA standards to provide a catch all evaluation of theses structures.

How should this change?

Part 3:
Within the existing Part 3, there is a small, dedicated section to Portable Classrooms. The problem with this section is that the result of its requirements does not provide the same level quality of space or protection of life safety that is expected or afforded to occupants of permanent educational buildings under the other parts of this same code.

Part 9:
Within the existing Part 9, (Section 9.10.21) there is a dedicated section for the installation of short term Construction Camps. This section could remain in place with the modifications that have been listed in Appendix B, or the requirements in their entirety could be absorbed into the new OBC Part Ten.

Addition of Part 10:
Creation of new Part 10 to specifically address the design and construction of Relocatable ICI Buildings
The existing OBC Part 10 should be changed to "Part 13 Change of Use".

[81] Ontario Building Officials Association (OBOA) www.oboa.on.ca

3.5 NATIONAL BUILDING CODE OF CANADA (NBCC) 2010

First implemented in 1941 with the goal of improving the health and safety of building occupants on a national level across all jurisdictions of Canada. With revisions taking place approximately every five years since 1960. The National Building Code 2010 also refers to relocatable structures in limited ways focusing on the two stereotypical typologies of the Park Model Trailer, and the Portable Classroom. It does not address in specific detail or precision the issues of theses types of structure being used in much larger agglomerations for a wide range of uses from Lunchrooms for 400 to Office Complexes, Locker and Change Facilities, to entire villages.

How should this change?

The changes proposed to the Ontario Building Code should be adopted in full to the National Building Code of Canada with the continued goal of National Harmonization of Codes and Regulations related to Construction of buildings. Where there are existing sections that are comparable to the OBC, review and modification of the wording of both should be undertaken to ensure that there are common rules throughout the country that prioritize the health, safety and well being of the occupants of relocatable buildings.
Where there is no existing section in the NBCC that is being proposed in the attached modifications outlined in Appendix B, the new wording should be adopted in full.

CHAPTER 4

REVIEW OF CURRENT AMERICAN VOLUNTARY INDUSTRY STANDARDS

4.1 COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS (CHPS):
Best Practices Manual For High Performance Relocatable Classrooms

4.2 AMERICAN SOCIETY FOR HEATING REFRIGERATION AND AIR CONDITIONING ENGINEERS (A.S.H.R.A.E.):
Advanced Energy Design Guidelines – K-12 Educational Buildings

4.3 AMERICAN PETROLEUM INSTITUTE (A.P.I.):
API RP 753 – PORTABLE BUILDINGS STANDARD

4.4 COMPANY SPECIFIC CORPORATE DESIGN STANDARDS

CHPS COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS PREFAB

ASHRAE

LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN LEED

energy API AMERICAN PETROLEUM INSTITUTE

INTERNATIONAL LIVING FUTURE INSTITUTE

CHAPTER 4

REVIEW OF CURRENT AMERICAN VOLUNTARY INDUSTRY STANDARDS

Outside of the current legislation and regulatory requirements for relocatable buildings, exist a series of voluntary standards developed by different interest groups to provide a level of consistency and quality control for a range of underlying goals. These voluntary standards include CHPS, ASHRAE Design Guidelines, API Recommended Practices and certain Company specific Design Guidelines and Engineering Standards. The adoption of these voluntary standards, offer many potential benefits, for groups that choose to follow these innovative developments in design criteria. The problem with the following voluntary standards and rating systems is that although they provide good technical guidance and the potential for an improved final product, the onus to ensure that one or more of these standards or systems is implemented and efficiently executed remains on the client, prospective owner or end user-group of the relocatable building. By shifting these standards from voluntary 'opt-in' strategies to mandatory, regulated and legislated requirements, the onus is redirected squarely onto the manufacturer's responsibility. By extension, such regulations level the playing field for the industry as a whole as all manufacturers of equivalent products are expected and forced to comply with equivalent performance criteria.

Unfortunately, voluntary requirements fall short in terms of wide adoption and implementation. Their benefits are usually limited to select few companies or individuals who choose to proceed for morale imperative, prestige, and leadership or public perception. Voluntary requirements or best practice guidelines are seldom if ever, universally, adopted by corporations or organizations. There are always some organizations, which will see the voluntary measures as unnecessary, excessive or a waste of money and not their priority. Universal adoption can only be garnered through regulation, development of mandatory minimum compliance standards, and followed through with methods and systems of enforcement.

We need both the voluntary 'best practice guides" as something to strive for and increased regulatory minimums to improve durability, manufacturing standards, implementation strategies, improved siting, fire rating and exiting requirements, while also encouraging some organizations to push the boundaries and go being basic minimum standards.

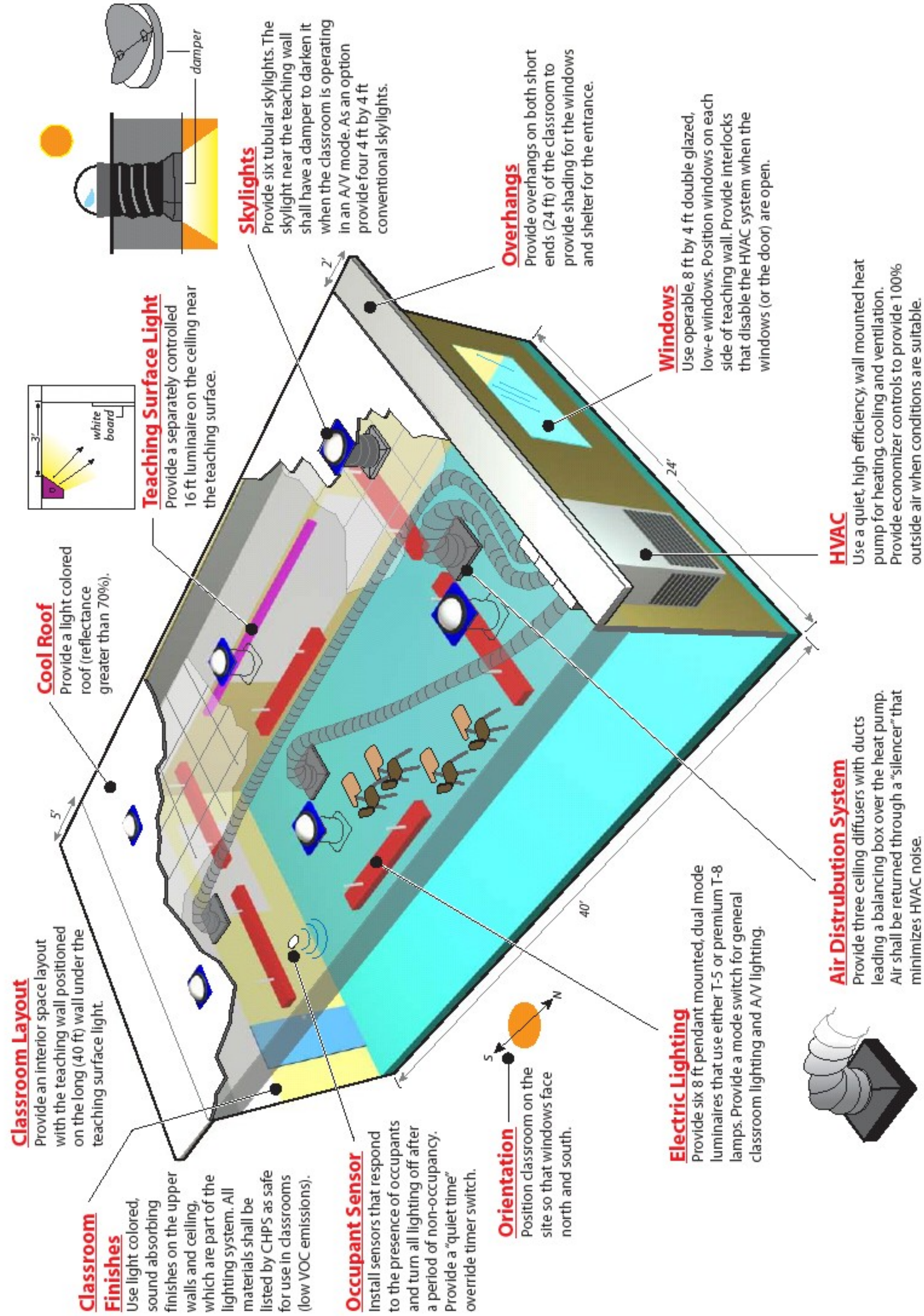


Figure 25: CHPS Relocatable Classroom Standard

4.1 COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS (CHPS): Best Practices Manual For High Performance Relocatable Classrooms

> "A high performance relocatable classroom is a comfortable classroom; the temperature and humidity are within the comfort range for the occupants, daylighting is the primary source of illumination, indirect electric provides pleasant and uniform illumination when daylighting is not available, and noise levels do not interfere with teaching. A high performance relocatable is efficient in its use of materials and is environmentally responsible. Energy efficiency is a cornerstone of high performance relocatables; achieving superior comfort levels while using less energy to do so. High performance relocatables are also easy to maintain and operate and provide safe and secure environments."[82]

This standard was developed by the Collaborative for High Performance Schools (CHPS) along side a series of other building standards geared towards permanent construction, with the underlying intent to improve the construction quality and improve the educational spaces of schools across the United States. While it is not a required standard, these best practice manuals have been adopted by a series of school boards in California and other states to facilitate improvements in the classrooms that their children are required to use. They recognized that the ability to provided good quality permanent buildings, to house classes, is not within the financial capacity of many jurisdictions today. Portable classrooms have filled a necessary gap created by shifting and fluctuating enrollment numbers and transient demographics, as children and their parents relocate from one neighborhood to another for work, family obligations and a host of other reasons.

This rating systems provides an equivalent evaluation tool, strategies and score card to the Leadership in Environment and Energy Design (LEED) Rating system for green buildings, although it is modified to be specifically tailored and customized to the occupancy and building type of high performance relocatable classrooms and high performance permanent classrooms. Within their rating system they have also developed Verified PREFAB specifications to aid in improving speed of delivery and quick turn around times while still providing a consistent, high quality and high performance end product.

While on the periphery of the relocatable prefabricated building industry there are significant examples of innovation and high-quality construction, the majority of the existing and standard new stock of modular, relocatable temporary buildings are riddled with problems. Depending upon the size and location of the relocatable structure a host of different regulations and codes may or may not apply.

CHPS Best Practices Manuals are a series of design guidelines developed by the Collaborative for High Performance Schools to improve the quality of schools throughout the United States.[83] Within the Best Practices Manuals, Volume VI – Relocatable Classrooms specifically deals with the issues and challenges presented by the use of Relocatable buildings for educational uses, and addresses their pervasiveness across American schoolyards.

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[82] CHPS Best Practices Manual: Relocatable Classrooms 2009. Pg.1

[83] www.chps.net Collaboration for High Performance Schools. Accessed April 2015.

> "Relocatables can be delivered and installed in a fraction of the time of conventional construction and provide the flexibility of being able to be moved to another school when the need arises. While relocatable classrooms provide a valuable asset to school districts, traditional relocatables often fall short in delivering quality learning environments and often use more energy than conventional classrooms. A successful high performance relocatable classroom addresses these deficiencies and ensures that these convenient spaces are also healthy and efficient."[84]

CHPS is helping to develop and advance the forefront of design and manufacturing systems and processes for relocatable classroom construction and provide an example of what can be implemented or achieved under ideal circumstances or on projects with large budgets.

List of key items and recommendations from CHPS Relocatable Classroom Best Practice Manual to be incorporated into the new PART TEN:

- Requisition and Ordering Process[85]
- Strategies for Natural Daylighting, Views and Natural Ventilation[86]
- Use of Energy Efficient Systems, Equipment and Fixtures including Lighting, HVAC and Plumbing.[87]
- Improved Building Envelope performance to improve occupant comfort, reduce heating and cooling loads and reduce energy demands.[88]
- Address Building Materials and Finishes[89]
    - Selection of Low impact products, which will not compromise the IAQ or health of children or Adults using the space such as Low or No VOC material specifications.
- Orientation and Siting[90]
- Commissioning Procedures to ensure final installed building is working as designed and intended.[91]

[84] CHPS Best Practices Manual: Relocatable Classrooms. Pg. 1.
[85] CHPS Best Practices Manual: Relocatable Classrooms. Pg. 22.
[86] CHPS Best Practices Manual: Relocatable Classrooms. Pg. 10.
[87] CHPS Best Practices Manual: Relocatable Classrooms. Pg. 12.
[88] CHPS Best Practices Manual: Relocatable Classrooms. Pg. 18.
[89] CHPS Best Practices Manual: Relocatable Classrooms. Pg. 20.
[90] CHPS Best Practices Manual: Relocatable Classrooms. Pg. 31.
[91] CHPS Best Practices Manual: Relocatable Classrooms. Pg. 36.

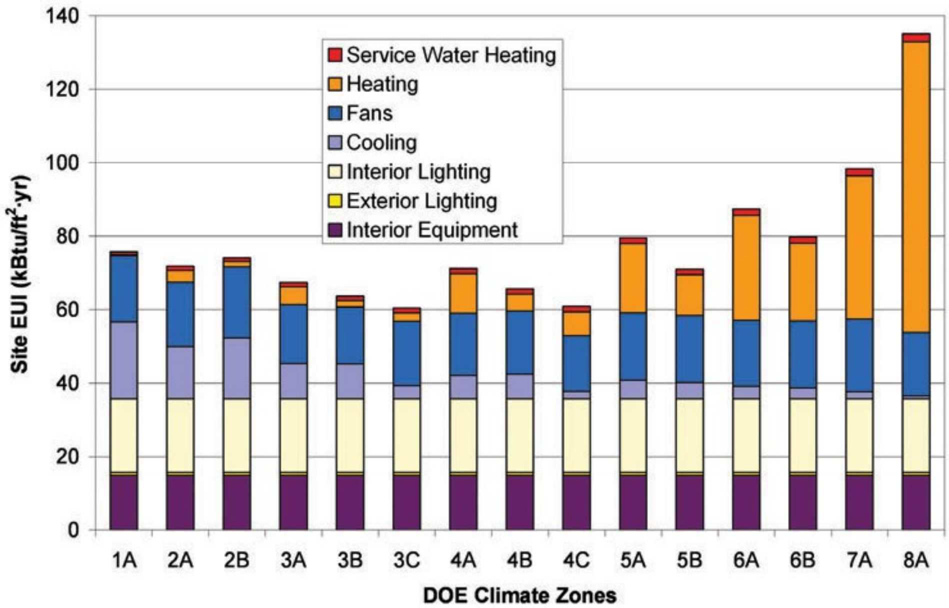

Figure 26. Elementary school annual baseline end uses across climate zone.

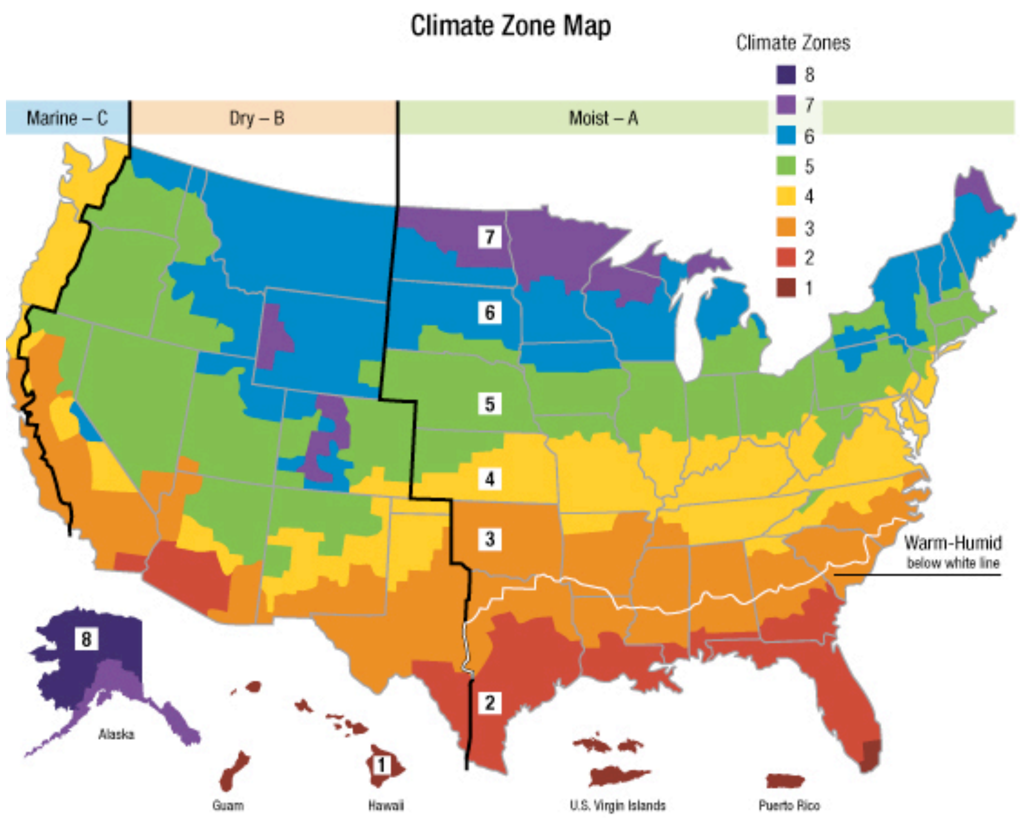

Figure 27. US Department of Energy (DOE) Climate Zone Map.

4.2 AMERICAN SOCIETY FOR HEATING REFRIGERATION AND AIR CONDITIONING ENGINEERS (A.S.H.R.A.E.): Advanced Energy Design Guidelines – K-12 Educational Buildings

Though not specifically targeted to the relocatable building market, the ASHRAE Advanced Energy Design Guidelines have been developed to increase the Energy Efficiency of buildings, and should be looked to as a model for incorporation within the baseline requirements of any modification of the listed regulation on the path to Net-Zero.[92] The K-12 Educational Buildings Guideline provides approaches to achieve 30% energy savings over the standard design requirements. The guideline provide recommendation which are targeted to the specific climate zones across North America, with specific responses to deal with the variations and nuances of each different climatic region. In addition to the strategies by climate zone, the guideline provide case study examples which highlight built projects which have implemented these strategies into their design and construction. Benefits of implementing the recommendations outlined in the Advanced Energy Design Guidelines include an improved learning environment for the students, reduced operating costs for school boards, reduced construction costs, opportunities to enhance the curriculum through direct example learning tools, improved efficiency of energy and water use, and a reduced carbon footprint. Recommendations pertaining to Southern Ontario would be primarily based in Zone 6.
The main areas of focus of the guideline are:

The Building Envelope – It provides specific targets for insulation values based on the structural composition of the wall, roof and floor assemblies. For Zone 6 recommendations pertaining to the standard construction of Wood-Framed Relocatable Classrooms would set Roof Assemblies at R-38 minimum, Exterior Wall Assemblies at R-13 + R7.5 continuous insulation (c.i.) and Swinging Exterior Doors at U-0.70

Lighting

Interior Lighting Through Daylighting:

High Efficiency Artificial Lighting Systems

H.V.A.C.:

High Efficiency Heating, Ventilation and Air Conditioning

Service Water Heating (SWH)

Efficiency of Water Heating Appliances

Commissioning

Effective Commissioning Procedures to be implemented to ensure all building systems are working to their optimal capacity and to the level that they are intended. Also to ensure that discrete systems are working in harmony.

Additional Savings

Articulate in terms of Ventilation rates and Indoor Air Quality (IAQ) recommendations and parameters.

[92] ASHRAE Advanced Energy Design Guideline K-12. Accessed April 2015.

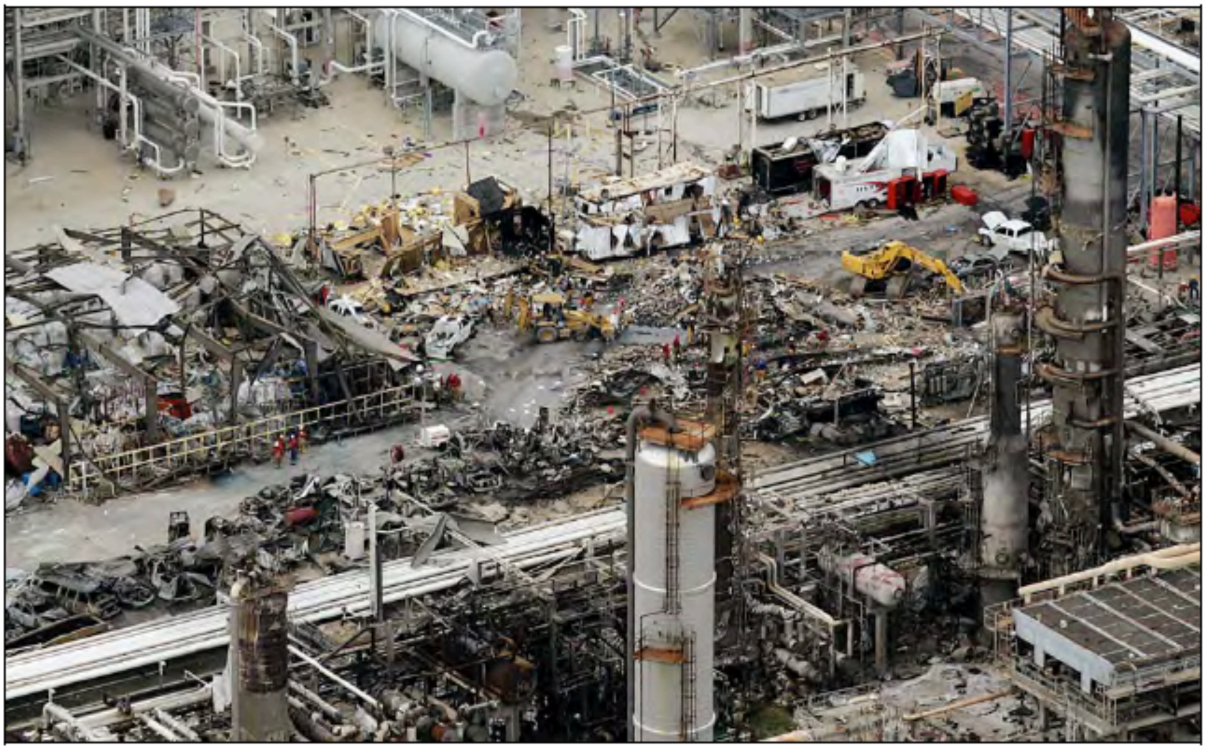

Figure 28: Texas City Refinery Explosion

4.3 AMERICAN PETROLEUM INSTITUTE (A.P.I.): API RP 753 – PORTABLE BUILDINGS STANDARD

This standard was created in light of a series of tragic industrial disasters, which had numerous fatalities. This reference standard intended is to be used and implemented by all Oil and Gas Producer who are members of the American Petroleum Institute. This document is a recommended practice, which has been encourage to be adopted by their member companies, but is not an enforceable regulation, and is not consistently adopted or implemented at member sites. It written in order to be used globally by member companies, and was developed as a response to a string of industrial catastrophes. One such example was the explosion in a process area at a BP refinery in Texas City[93] Texas in March of 2005, where standard relocatable portable buildings (construction trailers) had been sited within the confines of an industrial process area. Because of that explosion, fifteen contract workers were killed. The subsequent investigation of the incident revealed that "Most [of the workers] had been working in or near portable trailers located near hazardous equipment – the refinery's isom unit – during one of the most hazardous operations – a unit start up."[94]

Buildings sited within the context of a Petrochemical Refinery operation, or other high hazard industrial operations need to be specifically designed and sited in order not put the staff who inhabit such buildings in sever or sometimes even grave danger. Relocatable Buildings have formed a common building typology on many resource extraction and development companies' sites, as they are cheap and easy to come by, with few regulatory hurdles to prohibit their adoption. The situation in Texas City, was unfortunately not an isolated occurrence, and the relatively recent broader industry recognition of these hazards to their workers is still limited in its adoption as it is voluntary, and it takes many years for some of these facilities to catch up with current guidelines and adopt best practices.

List of Key items / Recommendations to be incorporated in Part Ten from API RP 753[95]:

- Identifying appropriate application and use of portable buildings in an industrial context and management of their use.
- Addressing issues of potential hazards on at site including:
    - Fire
    - Toxic Release
    - Blast
- Recommendations for the design, construction and installation of portable buildings.
- Siting of buildings in a manner consistent with the above goals.

93 Texas City. U.S. Chemical Safety Board – Final Report. 2006.
94 U.S. Chemical Safety Board. www.csb.gov/csb-board. April 23 2007.
95 API RP 753 – Management of Hazards Associated with Location of Process Plant Portable Buildings. Pg.1

4.4 COMPANY SPECIFIC CORPORATE DESIGN STANDARDS

Some multi-national companies, that have recognized the internal benefits of improving the quality of construction on their sites, have even gone so far as to develop their own internal corporate design and construction guidelines with regards to the installation of relocatable buildings and temporary construction camp installations. This is in recognition of some of the risks that they have been taking by not having standard policies around the implementation of these building installations, as well as addressing the current void in regulations around these types of buildings in many Canadian and International Jurisdictions. These companies are by far the exception, and do not reflect the norms of the industry. Their actions only serve to reinforce the need for consistent adoption of regulatory standards around these types of buildings, to improve the health, safety and energy impacts of these buildings, while having a more unified or harmonized approach to their development; making the whole industry more efficient and reliable.

Certain Global companies working in the Oil and Gas sector have taken it upon themselves to develop internal standards and requirements for Mobile and Construction Camps, recognizing the void in local building standards and the inconsistencies between various jurisdictions. This is a method for them to ensure consistent deployment of construction standards within their own company setting. Such standards include:

General Scope and References

Reference Terms, and external regulatory documents to be considered, as well as processes for receiving clarification on the specifics of internal design standards, and means of suggesting updates and modifications to the document itself.

Site Safety Assessment

With the understanding that these camps in industrial settings are often subject to a range of hazards not typically present in other building construction settings, hazard analysis of the specific site setting is an important factor in determining if a relocatable building complex or 'construction camp' can be an appropriate solution for housing workers at a given site location. In addition to the specific hazards encountered in the industrial setting, analysis of the general site from other planning considerations including climatic and environmental loads (wind, snow etc.) Each company employs different proprietary and specialized method of determining risk and hazards present in the workplace, this information is then translated into metrics which allow for the setting up of rules and design criteria for the layout of buildings and other site elements, as well as specific requirements for the detailed design of the building and its construction.

Design Criteria

Among the elements itemized within the design criteria of internal company standards are many similar items found in government issued building codes and standards, however, these criteria have generally been tailored to the industry specific requirements of that company's work and may not be applied as universally outside of that specific manufacturing or refining environment. Criteria include listing of Safety Critical elements that will affect the operation of the facility and it's employees, environmental conditions such as climatic, and geographic factors, as well as criteria for installation of portable buildings that will affect other types of operation within that companies facilities including transportation requirements, and use of cranes, and lifting equipment.

Structural Integrity

Similarly, structural integrity requirements provide expectations around the design and construction considerations to ensure that the product delivered for use at a site, meet the many different loads that might be encountered in that setting. It also provides expectations and requirements of detailed analysis to be performed on such units before procurement, construction and installation occur.

General Requirements

These provide an overview of the programing requirements and evaluation of site needs in order to establish the scope of a construction camp installation, while also identifying key considerations around siting and layout with regards to circulation, vehicular access, and emergency egress requirements – both from the buildings themselves and the complex as a whole.

Specific Requirements for Design and Engineering of Camps:

Detailed design and engineering requirements including require provision of space per person, based on occupancy are provided by these corporate standards. In some cases, the internal requirements and standards surpass the locally enforced codes and laws, to address specific safety concerns that have been raised or identified within the specific work environment. For example, the required minimum spacing of relocatable modular buildings for one such multi-national company is actually 2m larger than that of relocatable classrooms as addressed within the Ontario Building Code – increasing the distance from 6m to 8m as the threshold for requiring fire separations.

Given that these companies operate in many different parts of the world with varying systems of building and community development guidelines and regulations, these internal standards provide best practices, across different locations, ensuring consistency of quality and expectations for employees. By and large, these internal standards mimic the minimum standards found elsewhere in developed nations government issued building codes, however in some cases these internal standards surpass local regulations, even in Canada, and serve to improve the built environment on industrial sites where local codes and regulations are silent.

CHAPTER 5:

POSTIVE EXAMPLES OF RELOCATABLE BUILDINGS

5.1 SPROUT SPACE
– By Perkins Will & Triumph Modular

5.2 SAGE (Smart Academic Green Environment) Classroom
– By PSU, Blazer Industries and Pacific Mobile Structures.

5.3 SEEDclassroom (Sustainable Education Every Day)
- By Method Prefab

5.4 moBEE – Straw bale Portable Classroom
By Evolve Builders

5.5 reMOD – Green Construction Trailer
By Williams Scotsman and Skanska

CHAPTER 5

POSITIVE EXAMPLES OF RELOCATABLE BUILDINGS

Though there are many examples of poorly constructed Relocatable Buildings to cite, there are also some more recent examples of design firms and manufacturers willing to challenge the current thinking with new, affordable models that provide increased quality, higher energy efficiency, more windows for natural daylighting, improved material selection and improved durability. An outline of the benefits and qualities offered by these more recent examples informs opportunities and strategies that can be realistically adopted by the mainstream manufacturers of RBs through mandatory minimum standards.

Within the category of construction trailers and industrial accommodations, one positive example available on the market is 'reMOD' produced by a partnership between modular building manufacturer: Williams Scotsman and Shipping and Logistics company: Skanska[96]. Although some of their claims to 'upgraded' green features should be part of a baseline level of quality in standard production, it illustrates and initial step in a positive direction. Among the contemporary examples within the educational market in Ontario is a new straw bale portable classroom called mobEE developed by Evolve Builders[97]. In the American market there are several examples of new, innovative portable classroom designs, which emerged out of a competition lead by the Open Architecture Network and Architecture for Humanity in an effort to engage top design firms and architectural schools in rethinking the ubiquitous portable classrooms found throughout the United States. These include: SAGE (Smart Academic Green Environment) Classroom by Portland State University (PSU) in conjunction with Blazer Industries and Pacific Mobile Structure[98]; Sprout Space by Perkins Will and Triumph Modular[99]; and SEEDclassroom (Sustainable Education Every Day) by Method Prefab[100]. Each are strong examples of new ways to conceive of the portable classroom within the constraints of limited budgets, requirements for flexibility and relocatability and good quality construction, which benefits, rather than harms, the end users. Each of these collaborations provide their own strategy to improve the current end-product of construction trailers and portable classrooms for the users, while maintaining the issues of affordability and capital cost expenditure at the fore for owners.

While the outlined state of the relocatable buildings, paints a pretty bleak picture of the modular construction industry there are some promising companies who are trying to reshape the perceptions of their industry through thoughtful, innovative and dignified spaces designed to still meet the over arching client requirements of limited budgets, constrained timelines and limited or fluctuating durations of use.

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[96] www.willscot.com/green/ Williams Scotsman: reMOD Green Construction Trailer
[97] www.evolvebuilders.ca moBEE Straw bale Portable Classroom
[98] www.sageclassroom.org SAGE classroom
[99] www.triumphmodular.com Sprout Space Green Classroom
[100] www.methodhomes.com SEEDclassroom

Despite the significant number of poor examples there are of Relocatable Buildings, there are several hopeful examples of new approaches and designs for Relocatable Buildings that provide some promise to the industry that there is both desire in the market for improvements to these types of buildings and a reasonable means of implementing these changes. Such examples demonstrate that these improvements can be made in a cost efficient manner in keeping with the underlying requirements of these types of buildings. The following examples demonstrate how energy efficiency, and improved material choices can produce a more inviting, and energy efficient end product while also meeting the economic constraints and portability requirements of customers looking for a Relocatable building solution to current space needs. The following projects show opportunities and examples of people, groups and companies trying to get it right.

2009 Open Architecture Challenge: Classroom[101]

Design the classroom of the future:
According to the World Bank, educating all children worldwide will require the construction of 10 million new classrooms in more than 100 countries by 2015. At the same time, millions of existing classrooms are in serious need of repair and refurbishment. We asked designers and architects to partner with students and teachers to envision the classroom of the future.

The Open Architecture Challenge is an open, international design competition hosted once every two years on the Open Architecture Network. It reaches beyond the traditional bounds of architecture by challenging architects and designers to partner with the broader public to address architectural inequities affecting the health, prosperity and well being of under-served communities. By harnessing the creativity and energy of the design community and beyond, each challenge offers not one but many solutions to a different systemic issue facing the built environment. All are invited to participate. Funding from partners and sponsors goes towards constructing the winning designs.

[101] Open Architecture Network www.openarchitecturenetwork.org/competitions/challenge/2009

5.1 SPROUT SPACE

by: Perkins + Will, in association with Triumph Modular

Summary:

Sprout Space, by Perkins + Will in association with Triumph Modular, is another example of such a project, whose emphasis on non-toxic materials, natural daylighting, improved insulative values, more durable finishes, and more inviting overall designs shows how we can transition this industry to provide truly desirable places to work and learn on a short-term basis.

In this example the design team sought to elevate the perceived and actual quality of the portable classroom by selecting higher quality interior and exterior finish materials from the norm to communicate a more approachable and unique learning space. With large windows along several sides of the building, the layout opens up views of the surrounding environment to the occupants while pulling natural daylight in and reducing the dependence on artificial lighting during daytime hours. Simultaneously the large overhangs provided from the roof offer the opportunity for shading during time of the day with a high solar heat gain, also provides exterior shelter from rain and other elements in approaching the building.[102]

This connection to the exterior also serves to strengthen pedagogical goals of teaching students about the natural world around them and trying to physically and visually connect them to their surrounding environment. Goals of reducing energy use of the module are achieved through a highly insulative building envelope that is properly sealed to air infiltration and leakage. By placing an increase emphasis on the specification of and installation of non-toxic materials the design team was able to achieve an end design with an improve Indoor Air Quality (IAQ) when compared with their standard counterpart.

Critique:

Given the underlying concern for the increased fire resistance of all modular units in light of their 'flexibility' in siting and frequent relocation, questions arise with regards to the placement of these units in proximity to one another, especially in scenarios where there are windows in close proximity to one another from adjacent units. Limiting distances between classrooms should be thoroughly reviewed by designers and building permitting agencies to limit potential hazards from improper siting of these units.

While many of the initiatives and product selections included in the over-arching goals of this modules' design are admirable, economic forces would likely limit the adoption of all of these features in mainstream module construction. However, the key features that should strongly be incorporated into standards for portable classrooms are the increased insulative values provided for all construction assemblies, as well as the improved access to natural daylight.

[102] Triumph Modular. www.triumphmodular.com/sproutspace

Feature Design Elements of the Sprout Space Module[103]:

Essential Elements:

Healthy Learning Environments:

- **Low-emitting materials**

If the building starts with low emitting materials, less mitigation down the road is required to ensure good indoor air quality

- **Highest indoor air quality standards**

Implementing high Indoor air quality standards means a better learning and teaching environment for teachers and students. Good IAQ means less absenteeism, fewer illnesses and complaints, and a more alert classroom.-

Flexible Learning Environments:

- **Increased Natural Light and Connection with the Outdoors**

Increasing window area in the classroom and incorporating the use of skylights provide a more inviting and desirable space to learn, while also reducing the use of artificial lighting, (noisy ballasts, energy use) and increasing the opportunity for students to engage with the outdoor surrounding of the school visually.

Sustainable Learning Environments:

- **Ample natural daylight**

(See Above)

- **Overhanging eaves**

Provision of overhanging eaves provides increased protection of the exterior walls from the elements, and provides an opportunity for shelter of people from rain and snow. These overhangs are especially important where there are entry doors, and should be incorporated with a proper air lock vestibule in the cold climates in Canada.

- **High-reflective roofing**

Specifying a high reflectivity of the roofing material is an economically feasible feature for any portable classroom serves to aid in reducing the cooling loads that the relocatable building will be required to address during the warmer seasons.

Ideal Elements:

Flexible Learning Environments:

- **Well-suited for various teaching styles, seating configurations**

Portable Classrooms in general are open plan spaces that have some flexibility in the layout of furnishing – Sprout space, extends that flexibility to providing opportunities for specific outdoor learning settings by integrating a large platform gathering area outside as well as exterior marker boards for lessons.

- **Direct opening from classroom to the outdoors through large bi-fold doors**

While ideal, in temperate climates, this may or may not be feasible in cold climates, in an economic model.

Sustainable Learning Environments:

Each of the following features have great potential benefits to the users of portable classrooms, and the general environmental performance of portable classrooms as a whole, but they may not be economically feasible for inclusion in a base specification.

- **Integrated rainwater collection,**
- **Sustainable material selection**
- **Use of passive and active green building strategies.**
- **FSC-certified wood,**
- **Bio-based insulation.**
- **Bio-based flooring.**

103 Perkins Will. www.sproutspace.com

Figure 29 & 30: Sprout Space by Perkins + Will & Triumph Modular

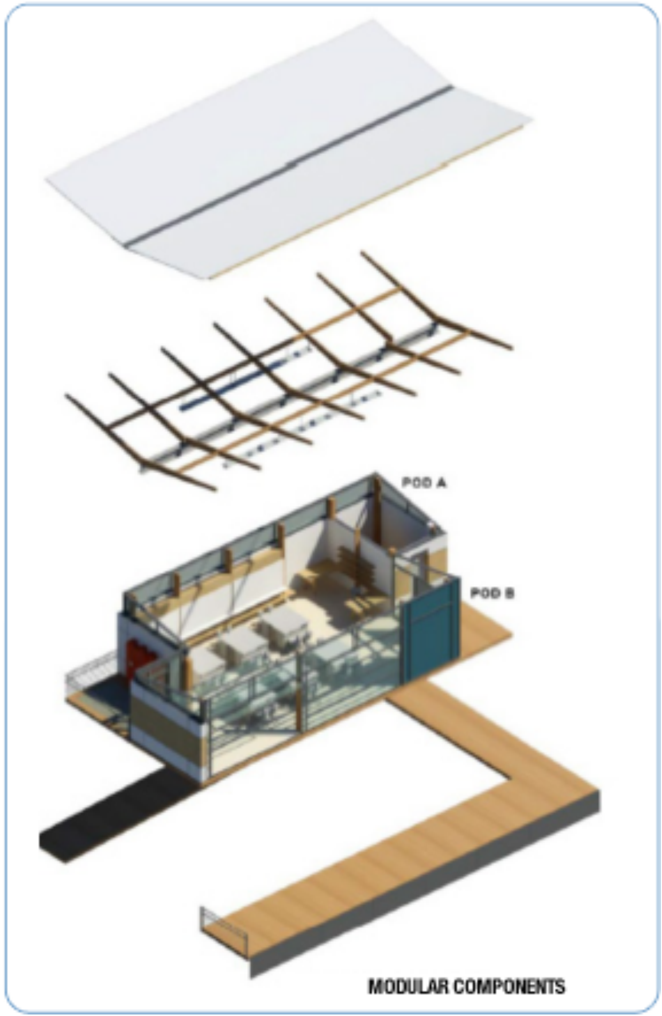

Figure 31 & 32: Sprout Space by Perkins + Will & Triumph Modular

5.2 SAGE "Smart Academic Green Environment – Green Modular Classroom by: Portland State University (PSU), Blazer Industries & Pacific Mobile Structures

Summary:

A collaborative project involving private industry and public academia, SAGE green modular classrooms set out to develop a model of affordable portable classrooms that raise the bar related to quality of design and space, while maintaining affordability at the front of mind. "It provides enhanced natural daylight, drastically improved indoor air quality, spaciousness, and high quality non-toxic materials in a compact and beautiful package, all for little more than the typical modular classroom.[104] This demonstration classroom made it's debut at the 2012 Green Build Conference in San Francisco and received many accolades for addressing many of the significant issues that contemporary schools struggle with in implementing portable classroom solutions within their school districts. "Although built in an assembly line with other portable classrooms, the project exceeds on-site construction code standards and minimizes waste"[105]

"An alternative to current poorly performing and uninspired modular classrooms […] attempting to raise the standards of educational environments"[106]

Critique:

The key elements of the SAGE classroom that should be adopted into mainstream portable classroom design and construction standards are the use of high-efficiency HVAC systems, the opportunity for natural ventilation through the provision of operable windows, natural daylighting into the learning spaces also provided by windows, and high efficiency artificial lighting.

Feature Design Elements of the SAGE green classroom:

Essential Elements:

Elements of the SAGE green classrooms that should be essential to the design and construction of all portable classrooms include:

- **Efficient HVAC System with Air to Air Heat Exchanger**

Higher efficiency of the systems installed in Relocatable Classrooms is critical to providing a more confortable and responsible environment in which to learn.

- **Energy Efficient LED lighting[107]**
- **Non-Toxic Materials**

The Indoor Air Quality (IAQ) cannot achieve optimal quality if the building materials are part of the problem.

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[104] SAGE classroom – www.sageclassroom.com/aboutus
[105] Anderson & Anderson. Prefab Prototypes. Pg.286
[106] SAGE classroom www.sageclassroom.com
[107] SAGE classroom www.sageclassroom.com

- **Natural Ventilation**

Natural Ventilation is essential for the well being of the occupants – both the teachers and the students.

- **Natural Daylighting**

Many windows are provided in the SAGE classroom modules, including a row of clerestory windows to bring in natural light

- **Proper Orientation**

When ever possible, as the school site allows, proper orientation of the building will provide critical benefits to the operation of the portable classroom. Unfortunately in urban locations especially, this is not always possible.

Ideal Elements:

Some of the excellent features of this design may not be economically feasible for all school boards looking to procure portable classrooms for their schools.

- **Increased Portability**

While light-weight materials that ease the portability of the structure do provide added benefits of reduced fuel costs and transportation costs, as we have seen, the frequency of relocation of these modules is not as high as often initially anticipated. Ease of transport is less critical to the successful implementation and use of the buildings that the quality of the product once installed on site.

- **Reduced Site Infrastructure**

For remote schools, this may also be a critical benefit, but for the average school board or district looking to quickly expand their classroom space, the reduction of site infrastructure is beneficial but not essential, and would need to be evaluated on a case-by case basis to understand its direct value to a particular installation.

- **Phase Change Materials**

Phase change materials have the benefit of providing the advantages for thermal storage of passive solar energy that would traditionally be achieved with the use of heavy mass materials, such as concrete and brick, in light weight and thin construction assemblies. When properly incorporated into the assemblies these can provide improved thermal comfort and efficiencies to the building's operation, but would not be considered essential to basic improvements of Relocatable buildings.

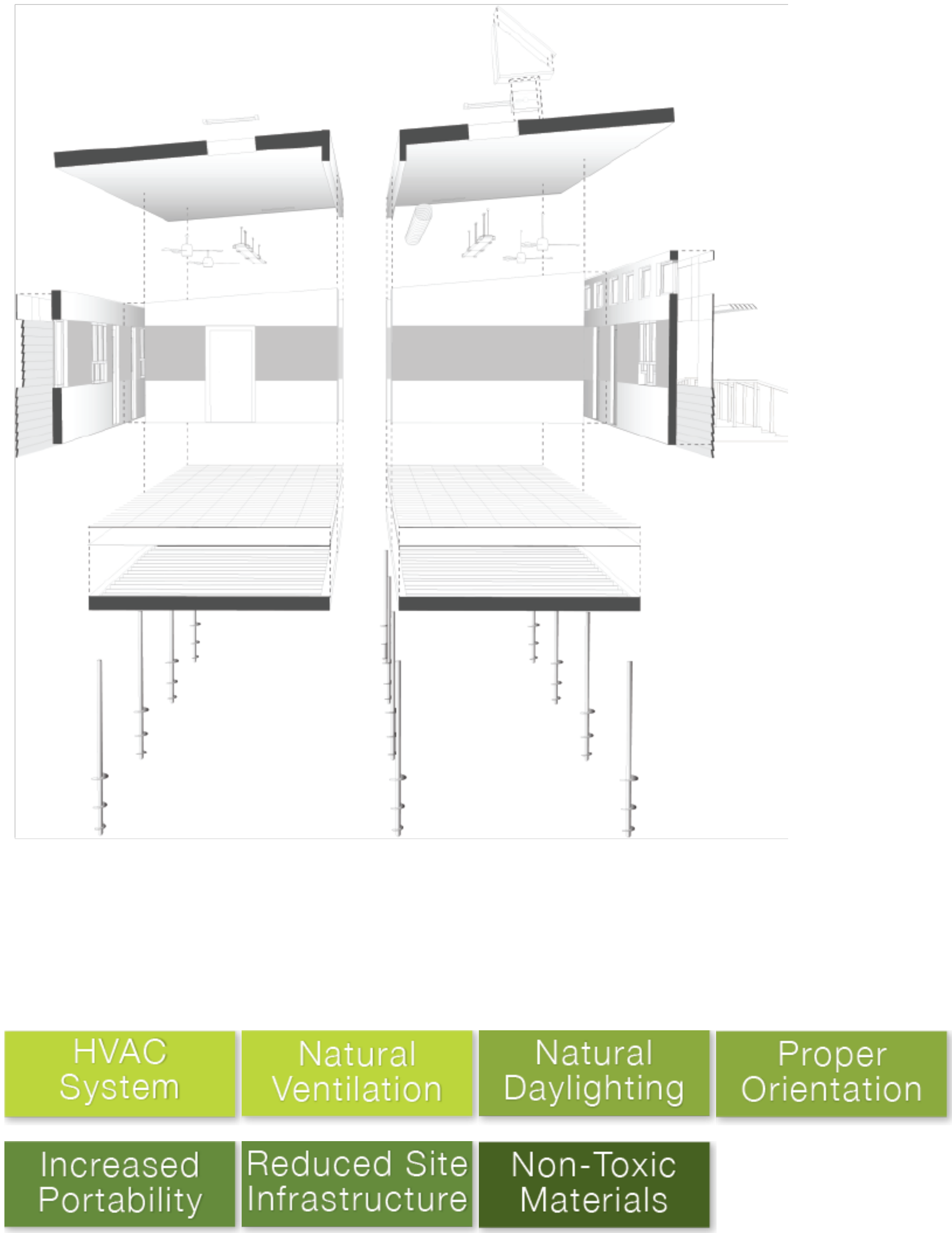

Figure 33: SAGE Green Modular Classroom by PSU, Blazer & PMS

Figure 34, 35, & 36: SAGE Classroom by PSU, Blazer Industries & Pacific Modular

5.3 SEEDclassroom (Sustainable Education Every Day) by: Method Homes Prefab

Summary:

SEED Classroom claims to be the best on the market in the relocatable classroom sector, and if it meets even half of what it claims to accomplish it is a significant improvement over the status quo.

SEED Classroom is designed for a temperate climate. Certain elements, which they have incorporated into the package, could definitely be teased out to reduce the overall cost of the project. An important differentiation that this product makes from other innovative examples in this field is the emphasis of conservation of Water as well as Energy. Water usage and needs are often placed secondary in importance to energy use in terms of environmentally appropriate solutions, however emphasizing the responsible use of water and demonstrating those techniques and technologies directly in the classroom is critical to engaging young people. There would be a significant learning curve for some school districts to adopt this model of portable classrooms. Maintenance of some of the alternative systems could prove challenging and in the long run be ignored, or dismissed, leading to diminishing returns and reduced effectiveness of the design over its lifespan. The key elements that should inform an improved minimum standard for relocatable classrooms include the following blue highlighted elements from their list of key features:

Critique:

It is not realistic to try to widely implement some of the more innovative features of the SEED Classroom, however key approaches to the design could and should be implemented to provide real benefits to the users of portable classrooms. These include the selection of building materials compliant with the Living Building Challenge Red List, providing Abundant Natural daylighting for the occupants. Incorporation of highly efficient mechanical HVAC system and use of Structural Insulated Panels for the floor, wall and roof assemblies are both strategies that could readily and economically incorporated into the specifications and design of mainstream portable classrooms and similar relocatable buildings.

Feature Design Elements of the SEEDclassroom[108]:

Essential Elements:

- **Structural Insulated Panels (SIPs**)

High insulative values of all building envelope components including the floor panels, wall panels and roof panels are absolutely necessary to the improvement of minimum standards for relocatable buildings. While they do not necessarily need to be constructed with SIPs, this approach of integrated structure and insulation could be a key strategy for the industry to provide better building envelopes to these built 'products'.

- **The most efficient mechanical systems available.**

Increased efficiency of mechanical systems is critical to be incorporated into all relocatable classroom. By improving the efficacy of these systems, improved occupant comfort as well as reduce energy use and lowered

[108] SEED classroom. www.seedcollaborative.org

operational costs can be achieved for the building owners.

- **Living Building Challenge (LBC) materials Red List compliant.**

Exposure of Student and teachers to building materials which contain toxins, Volatile Organic Compounds (VOCs) or other off-gassing substances has many potential short term and long-term health effects both known and unknown. Seeking to limit or eliminate use of such materials is very important.

- **Abundant natural day lighting.**

Improved daylighting provides a beneficial learning and teaching environment for the occupants, in addition to improved natural daylight provided by increasing the number of windows in a unit is view to the exterior and connection with the surrounding environment.

Ideal Elements:

- **Net-zero water and Net-zero energy**.

Ideally, all buildings would be net-zero users of energy and water, however it is not realistic to make this a minimum standard for relocatable buildings.

- **Solar photovoltaic array**.

While potentially very beneficial, adding solar panels to a relocatable classroom should be an optional feature, depending on the appropriateness of the location and the related electrical grid that such a generating source can tie into.

- **Rainwater treatment for sinks.**

Treatment of collected rainwater is a fantastic opportunity to reduce the volume of water that would be required by the user. However, this would be significantly tied to the volume of rainfall available in the local climate and should be incorporated as an optional improvement to relocatable buildings where appropriate.

- **Rainwater collection and filtering**

While rainwater collection should be incorporated into all site designs to be used for irrigation, etc., this should be an optional improvement as it is not critical to the improved minimum function of the relocatable building in and of itself. Improved site design should be

- **Living wall fed by treated greywater.**

A Living wall system is an excellent opportunity to introduce more living systems into the classroom setting. While there are many potential benefits to the incorporation of a living wall into this environment including the increased oxygen levels brought with the living plants, there are also several detractors including problems around maintenance and potential for issues with mold if the system is not properly cared for. This should be an optional improvement

- **Ongoing performance monitoring led by students**

This is a great way to engage the occupants of the buildings in both the operation of the modular unit, as well as providing the content for learning opportunities. While many great educational opportunities could arise from student monitoring, this is not likely to a viable activity over the long term as the novelty of such systems wear off, or the other educational requirements to be covered within the classroom take hold.

- **Composting toilet**

This should be an optional improvement. Composting toilets would not be appropriate in all locations and application

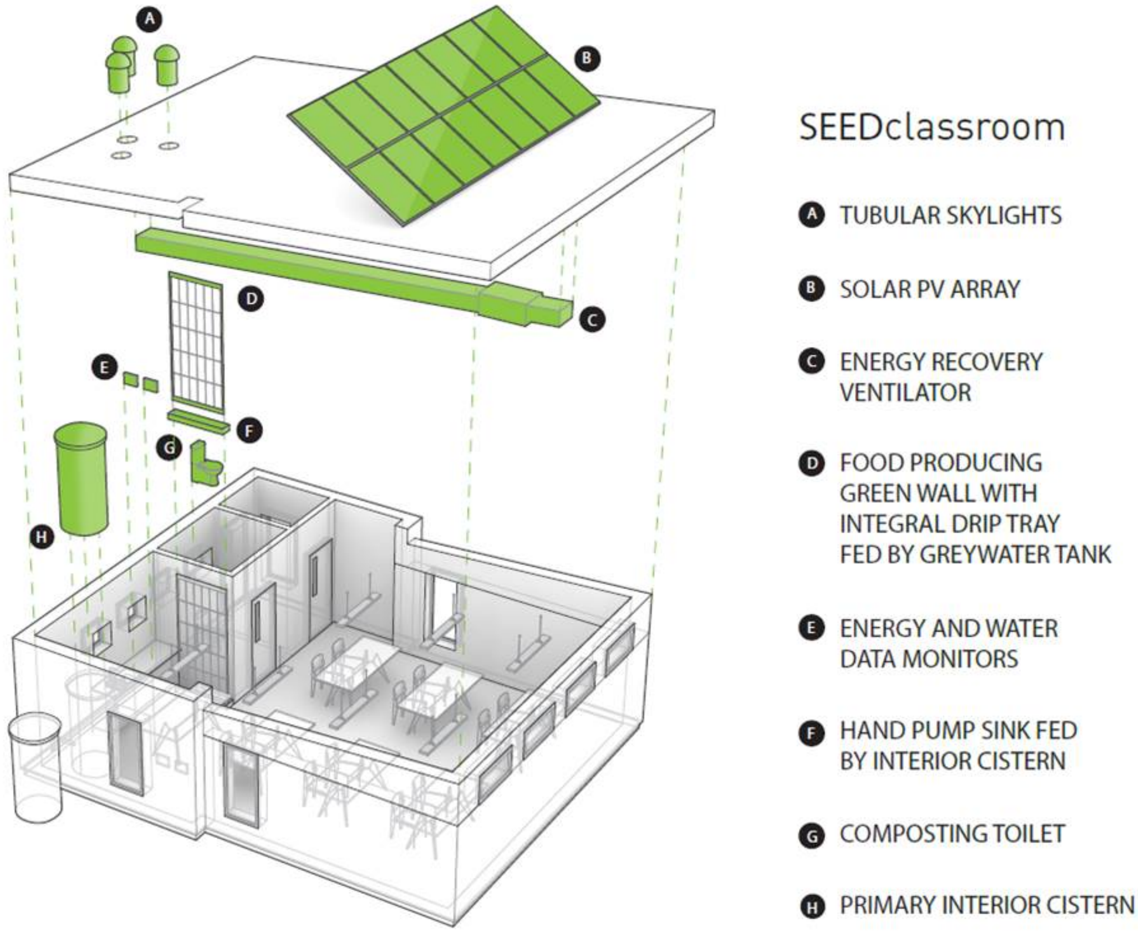

Figure 37: SEEDclassroom by Method Prefab – Diagram of Systems

Figure 38 & 39: SEEDclassroom by Method Prefab: Interior & Exterior

5.4 mobEE : mobile eco enclosure

by: Evolve Builders, Guelph, Ontario

Summary:

Within the Canadian context there is an example of the design, construction and implementation of a "Straw-Bale Portable Classroom" demonstrates that there are groups of designers and contractors interested and willing to tackle the subject of "portable Classrooms" from a new perspective. This particular example is especially relevant to our issues in Ontario as it was designed and constructed by a company located here and familiar with the particular issues that the Ontario climate presents to these types of buildings. The structure and materials that were selected for this project show that much greater attention to issues of occupant comfort, indoor air quality and energy efficiency have been incorporated into the building design. The Straw Bale Exterior walls have provided significant increases in the thermal value of the building envelope and combined with the plaster finish ensures that the enclosure provides protection from not just the outdoor elements, but also provides increase FRR when compared with the typical wall assembly construction provided in standard Portable Classrooms. Other elements of the design contribute to a much more durable end products including sheet flooring rather than lay-in VCT and higher quality windows improving air-tightness and overall R-value of the building enclosure.[109]

Critique:

Issues of daylighting still pose a significant concern for occupant comfort.

Very spare details are provided by the manufacturer to review their claims, of energy efficiency and material improvements over the current base models presently on the market. It does, however, illustrate a conscious effort to step beyond the current thinking and try alternative approaches to dealing with this building program requirement. A review of the key features that are offered by mobEE provides additional key features that should be incorporated into the minimum standards, which Ontario Building Code, and CSA Standards enforce for relocatable classrooms. The features highlighted in blue, should be incorporated into minimum standards of relocatable classrooms.

There are elements that should be incorporated into mainstream production for portable classrooms from the moBEE portable classroom. These include the increased emphasis on the use of a fire-resistant building assembly, incorporation of high-efficiency Insulated Glazing units in the windows provided, high efficiency artificial lighting fixtures and lamps, high efficiency HVAC units, and provision of basic interior furnishings, which increase the functionality of the space. While aspects of this design have much potential, the interior finish space remains quite similar to the exiting standard modules which are dark, and 'cold', the exterior appearance needs increased detailing to further set this model apart from the competition. The skirting shown in the examples provided is not different from the standard Pressure Treated Plywood skirting used in

[109] Evolve Builders. http://evolvebuilders.ca/blog/project/item/mobee-eco-friendly-portable-classroom/

conventional modular building complexes, and is highly questionable from the stand point of durability, resistance to rodents and moisture, and does not help with the above mentioned issue of exterior appearance.

Feature Design Elements of the mobEE – mobile eco enclosure:

Essential Elements:

- **Relocatable Classrooms should provide a FRR for the entire exterior envelope. (Standard)**

The Exterior envelope should be Fire Resistant, but the material selection should be variable.

- **Fibreglass-framed high-efficiency windows (Standard)**

High-Efficiency, Windows, Window Frames and Insulated Glazing Units should form an important part of the base requirements of Relocatable Buildings.

- **LED warm-white light fixtures (Standard)**

Energy Efficient Light Fixtures should be required in all Relocatable Buildings.

- **Air conditioning (Select)**

Climatic Requirements in Ontario make air conditioning an essential part of any building design for occupancy through the shoulder seasons and summer.

Ideal Elements:

- **Coat rack and black, white or tack board packages (Select)**

Incorporation of these elements is a nice additional feature, for the classrooms to be properly provided with necessary fit out, but not essential to the base building. These items might be provided from other sources.

- **Fire resistant straw bale insulation (Standard)**

The Exterior envelope should be Fire Resistant, but the material selection should be variable.

Glass viewing window into wall core (Standard)

This is specific to the Straw bale, teaching mandate, and is not essential for all Relocatable Buildings.

- **Structural insulated panel floor & roof (Standard)**

SIPs provide an excellent approach to constructing a Relocatable Building, but are not the only method.

- **Natural, vinyl-free, wax-less, antimicrobial linoleum flooring (Standard)**

Flooring finishes should be low VOC but the particular specification should have variability dependent upon the substrate and the climate

- **Mineral based wall paints, in and out (Standard)**

Paints and finishes should be Low VOC, but the particular specification should have variability dependent upon the substrate and the climate.

- **Wood soffit with natural finish (Standard)**

Soffit finishes should be suited to the overall finish of the Relocatable Building.

- **Steel roof with recycled content or low emissivity white roof membrane (Standard)**

The roofing material does not necessarily need to be Steel or White on a basic model relocatable building, but both options would provide benefits to the long-term efficiency and durability of the structure.

- **Combination air-exchanger/heater (Select)**

Some form of ERV or HRV would provide improved efficiency of the mechanical system and improved energy efficiency.

- **Solar hot air collectors (Select)**

This is an optional benefit, but could serve to provide back up power to the unit during power outages on the main grid.

- **Solar photovoltaic panels (Select)**

This is an optional benefit, but could serve to provide back up power to the unit during power outages on the main grid.

- **Custom architectural flooring patterns (Select)**

This aesthetic option is non-essential, but could serve to provide a more inviting atmosphere for the occupants.

- **Custom colour-matched paint scheme (Select)**

This aesthetic option is non-essential, but could serve to provide a more inviting atmosphere for the occupants.

- **Curriculum-specific lesson plans (Select)**

The educational mandate is beneficial to the manufacturer to provide to the client as a way of developing a greater level of acceptance and buy in of the occupants for this type of classroom solution.

Figure 40 & 41: mobEE – Eco Portable Classroom: Exterior and Interior Photos

Figure 42 & 43: mobEE – Eco Portable Classroom: Interior Photos

5.5 reMOD – The Green Construction Trailer
by: Williams Scotsman & Skanska (North America Wide)

Summary:

This example of an improved adaptation of the typical construction trailer has been developed by the company Williams Scotsman in association with Scandinavian Construction Firm: SKANSKA and is called reMOD. The product is actually a range of Construction Trailers available in the North American Marketplace that are geared to provide more sustainable solutions for the Construction Trailer market. There are 3 levels of "green-ness" that the Manufacturer offers, depending on the level of investment, and features include upgrades in insulation and air tightness, material and finish selections with reduced VOC content, more energy efficient windows and day lighting options, as well as more energy and water efficient mechanical and plumbing equipment.[110] These models still are largely an exception to the standard level of quality offered in their base stock trailers, but it does demonstrate a level of leadership and initiative that these buildings even when inhabited on short-term basis can provide a more comfortable and inviting space for the occupants with a reduced footprint on the environment.

Critique:

All of the "upgrades' offered under the guise of improved sustainability for the Light Green categories should really be part of their basic stock, and should also be part of the minimum standard specifications for all relocatable buildings these items marked with (LG) are not so much features, but rather basic elements of a standard building. Weather Stripping on doors and Insulation in walls should not be highlighted as a special feature. The inclusion of these components should be expected. Many of the 'upgrades' offered under the category of Medium Green (MG), should similarly be considered basic amenities and incorporated into their base fleet of buildings as standard issue, and not marketed as some special added feature. While there are a couple listed options in the Dark Green (DG) category that would be considered somewhat exceptional for a construction, the majority of elements in the dark green category should also be considered standard. Overall, the quality of current existing construction trailers is so low that basic amenities are being marketed to clients in a way that tries to set this company apart. In reality, the industry as a whole, need to provide a better quality minimum trailer.

[110] Williams Scotsman. www.willscot.com/green Green Modular Solutions

Feature Design Elements of the reMOD Green Construction Trailer:

Essential Elements:

- **Programmable Thermostats (LG)**

This should be a basic part of the HVAC unit system incorporated with the design of the relocatable building. Cost of this technology is no longer prohibitive, and the payback for the owner/operator of the building in reducing the energy usage is significant

- **Energy saving ballasts, T-8 lamps on fluorescent lighting (LG)**

All models of relocatable buildings including the most basic construction trailers should be provided with energy efficient lighting.

- **Motion sensor wall switches (LG)**

As well as high efficiency light fixtures and bulbs, the associated control points such as motion sensors should be a mandatory part of standard relocatable buildings when appropriate for the occupancy.

- **Improved weather stripping (LG)**

This does not seem to be a "feature" per se, but should be a required component of all relocatable buildings to improve the air sealing around all openings for doors and windows.

- **Low VOC paints and sealants (LG)**

This needs to be a minimum standard, as addressing Indoor Air Quality is best achieved by addressing the building materials that are used.

- **Building HVAC system upgrades (MG)**

Efficiency requirements to come inline with the new mechanical efficiency required by ASHRAE 90.1

- **"Eco-minded finishes" (MG)**

This is a very vague feature description. Potential to reduce exposure to toxic materials but unclear.

- **Low 'E' window upgrades (MG)**

Valuable for the reduction of solar heat gain, and assisting to reduce cooling loads of the building.

- **White Roofing (MG)**

A simple standard upgrade which can help to reduce the cooling load of the building with minimal cost increases to the construction.

- **Insulation Upgrades (MG)**

Absolutely necessary to improving the performance of the building envelope and the energy efficiency of the building.

- **Daylighting Strategies (DG)**

(Demountable partitions, glass and aluminum recycled content)

- **Building Envelope upgrade (SIP Exterior System) (DG)**

Necessary, only in that this type of structural system may provide a more durable assembly and increased levels of insulation.

Ideal Elements:

- **High Recycled Content (HRC) ceiling panels (DG)**

Minimizing the use of virgin resources and making use of recycle content wherever possible and appropriate should be emphasized.

- **Enhanced work flow patterns (DG)**

This does not really seam like a feature – rather an issue of designing circulation patterns properly.

- **Reclaimed furnishings (DG)**

This is a way of marketing used furniture as an upgrade.

- **Local materials (DG)**

Where appropriate, manufacturers should be using locally sourced building materials such as wood framing.

- **Solar shades and light shelves (DG)**

These are a nice additional feature to improve the reach and efficacy of natural day lighting to penetrate into the space while reducing excessive heat gain.

- **Reclaimed water systems (DG)**

Rainwater harvesting and recycling of greywater for uses including toilet flushing are essential to reducing our use of water resources.

- **"System Enhancements" (MG)**

This is a vague description of a feature that is potentially beneficial but unclear what exactly the system enhancements entails, or their value.

- **Solar and other renewable energy systems (DG)**

These systems would ideally be incorporated to offset or support the energy needs of the building while also providing an alternate back-up power source in a scenario where the grid power is not available.

- **Paperless gypsum (DG)**

Reduction of Vinyl Content within the space.

Figure 44 & 45: reMOD by Williams Scotsman and Skanska

Figure 46 & 47: reMOD by Williams Scotsman and Skanska

CHAPTER 6

SUMMARY OF PROPSED CHANGES TO CODES AND STANDARDS

6.1 Proposed amendments to CSA Z240 Standards

6.2 List of Proposed Changes to CSA Z240:

6.3 Proposed Amendment To Ontario Building Code 2012

6.4 List of Modifications to Part 3 (3.9 Portable Classrooms Specifically)

6.5 List of Modifications to Part 9 (Housing and Small Buildings)

6.6 New Part 10 Relocatable Buildings

6.7 Proposed Amendment To The National Building Code of Canada (NBCC) 2010

CHAPTER 6

SUMMARY OF PROPSED CHANGES TO CODES AND STANDARDS

The overarching intent of the proposed modifications to each of are to improve the minimum quality standards required to be incorporated into the construction of relocatable buildings, including Manufactured Homes. While the emphasis and focus of the research within this paper is not on residential construction, this Standard remains to be the current specification guideline used for all occupancies of relocatable buildings in the current context of Ontario, Canada.

The ongoing work to harmonize the provincial and national building codes across Canada is an important step towards improving the quality, legibility and consistency of construction

The following changes are summarized for each standard, which is being evaluated through this research, while detailed proposed modifications to the specific wording of the codes and standards documents are provided in detail at the end of the research in Appendix B.

6.1 Proposed amendments to CSA Z240 Standards

The intent of the following modifications to the CSA Z240 Standards is to improve the minimum standards of design and construction for Manufactured Homes. While the focus of this research is not residential construction – this document has a significant impact on the non- residential sector as well.

In addition to adoption of modifications to the existing standard, development of separate, distinct CSA standards is necessary to outline specific requirements that recognized the divergent conditions and concerns between the specific needs of varied occupancy types and agglomeration sizes. Noting that a single construction trailer on a site for a six-month duration probably does not need to meet the same requirements as a twelve-module industrial lunchroom complex for several hundred people. Tailored regulations will serve to streamline the approval process for such different types of installations by clarifying expectations and requirements for different key groups. Differentiation and acknowledgment of the wide range of uses and applications that relocatable buildings have in modern life is an important first step to defining clearer expectations and requirements for such structures.

While some might argue that the existing Ontario Building Code provides such differentiation, I would respond that such clarity is not currently present due to references citing the CSA standard in question for building that are not fully appropriate for non-residential applications.

List of Proposed Changes to CSA Z240: See Detailed Modifications in Appendix B

- Provide more detailed requirements to manufacturers, in order to meet the objectives listed in the Scope of the Standard.
- Provide more detailed and clear definition of "good engineering practices" in order to achieve the objective of "durable, livable and safe housing" Provide definitions of each of these objectives.
- Need for Design of the Buildings to consider specific climatic conditions and loads that relate to the local site – less generic solution, more tailored regional approach.
- Need for structure to be built capable of supporting wall/roof/floor assemblies including materials necessary to achieve required fire resistance ratings (including: GWB in many circumstances)
- Need for proper and adequate closure and sealing of all exterior assemblies to prevent air leakage, moisture damage and ingress of pests and rodents including especially the underside of floor assemblies that are frequently ignored or overlooked and covered with sub-standard material finishes.
- Need for anchorage to address local wind-loads etc.
- Need for use and installation of proper exterior sheathing materials (Structural Stability, FRR, etc.)
- Need for increased insulation values overall, and implementation of continuous exterior insulation to prevent thermal bridging and improve occupant thermal comfort.
- Increase minimum corridor widths to meet OBC standards and allow for BF access to all spaces as is outlined in 3.8 of the OBC.
- Blower Door Testing of units prior to leaving factory and again once in place at the designated site shall be required to ensure adequate sealing of building envelope.

6.2 Proposed Amendment To Ontario Building Code 2012

The intent of the following modifications to the Ontario Building Code are to improve the overall quality of the design, construction and installation of portable classrooms as well as relocatable buildings used in the industrial, commercial and institutional sectors in the province of Ontario.

The new Part Ten to be added to the Ontario Building Code is based on the model provided by the 2006 Alberta Building Code with select specific provincial modification to references. It should be adopted in its entirety, with additional modifications made to the base document in order for it to suit the specifics of the Ontario Context. The existing Part 10 "Change of Use", of the current Ontario Building Code, shall be relocated to Part 13 in order to contribute to the goal of code harmonization & standardization across Canadian provinces.

List of Modifications to Part 3 (3.9 Portable Classrooms Specifically)

See Detailed Modifications in Appendix B

- **3.9.3.1** Agglomerated Building Areas will only be acceptable where fire resistance ratings of wall assemblies are provided between individual classroom areas.
- **3.9.3.2** Spatial Separations between classrooms without adequate FRR of assemblies shall be increased from 6m to 10m to meet standards and requirements of other occupancies. Requirements around groupings of classrooms will be made more stringent to improve occupant safety.
- **3.9.3.3** Installation of integrated Fire Alarm Systems in all portable classrooms, connected back to the main school building shall be required, regardless of the number of classrooms or their proximity to one another.
- **3.9.3.4** Provisions for Fire Fighting shall be addressed with any portable classroom installation, on any site, regardless of total number of units or proximity to one another.
- **3.9.3.7** Fuel Fired Appliances – Ensure that building components around fuel fire appliances are of a suitable material.
- **3.9.3.8** Provision of Washrooms
- **3.9.3.9** Barrier Free Access – Accessibility should be provided for all Portable Classrooms and meet the spirit and intent of Section 3.8 of the OBC.
- **3.9.3.10** Installation Exit and Egress Signage this clause would be a new addition to the section requiring all portable classrooms to be fitted and installed with Exit and Egress signage in compliance with the OBC requirements for permanent school buildings.
- **3.9.3.11** Entry Vestibules (Climate specific) –
- **3.9.3.12** Windows and Daylighting
- **3.9.3.13** HVAC Equipment

List of Modifications to Part 9 (Housing and Small Buildings)

See Detailed Modifications in Appendix B

- **9.1.1.9** Site Assembled Factory Built Buildings – definition needs to expand to include none residential building types that are configured from Site Assembled, Factory Built Units including Office Mercantile, Industrial and Assembly Occupancies.
- **9.5.1.1** Expand the application of this section of the code to include buildings which are not occupied year round, or which are inhabited on a short term basis throughout the year.
- **9.10.3.3** Fire Exposure – change the definition of wall assemblies for factory assembled buildings to ensure that fire separations are designed for exposure from both sides of the wall (or floor, or roof) both interior and exterior.
- **9.10.10.7** Emergency Power Installations
- **9.10.14** Spatial Separations between Buildings
- **9.10.21.1** Fire Protection of Construction Camps - requirements of this section shall apply to multiple occupancies, not solely residential type encampments
- **9.10.21.2** Separation of Sleeping Rooms
- **9.10.21.3** Floor Assemblies between 1^{st} and 2^{nd} Storey
- **9.10.21.4** Walkways Connecting Buildings
- **9.10.21.5** Spatial Separations
- **9.10.21.6** Flame Spread Ratings
- **9.10.21.7** Smoke Detectors
- **9.10.21.8** Portable Fire Extinguishers
- **9.10.21.9** Hose Stations
- **9.10.21.10** Spatial Separations

New Part 10 Relocatable Buildings - List of Modifications to base documents

See detailed list of modifications in Appendix B

- **10.1 Application**
  - **10.1.1.1** Responsibility for Compliance
  - **10.1.1.2** Application
  - **10.1.1.4** Renovation Requirements of Existing Units
  - **10.1.1.5** Temporary Facilities
  - **10.1.1.6** Combined Activities
- **10.2 Structural Requirements**
  - **10.2.1.1** Structural Design
  - **10.2.1.2** Foundations
  - **10.2.2.3** Floor Loads
  - **10.2.3.1**. Design
  - **10.2.3.2** Tie Down Devices
- **10.3.1.1 Heights**
- **10.4 Fire Safety**
  - **10.4.1.2** Membrane Protection
  - **10.4.1.3** Sleeping Rooms
  - **10.4.1.4** Service Rooms
  - **10.4.1.5** Exterior Wall Requirements
  - **10.4.1.6** Fire Separations
  - **10.4.4.1** Windows
  - **10.4.6.1** Number of Exits and Travel Distance
  - **10.4.7.3** Portable Fire Extinguishers
- **10.5 Health Requirements**
  - **10.5.1.2** Insulation – Units shall be required to provide continuous insulation on all building assemblies to prevent thermal bridging and increase occupant thermal comfort.
  - **10.5.1.5** Forced Air System
- **10.6 General Safety**
  - **10.6.1.1** Spatial Separation
  - **10.6.1.3** Proximity to Vegetation
  - **10.6.1.4** Proximity to Process Areas
  - **10.6.1.5** Proximity to Blast Zones
  - **10.6.2.1** Skirting
  - **10.6.2.2** Underside of Units
  - **10.6.4.2** Kitchen Hoods, Canopies and Exposed Exhaust
  - **10.6.5.1** Emergency Lighting
  - **10.6.5.2** Exit Signs

6.3 Proposed Amendment To The National Building Code of Canada (NBCC) 2010

The ongoing work to harmonize the provincial and national building codes across Canada is an important step towards improving the quality, legibility and consistency of construction standards and practices throughout this country while simultaneously allowing the adoption of new and innovative performance based strategies to improve buildings. The proposed modifications to the National Building Code of Canada documents should mimic those of the proposed changes to the Ontario Building Code Compendium in an effort for increase harmonization between the code requirements of different provincial and territorial jurisdictions in Canada. For specific regional concerns, including Seismic or Earthquake considerations, additional modifications should be added to the National Building Code in an appendix to address localized regional concerns.

In some respects the modifications and additions to the National building Code are greater than that of the Ontario building code as there are a larger number of parts that would need to be added to more fully address portable classrooms and relocatable buildings on a national level.

Modifications to Part 3 Fire Protection, Occupant Safety and Accessibility

The NBCC does not currently have a specific section in Part 3 that deals with portable classrooms – Part 3.9 Portable Classroom from the OBC – as amended by this proposed document shall be adopted

Modifications to Part 9 Housing and Small Buildings

The NBCC does not currently address the specific topic of camp for housing workers – this section 9.20 shall be adopted from the Ontario Building Code – as amended by this proposed document.

Addition of Part 10 – Relocatable Buildings

In its current format, there is not a Part 10 in the NBCC, nor is there a section which directly addresses relocatable buildings. As such, Part 10 Relocatable Industrial Accommodations from the ABC – as amended by this proposed document shall be adopted.

See Detailed Modifications in Appendix B

Conclusion

> "Finally the design and production focus must include objects beyond efficiency, affordability, logic and systemic sustainability and must include the larger functionality of human desire for culturally rich, environmentally responsible and enjoyable inhabitation for all people."[111]

Goal of the Thesis

There are companies who are voluntarily producing higher quality of prefabricated relocatable buildings that can be looked to as models for how to modify and improve the industry and the output of this industry as a whole. Although this higher quality of output is not the current norm, it is possible. Additionally, this level of quality is unlikely to be widely adopted by other manufacturers unless it is mandated through legislation and regulation. Without modifications to legislation and regulations, such as the ones suggested in this thesis, some of the most vulnerable people within our society: including poor, marginalized communities, children, and low income workers will continue to be adversely affected by these types of buildings. These groups will continue to be required to inhabit substandard, and in some cases precarious spaces.

This thesis focused specifically on Relocatable Buildings (RBs) used in the Industrial, Commercial and Institutional (ICI) Sector, in order to highlight and provide suggested reforms to address the existing issues surrounding regulations governing the design, production and installation of this type of structure. Furthermore, the recommendations are intended to raise the level of quality required by the governing bodies through increased regulations of this industry. By implementing modification to the existing Ontario and National Building Codes, alongside the specific CSA standards that govern these buildings; there is a potential opportunity to raise the quality of construction of all new Relocatable Buildings across Ontario. Such regulatory changes could serve to bolster the mandate for the development of useful, functional, safe, durable, and culturally appropriate relocatable structures.

Key Improvements to Relocatable Buildings Required:

- **Quality of Product** – Experience of User
- **Durability -** Embodied Energies and Life Cycle Costs of Disposable Construction
- **Fire & Life Safety -** Minimizing Potential for Harm
- **Human Comfort –** Meeting Occupant Needs
- **Energy Efficiency -** Responsible Resource Use

Even though architects presently have a limited level of involvement in the Relocatable Buildings industry, there are many reasons why architects could take on a larger role with regards to this segment of the built

[111] Anderson and Anderson. Prefab Prototype. Pg. 18.

environment. While the individual construction value of any single one of these structures may not be tempting most firms for prospective fees, as a whole business sector between new, lease etc.[112] Architects choosing to develop a specialty for consulting with prefabricated building manufacturers, have an opportunity to capture a larger part of the relocatable buildings market segment.

> According to the Canadian Manufactured Housing Institute (CMHI), in their 2012 Annual Report, the manufactured building industry in Canada is worth $1.3 billion annually, and the residential units produced by this industry represent nearly eleven percent of all single-family homes started in 2012.[113]

Beyond the financial opportunities that lie within this market segment, is the potential to significantly impact a large number of individuals, through small policy modifications. The more institutional, commercial and industrial clients look to these types of short-term, 'make-shift' solutions for their building needs, the less they are investing in quality permanent building solutions, and the less quality work that architects have to design. Architects are a part of the community and what affects the health and well being of the above group of individuals and users, ultimately affects us.

Many within the architectural field have turned their attention towards the various merits and pitfalls of 'pre-fabricated construction' championing one approach to efficiency vs. another, lauding the grand possibilities of the industry "if only" consumers and industry would catch up with the innovations and theories that designers are putting forth. Architectural magazines, websites and journals celebrate the cutting edge applications of "prefabricated" and "modular" design concepts and products but seldom zero in on the state of the industry in clear terms or identify where the true needs and opportunities for design innovation lie relative to this approach to construction.

In the current economic environment, expenditures by large companies on capital investments continue to diminish. The notion that the minimum requirements are equal to the maximum expenditure continues to permeate attitudes towards investment in temporary or relocatable buildings. Multinational organizations and government departments are determined to cut costs and reduce budgets and look for all manners of cost savings to achieve these ends – often with unintended deleterious results. As companies continue to shrink investment in basic capital items such as buildings and infrastructure, it is critical that regulations and codes maintain adequate standards for the construction of buildings and consumer products.

This large-scale divestment in permanent structures and adoption of 'temporary building' strategies is harmful to the built environment, and the development of long term, viable and sustainable communities in many ways. While there are legitimate reasons and uses for the installation of short-term use buildings in exceptional conditions, increasingly companies and government agencies are using these substandard shelters to fill long-term needs and in the process affecting each of the following groups:

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[112] www.modular.org - Modular Building Institute – Baird Report.

[113] Canadian Manufactured Housing Institute, 2012 Annual Report – Forum Edition, October 2013, Pg. 1

- Architects / Engineers / Designers
- Construction Industry
- Inhabitants / Occupants of these structures
- The families of the occupants
- The morale of the employees and the workplace as a whole
- The overall community

Unfortunately, the implication that relocatable buildings will be in place for a "short time" has given license to owners and manufacturers in the past to circumnavigate the laws requiring construction of a certain level of quality and durability. The result is a raft of disposable buildings, which are inevitably occupied well-beyond their "expiration date" because of the high costs for transportation, logistics and replacement. Those costs associated with relocation of occupants and mobilization and logistics stay constant regardless of the quality of construction that is erected. Therefore the poorer the quality of construction of modular units, the more frequently they will be required to be replace, the more that an organization spends on: relocation, mobilization, logistics., and the more headache, frustration and loss of employee morale from the disturbance and upheaval within the workplace. Additionally, based on the current quality of construction that these units presently conform to, there are preconceptions of these building typologies including impermanence, transience, and poverty. There is an opportunity for these existing stigmas to be removed.

> "Owing in large measure to the arrogance of its visionary architects, the past century has seen the failure of vision after vision of a new and better world of a more accessible architecture….Needed here to sustain the dream of an accessible architecture is a commitment to a pluralist process. Rather than the imposition of architectural vision on contemporary modes of construction, the process must be a broadly based fusion of all possibilities and capacities across the entire spectrum of those who make architecture. We need a new vision of process, not just product. Along with architects, the vision must include those who own and use the architecture, those who assemble buildings and those who develop materials and engineer the new products that become our architecture. The vision of an integrated process, in which a collective intelligence replaces the architects singular imposed intelligence must become widespread before off-site fabrication can become the standard means of architectural construction."[114]

While building codes and regulations can be perceived by some as a hindrance and a limitation to creative expression, used as the scapegoat on which other goals are sacrificed; if their underlying purpose is embraced, these same codes and regulations can be a generator for improved quality of final product output. Regulations can serve to empower clients and building occupants to ask for and expect even the most simple and economical structures to fulfill fundamental requirements of safe, functional and comfortable shelter. The raising of minimum standards also will serve to ensure that contractors, and manufacturers are required to compete on a level playing field. The initial purpose of building codes and their very reason for existence is specifically to protect the public.

[114] Kieran and Timberlake. Refabricating Architecture. Pg. 107.

Opportunities for the Profession

> "…an examination of the history and development of portable architecture does reveal that this significant part of constructional design has been largely ignored both in terms of the opportunities it presents for appropriate solutions to specific problems, and as a source of theoretical, formal and technological inspiration in the creation of architecture in general."[115]

Robert Kronenburg, editor of a series of books entitled Transportable Environments, discusses the architectural profession in relation to the development of relocatable buildings and highlights the lack of direct involvement with this area of construction by the architectural profession at large. While architects have traditionally had minimal involvement in the design and development of relocatable building units, there are opportunities to work with clients and manufacturers of this industry segment to develop new design relationships and aid in the improved quality and layout of these structures both within the units themselves as well as in their overall placement and siting. The present standards and regulations for manufactured buildings used for occupancies other than the 'park-model' manufactured home are significantly lacking and the vagueness around these standards has resulted in a hodge-podge of implementation strategies with varying success and results and layer upon layer of frustration for the owner, client, consultants and municipalities alike. As each tries to navigate the inconsistent and unclear, requirements set out for this type of construction.

In his book, Home Delivery, Barry Bergdoll issues a 'challenge for the next generation':

> "To pursue a deeper engagement with the techniques of fabrication and an expansion on the range of issues that the new experimental impulse is poised to tackle. The history of standardization is rife with lessons to be learned, not disregarded, even as the constriction of designing in a digital environment and making in a globalized world are reconfiguring the very space in which this practice takes place."[116]

Bergdoll's challenge to architects and designers, to engage techniques of fabrication can also extend to engagement with the regulatory frameworks and policies that shape the buildings inhabit, in direct and indirect ways. By engaging with the process of policy development and regulatory modifications, architect have an opportunity to drive systemic changes across and entire industry rather than incrementally, one building at a time. For building typologies such as relocatable buildings, whose client base (purchasers) it often very removed from the occupants of the space, making changes that require wide scale adoption of improved standards is a much more effective method of implementation.

Through the adoption of a clear set of regulations and guidelines, tailored to the specific nature and nuances of the relocatable building industry, the province of Ontario can take a more consistent, even and fair approach to implementing increased construction requirements for the manufacturers within this industry. Simultaneously, those same regulations and guidelines can drive much needed, and long overdue, improvements for the

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115 Robert Kronenburg. Transportable Environments 2: Theory, Context, Design & Technology. Pg. 52.
116 Barry Bergdoll. Home Delivery. Pg. 25.

individuals, groups and communities using Relocatable Buildings of various types. Additionally, such regulatory changes will also serve to aid municipal planning departments confronted with applications for relocatable building developments, by clarifying standards and requirements for their installation.

Epilogue

Emerging from the discussions that were started in the oral defense of this thesis, were several very interesting potential areas of exploration that could inform future related research and investigation. Below is a summary of some of the key questions that arose and reflection by the author on the research.

1. How does the integration of a new Part 10 impact the role of architects in the design and development of the relocatable buildings proposed for coverage under this umbrella? Will such an addition to the Building Code Compendium serve to further diminish and remove Architects from involvement in these building types, as has been the case in the development of the Part 9 designation of smaller buildings? To what extent does the proposal to add Part Ten, to the OBC and NBCC, further erode the role of Architects in the design and shaping of the built environment? This was experienced subsequent to the introduction and adoption of Part Nine: Housing and Small Buildings to the Ontario Building Code: which has allowed non-architects to design a large portion of buildings.

"Part 9 – Housing and Small Buildings" of the Ontario Building Code and National Building Code of Canada has been used to allow non-architects to design buildings based on a perception that smaller buildings are not as complex and therefore might not required the same level of skill or attention that large buildings need. This position has been very harmful to the architectural profession, as it diminishes the work performed by architects in the smaller scale building market, and often places them at a distinct disadvantage, as they compete for work with individuals who have lesser education and training, and who charge lower fees. The result is that few architects outside of major metropolitan areas are able to find work designing single-family homes or other small-scale buildings as the clients do not see the services of an architect as warranted or necessary.

The intent of the author within this work, and through the proposal of a new Part 10 of the OBC is not to further whittle away the number and or type of buildings that required the involvement of an architect, quite the opposite in fact. By separating out and clearly identifying more stringent requirements that would apply to buildings of this typology, it is meant to clarify the requirements that need to be met in the minds of current and potential owners of these building. Consolidating the typical requirement in a concise section of the building code while also stream lining communication between the various parties involved can improve the processes of selection, procurement, site layout and the various levels of permitting required. By providing consistency in the expectations of manufacturing companies, contractors, and future owners across the province a more predictable, reliable, durable and efficient product can be designed and delivered.

The Part 10 proposed to be added to the OBC through this thesis proposal would continue to require that architects be involved throughout the process of module design, site design and construction / installation.

Steady erosion of the role and importance of architects in the design and development of buildings has occurred since the introduction of Part Nine in the building code, which separates out Housing and Small Buildings from the main purview of the Building Code. Fewer qualifications and requirements are necessary for the individuals overseeing these types of projects – would Part 10 Continue this trend of further excluding architects from involvement in projects implementing Relocatable Building Modules?

No, the opposite is true of the author's intentions. This proposed additional code section would serve to clarify and reinforce the Building Code Requirements that apply to these types of structures, but would not remove architects from their role of designer and facilitator. By creating a condensed, specific section geared to Relocatable Buildings it emphasizes that the industry must comply with OBC requirements and would serve as a 'way-in' to complexes that would require more thorough and involved evaluation through Part three. Part Ten would serve to draw attention to these specific types of buildings in a manner to make manufacturers and owners more accountable for their decisions to ensure the appropriate professionals (architects and engineers) are engaged and that construction and installation is in compliance with the local (Ontario) standards.

2. Considering that pre-fab modular classrooms and relocatable building modules appear, in many ways, more like a consumer product; more akin to a refrigerator to be bought, used and disposed of at the end of its useful life, than a permanent structure. Would it be better for these types of buildings to be regulated by another Authority Having Jurisdiction (AHJ) such as the ISO organizations, CSA, or transportation department?

The question of Relocatable Buildings being considered as a product appears to only have a viable application when considering or evaluating a single module in isolation. Once the unit becomes part of a larger agglomeration; whether that is a combination of 2 or 25 units, whether the units are physically connected or placed in close proximity to one another that definition changes. By virtue of combining the 'building blocks' together, the nature of the object is altered and the ability for the design and manufacture of the product in isolation to respond adequately and appropriately to the new context in which it is placed is questioned. The ability for the unit as a 'product' to ensure its quality and performance in a clustered community arrangement is diminished or compromised if the siting and placement of the units is not taken into account. The role of the architect in the design, detailing and contextual siting of these units is crucial to planning for occupant health, safety and comfort over the long term and developing a framework or master plan for the appropriate expansion and growth of a Relocatable Building Complex over time. Navigating aspects of building proximity and relational siting considerations are critical, not only to issues of life safety but also in developing functional and flexible site plans that work in the larger community context.

3. Discuss your Speculation on an Expanded Projective Practice, which could emerge from this research inquiry into Relocatable Buildings.

Beyond adoption and implementation of increased Building Code Regulations, the goal of this thesis work, to improve the lowest of the low performing portable classroom and industrial accommodations. There is a vast amount of research and work that can be undertaken to move beyond those improved minimum standards to develop Efficient, Economical and Inspiring Spaces. Incorporation of new technological approaches to manufacturing will, without doubt, play a significant role in changing this industry.

Architecture can be a means of Social Advocacy. Architectural work has the opportunity to provide unique ways of seeing, understanding and helping to address social problems, which differentiates itself from much of the social justice work of our professional colleagues; in professions such as law or medicine. This is primarily because in some cases we can step back from the problem at hand and create visions, or ideas of the big picture, helping to shape a community or space for decades into the future. Our colleagues in other fields have to address the immediacy of a situation, while we plan and design for much longer horizons.

Architects have a unique skill set to bring their communities and should be encouraged to engage and develop those skills for social advocacy early on. Our role in shaping communities, buildings and spaces in which the public lives, works, plays and learns behooves us to speak up for those populations or groups which are underserved, vulnerable, or disenfranchised and make space for them.

The notion of design advocacy (speaking up, speaking out) meshes into that of design empathy, and in some ways serves as its foil. Design Empathy (being open and receptive to the diverse needs of client user groups) encourages the architect to provide spaces for a range of needs, sensitive to that fact that we each navigate our space and our world in individual ways.

4. How does the Research into Design Empathy inform the development of Relocatable Building Standards, specifically the design of Portable Classroom Modules?

Architects and members of the design and construction industry have a moral obligation and ethical duty to accommodate all (as many as possible) members of society when constructing building facilities, especially those for use by the public such as schools. The concept of 'Design Empathy' that AJ Paron-Wildes is promoting through her research and design work at Allsteel, a systems furniture design and manufacturing company, is predicated on the importance of "how our spaces need to accommodate a variety of sensory

experiences."[117] The spaces that we design for classroom settings, work environments and homes need to be created with an understanding of the role that sensory stimulation of *all five senses* has on occupant health and comfort. Stemming from her own experience, with her son who is on the Autism spectrum. Paron-Wildes' emphasis that just as there are different types of learning comprehension skills, so are there elements in the surrounding environment of a classroom or workspace that can distract, or inhibit the capacity of some individuals within that space. Excessive noise, and poor acoustic separation of spaces can be very detrimental to the capacity of students, especially those with learning disabilities, autism, or other cognitive impairments, to learn. Similar to the problem of auditory distractions, are flickering fluorescent light bulbs and or computer screens and intense colour schemes, or excessive smells from off-gassing materials or the development of mould, which further detract from the students' attention span.
Beyond providing a space, which provides safe and quiet shelter, classroom spaces and other work environments need to be designed in a manner that does not assume a 'one-size-fits-all' approach is the best way forward.[118] Variety within rooms to provide opportunities to retreat, and focus
In -A.J. Paron-Wildes' words: "What I have always found is that when you design for autism, the general population benefits"[119]

By designing facilities and spaces that accommodate the most disadvantaged and challenged members of our communities, we improve the quality of building for everyone, and bolster the work of creating a more accepting and inclusive society.

Reflecting on the topics addressed by this thesis post-defense, there are many directions that continued research and investigation could take to further the goal of improving Portable Classrooms for students and teachers and other relocatable buildings for a variety of user groups. Some of the next steps that others looking to further develop this line of work could focus on would include a further detailed energy modeling of these existing buildings within the Canadian context. This research looks to the larger North American Community for examples of what is currently available and possible, however, testing some of these various models against our local climate would serve to reinforce the previous findings illustrated by the two American Study groups.

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[117] Szenasy, Susan S. Metropolis. August 6, 2014.
[118] Szenasy, Susan S. Metropolis. August 6, 2014.
[119] Bozikovic, Alex. 'Design Empathy' builds inclusive spaces for people with Autism. Globe and Mail. April 15. 2015.

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APPENDICIES

This example shows a small washroom trailer that has been equipped with Barrier Free Fixtures and stalls and indicates the potential location of a Barrier Free access ramp. Such ramps are seldom provided upon initial installation.

APPENDIX A – Sample Relocatable Building Drawings

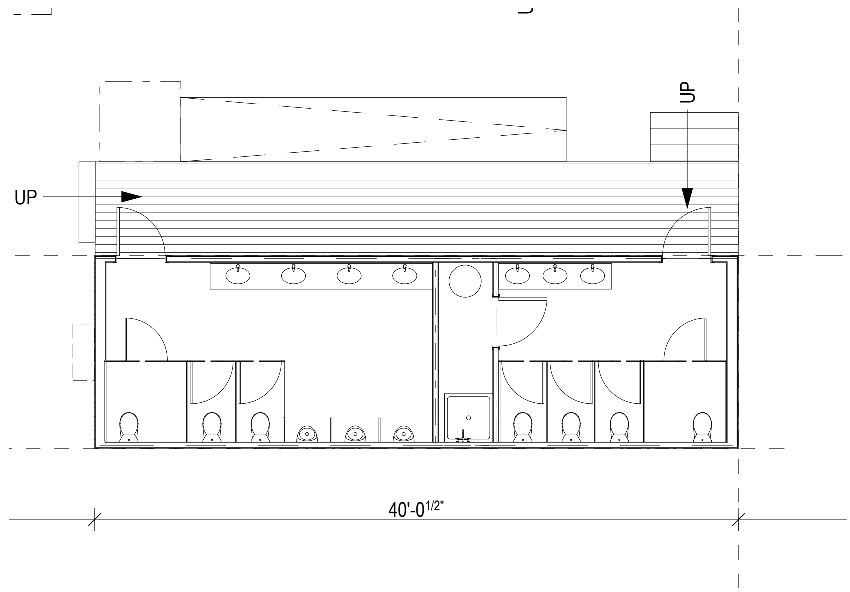

Figure A-1: Small Washroom Trailer Layout

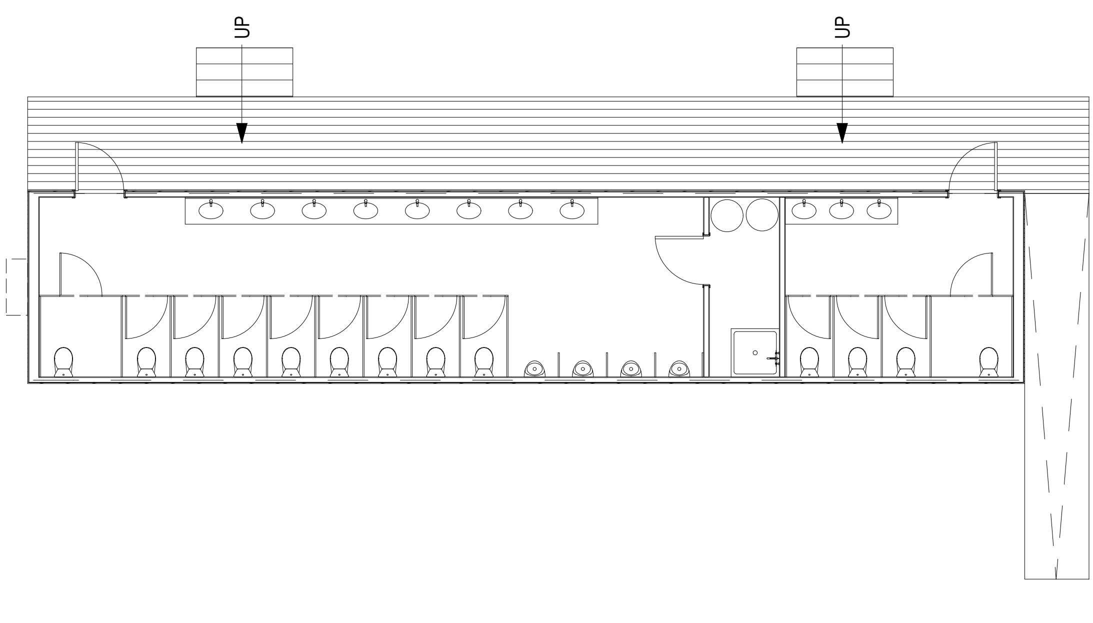

Figure A-2: Large Washroom Trailer Layout

These configurations depict as single module for two different potential applications. The base module is the same, while the Locker room is fitted with basic lockers and benches, and no windows are installed. For the Offices module, once closed office and one small meeting room make up the two ends of the unit while an open workspace is provided in the centre of the module. In both of these examples, vestibules are not provided, compromising both thermal performance of the units as well as privacy issues for the occupants.

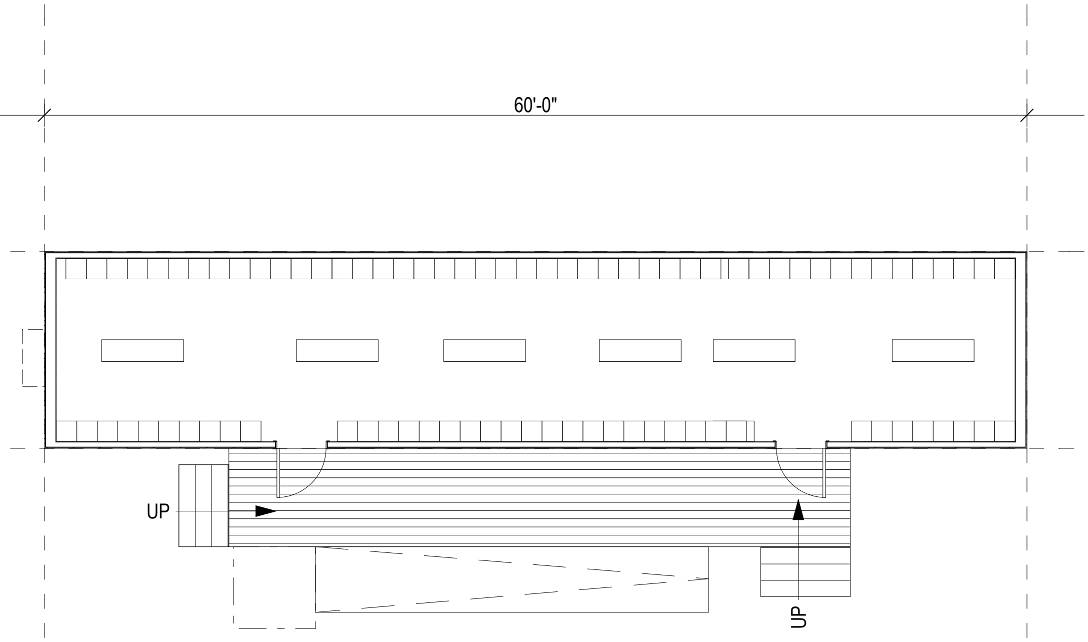

Figure A-3: Locker Room Trailer Layout

No washrooms are provided – They are to be provide by a separate washroom module

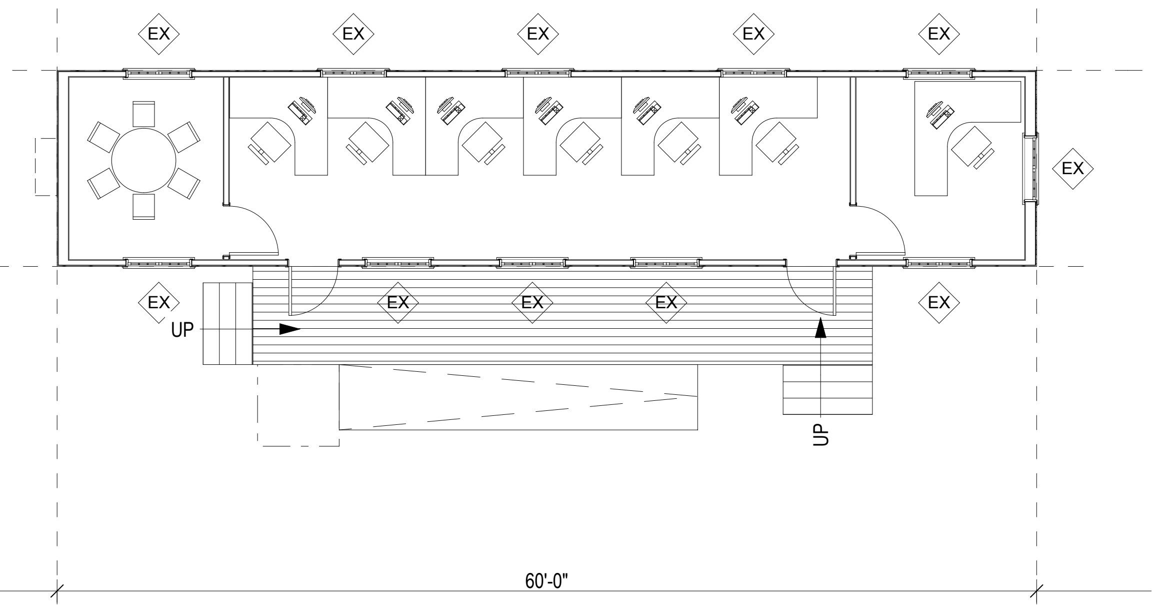

Figure A-4: Office Trailer Layout

This example of a double module unit for an office space provides two private offices, a medium sized meeting room and a small mechanical /electrical room with the central portion of the combined units being used for open workstations. Similar to the Single Trailers, no vestibules are furnished, and while this drawing indicates the potential location of a Barrier Free access ramp, these are seldom provided in industrial settings.

No washrooms are provided – They are to be provide by a separate washroom module

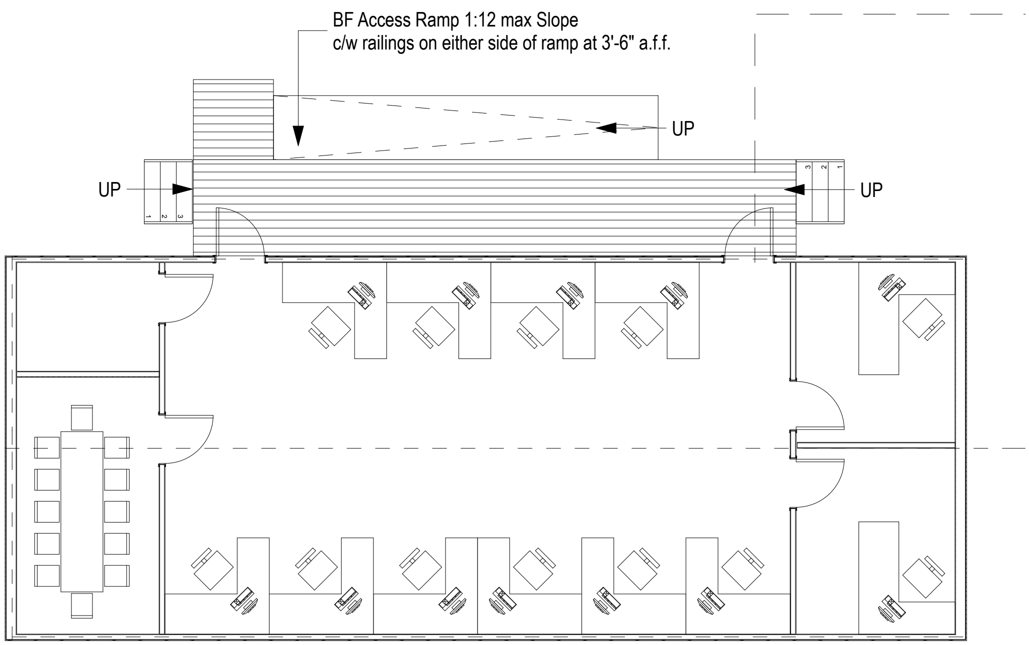

Figure A-5: Double Unit - Office Trailer Layout

This example of a double unit Lunch and locker room arrangement show a potential layout, which separates the work clothing, coveralls and PPE from the eating spaces in accordance with OHSA standards As with the other modules, no vestibules are provided, not hand wash sinks are provided,

No washrooms are provided – They are to be provide by a separate washroom module

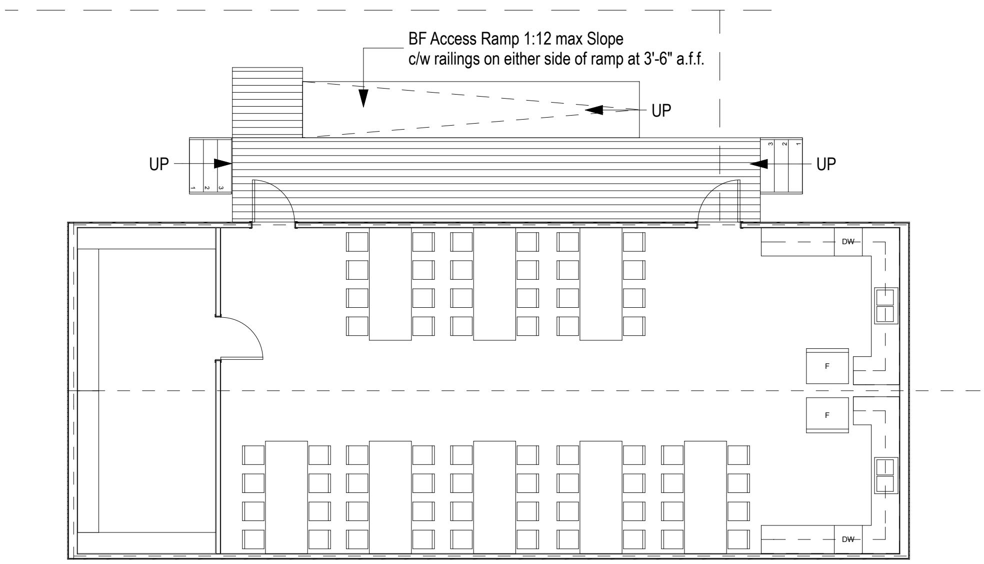

Figure A-6: Double Unit – Lunchroom Trailer Layout

This is an example of a six module office complex. The arrangement is intended for the complex to be used by two separate sub-contractors on the same site. While Privacy is provided in the form of a wall separating the two sides of the complex, sound insulation levels are typically minimal, and sound and heat transfer can be an issue

No washrooms are provided – They are to be provide by a separate washroom module

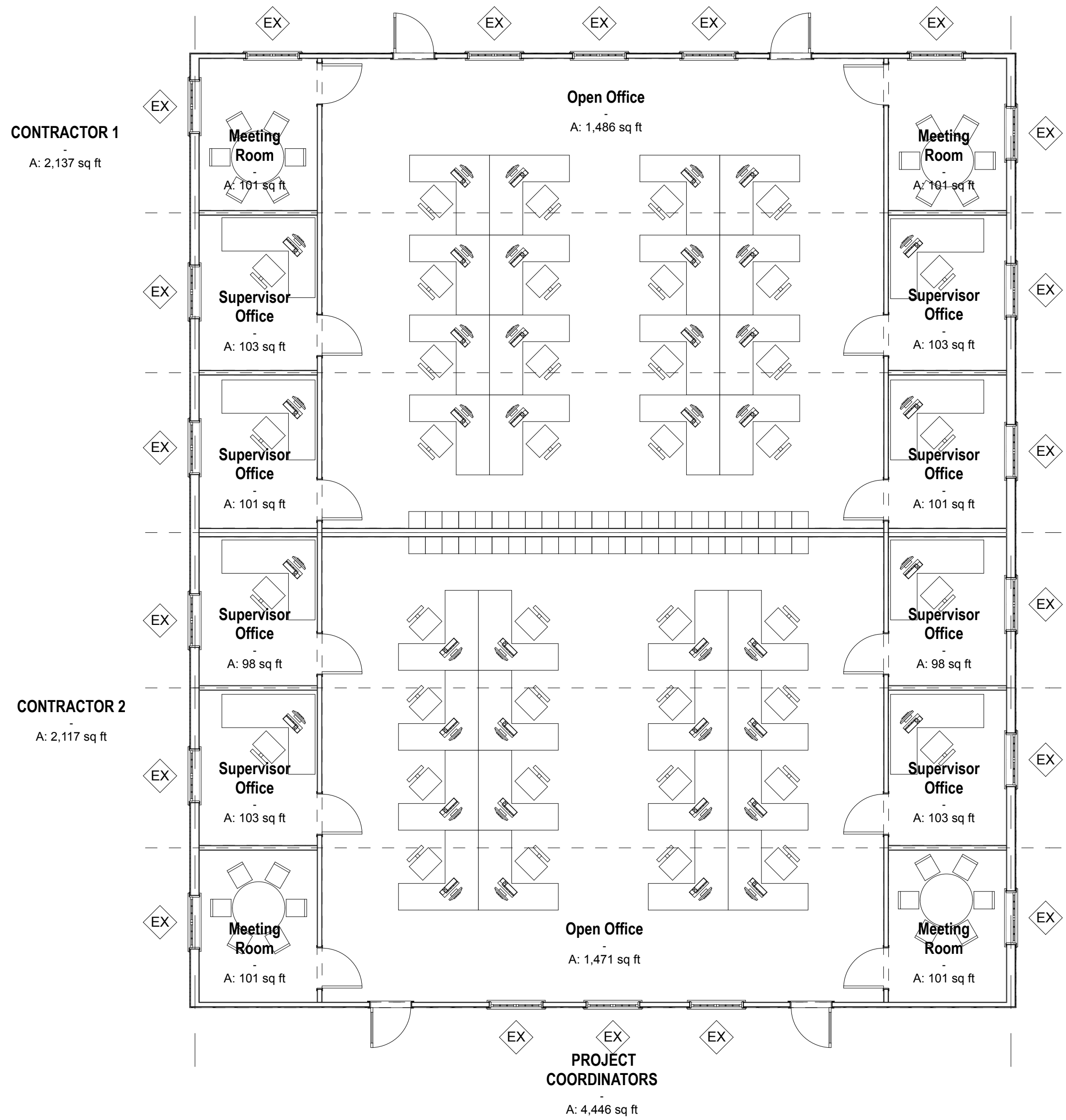

Figure A-7: Multi-Unit - Office Complex Layout

Sample arrangement of another 6 module office complex which combines open workstations with private offices and small meeting rooms. This particular arrangement is intended for a combination of 6 different sub contractors working on a single site, with an internal corridor that functions as a vestibule.

No washrooms are provided – They are to be provide by a separate washroom module

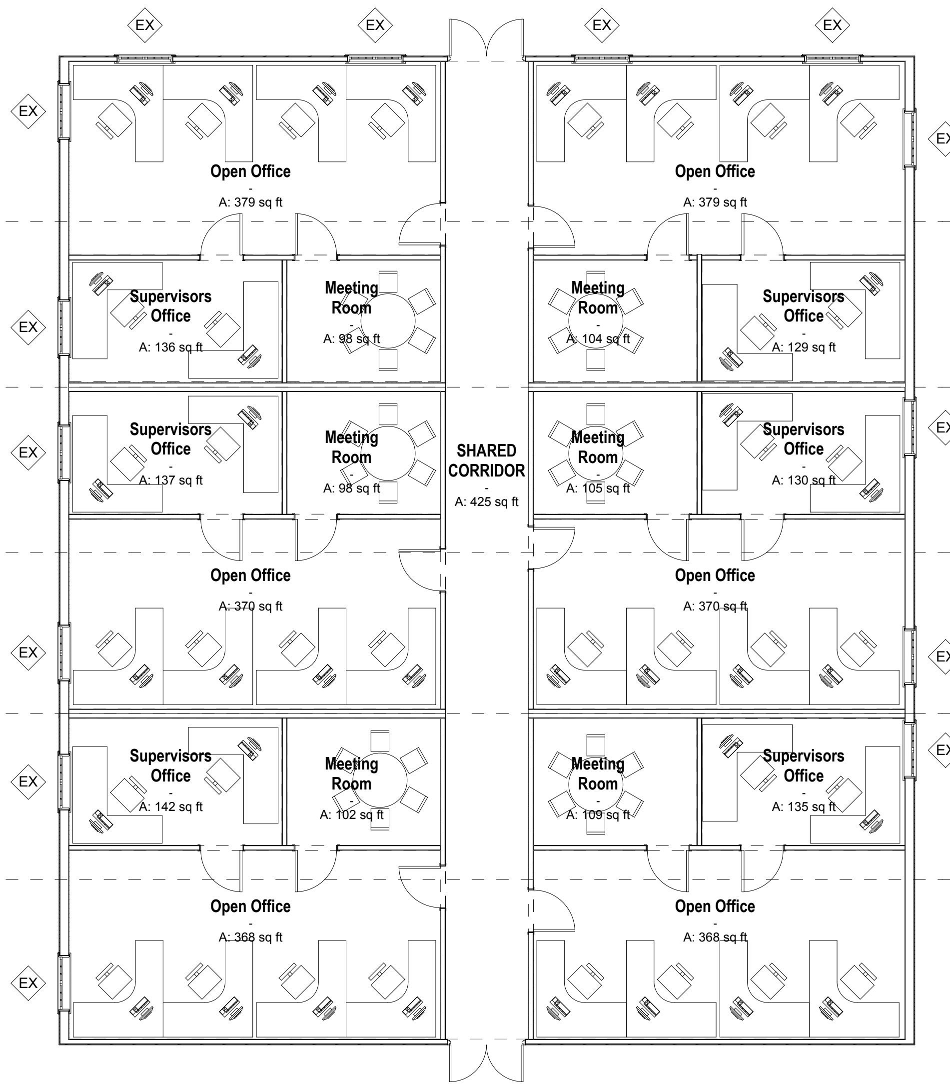

Figure A-8: Multi-Unit - Office Complex Layout (Multiple Contractors)

This layout is of a 7 module office complex designed to serve 4 sub contractors of varying sizes and compositions on a single site within the same building.

The Layouts Provide a combination of enclosed private offices, small and medium meeting spaces, and open office areas.

No vestibules are provided,

No washrooms are provided – They are to be provide by a separate washroom module

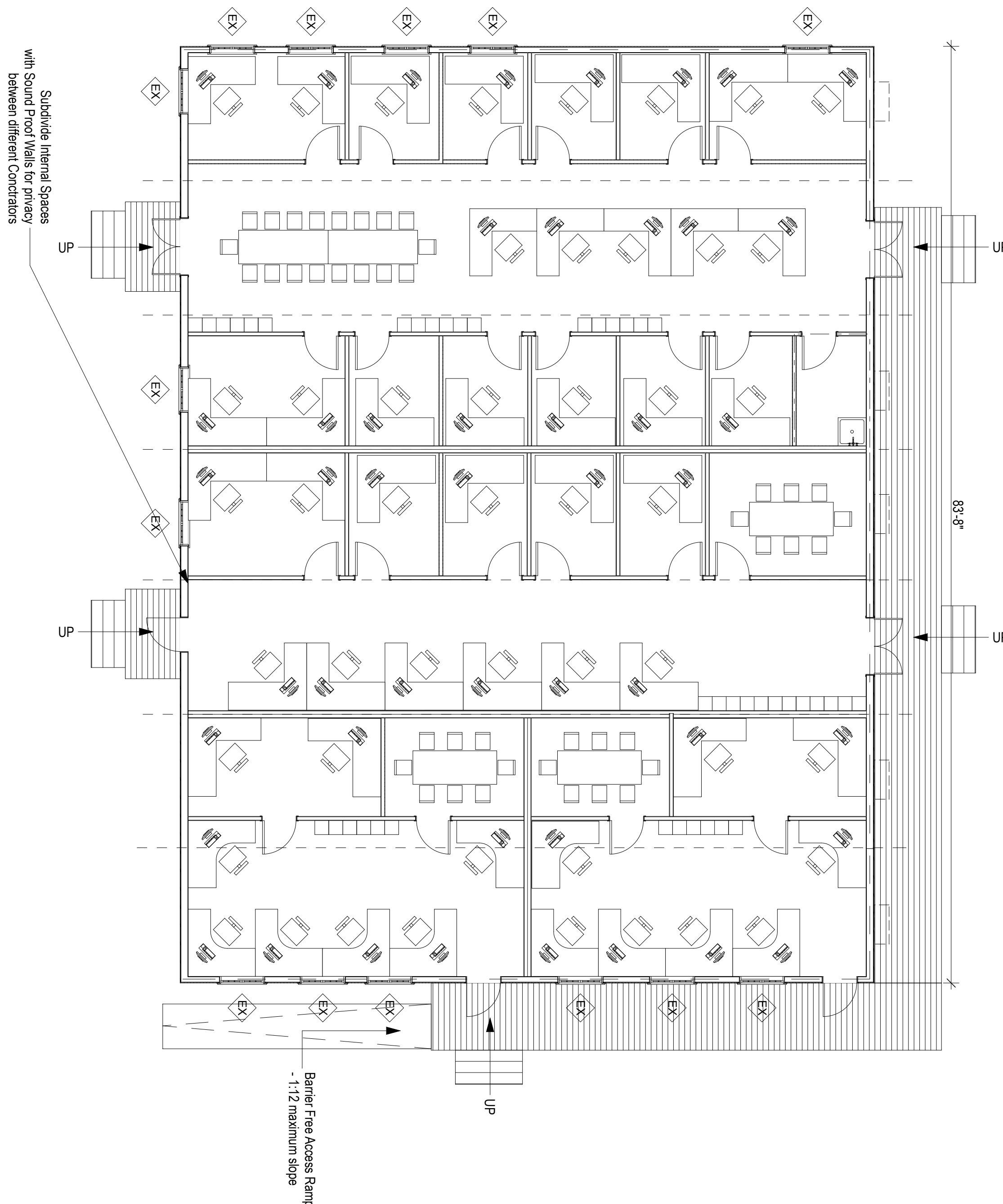

Figure A-9: Multi-Unit - Office Complex Layout with Meeting Areas

APPENDIX B

Detailed Proposed Modifications to Codes and Standards.

Legend for reading the following proposed revisions to each of the attached standards:

Black text
– No change is proposed to the original text.

Highlighted Black text
– The author suggests removing or modifying these clauses

Red Text
– New Clauses or wording are proposed by the author

Blue Text in Side Bar
- Commentary and/or background explanatory information on why changes are being proposed for a given clause.

(1.1)
The stated objectives listed in section 1.1 do not seem to align with the reality of typical construction emerging from the manufactured homes industry. Given the level of general deterioration and decay that these structures undergo in a very short time space, it is difficult to reconcile the stated goals with the standard product.

This needs to change.

The quality of living space is not addressed at all nor is energy efficiency of the 'home' as a system.

CSA Z240.2.1-09

Structural requirements for manufactured homes

1 Scope

1.1

This Standard specifies the minimum requirements for materials, products, equipment, and quality of work needed to ensure that manufactured homes will provide adequate

(a) structural strength and rigidity;
(b) protection against corrosion, decay, insects, and other similar destructive forces;
(c) protection against the hazards of fire
(d) resistance to the elements; and
(e) durability and economy of maintenance.

1.2

In CSA Standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; "may" is used to express an option or that which is permissible within the limits of the standard; and "can" is used to express possibility or capability. Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material. Notes to tables and figures are considered part of the table or figure and may be written as required. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below including all amendments published thereto.

3 Definitions

In addition to the definitions specified in CSA Z240.0.1, the following definitions shall apply in this Standard:

(Comprehensive list of definitions excluded in this reprint and analysis as no specific changes or critiques to the definitions are listed.)

4 General requirements

(4.1)
Clearly there is a wide ranging number of responses to what might be considered "good engineering practices" in the context of manufactured homes and relocatable buildings in general. The standard needs to be more specific with its requirements for quality control if tangible improvements are to be made to the base requirements of models outlined in this document

This reiterates the fact that this standard was not developed to address non-residential occupancies or typologies

4.1 Equivalence

Unless based on an accepted engineering design for the intended use, new manufactured home materials, equipment, systems, or methods of construction not covered by this Standard shall be subject to tests that simulate conditions that occur during normal use. An engineer or architect, as appropriate, shall verify the materials, equipment, systems, or methods of construction will provide performance equivalent to that required by the CSA Z240 MH Series of Standards.

4.2 Minimum requirements

The design and construction of a manufactured home shall meet the requirements of this Standard. Requirements for any size, mass, or quality of material modified by terms such as "minimum", "not less than", and "at least" shall be considered minimum standards. The manufacturer or installer may exceed the minimum standards if such deviation does not result in inferior installation or defeat the purpose of this Standard.

4.3 Construction methods and quality of work

Construction methods and quality of work shall comply with good engineering practices to ensure durable, livable and safe housing.

Durable – capable of lasting or able to withstand change, decay or wear.[120]
Livable – (of a house, room, climate, etc.) fit to live in.[121]
Safe – free of danger or injury.[122]
Housing – shelter, lodging, accommodation[123]

(4.3)
Definitions of each of the qualities listed here is essential:
Durable
Livable
Safe

4.4 Lumber

4.4.1 Grading

Lumber used in the construction of manufactured homes shall be graded in accordance with Table 1 (at a minimum) and in accordance with CSA 0141.

4.4.2 Remanufactured lumber

Lumber remanufactured after original grading and grade marking and intended for structural use shall be regarded, except when used for wall plates or for blocking. When remanufactured lumber is too small to be graded under the NLGA's Standards Grading Rules for Canadian Lumber, the following requirements shall apply:

(a) the slope of grain shall be limited to the equivalent of construction grade (1:6) and

(b) the limit for defects in the wide face, the narrow face, or the wide and narrow faces combined shall be one-third of the cross section of the member (see Figure1).

4.4.3 Trusses

When trusses have been tested in accordance with and meet the requirements specified in Clause 7, only lumber of a strength and stiffness equivalent to that of the test trusses shall be used. Equivalence shall be determined in accordance with CAN/CSA-086.

[120] Oxford English Dictionary Pg. 434
[121] Oxford English Dictionary. Pg 838.
[122] Oxford English Dictionary. Pg 1269.
[123] Oxford English Dictionary. Pg 686.

5 Structural Design

5.1 General

5.1.1 Design and construction

A manufactured home shall be designed and constructed as a completely integrated structure capable of sustaining the design loads required by this Standard, and shall be capable of transmitting such loads to foundations, including piers, without causing unsafe deformation or abnormal internal movement of the structure or its structural parts. During transit, the integrated structure shall be capable of transmitting the specified in-transit loads to the wheel assembly, which in turn, shall be designed to transmit these loads safely to the ground.

(5.3.1.1) The structural requirements of these units need to be modified in order ensure that all models can adequately support membranes to provide necessary fire separations and fire resistance ratings of the assembly. Therefore, the structural requirements shall be increased for all assemblies to adequately support gypsum board interior and exterior membranes, or other non-combustible sheathing.

5.1.2 Structural members and their connections

When the sizes of and connections for structural members are not specified in this Standard, the members and their connections shall comply with CAN/CSA-086, CAN/CSA=S16, CAN/CSA-S136, CAN/CSA-S157, and the Canadian Wood Council's Engineering Guide for Wood Frame Construction, except that the design live loads shall meet the requirements of Clauses 5.2.1 to 5.2.3 and deflection limits shall beet the requirements of Clause 5.3.

5.1.3 Equivalency of performance

5.1.3.1 General

Unless based on accepted engineering design for the intended use (), new manufactured home materials, equipment systems or methods of construction not covered by this Standard shall be subject to tests that simulate conditions that occur during normal use. An engineer or architect, as appropriate, shall verify that the materials, equipment, systems, or methods of construction will provide performance equivalent to that required by the CSA Z240 MH Series of Standards.

5.1.3.2 Test procedures

In the absence of standardized test procedures specified in this Standards, a manufacturer electing to obtain acceptance based on testing as specified in Clause 5.1.3.1 shall develop test procedures sufficient to demonstrate the structural properties and significant characteristics of the material, method of construction, equipment, or system. These procedures shall be submitted to the certification body for approval and shall, upon notification of approval, be considered acceptable for their specified purpose and become part of the manufacturer's approved design.

5.1.3.3 Independent Testing

Tests carried out with Clauses 5.1.3.1 and 5.1.3.2 shall be witnessed by an independent licensed engineer or architect or by a recognized testing organization. Copies of the test results shall be kept on file by the home manufacturer. Copies of the test results shall be provided to the purchaser or parties representing the purchaser for verification and review upon request.

5.2 Loads

Note: *See also Clause 5.1.2.*

(5.2.2)
It is essential that local weather and climatic conditions be incorporated into the design of the relocatable building modules, and that once built, the capacity of a given module is clearly labeled and aligned with specific regionally appropriate siting requirements.

(5.2.3)
Given the underlying requirement of relocatable buildings to move from one location to another, it is difficult to anticipate the required wind loads of a specific future location during the manufacturing process. As a result, the minimum design wind loads shall be increased to better prepare such units

(5.3.1.1(2))
All roofs shall be sized to adequately support the necessary amount of gypsum board to ensure that the assembly provides a 1hr FRR for the occupants.

(5.3.1.1(3))
All underside of floor systems shall be provided with a

5.2.1 Floor Loads

Floor Loads shall meet the requirements specified in Clause 9.23.4.2, Part 9, Division B of the *National Building Code of Canada or the Ontario Building Code*.

5.2.2 Specified Snow Loads

Specified snow loads shall meet the requirements specified in Clause 9.4.2.2, Part 9, Division B, of the *National Building Code of Canada or the Ontario Building Code*.

5.2.3 Wind Loads

The exterior wall framing shall be designed to resist a full design wind load of at least 0.7 kPa. The roof shall be designed to resist and uplift wind load of at least 0.4 kPa.
Prior to manufacture, installation, or re-installation of existing module, wind loads specific to the local site conditions shall be verified and re-calculated.

5.2.4 Component fastening

Structural components (roofs, walls, floors and support frames) shall be securely fastened together to prevent any adverse effects when subjected to the loads specified in Clauses 5.2.1 to 5.2.3.

5.3 Deflections

Note: *See also Clause 5.1.2.*

5.3.1 General

5.3.1.1 Structural members

The maximum live load deflection of structural members, when based upon accepted engineering design or the load tests described in Clauses 7 and 8, shall not exceed the following (where L is the clear span between supports):

(a) floor joists and floor trusses: L/240;
(b) roof beam (not supporting plaster or gypsum boards: L/240;
(c) roof beam and rafters or trusses (supporting plaster or gypsum board): L/360
(d) roof rafters or trusses (not supporting plaster or gypsum board and exceeding 4.3m in overall span): L/180
(e) roof rafters or trusses (not supporting plaster or gypsum boards and exceeding 4.3 m in overall span): L/240

Notes:
(1)*To limit floor deflection and vibration, structural subflooring panels should be applied to the floor joists with a panel adhesive capable of developing composite action with the joists and should be secured with mechanical fasteners to allow the bond to develop.*
(2) *Because no drywall sheathing is installed on the underside of a floor system when the home is installed over a crawl space there is no need to be concerned with ceiling cracks and a deflection limit of L/240 for floor joist of single storey manufacture homes is appropriate.*
(3) Appropriate weather resistant sheathing shall be installed to the underside of all units for both transportation and final installation.

5.3.1.2 Subfloor

When subjected to the load specified in Clause 5.2.1, the subfloor shall not deflect more than 3 mm between supports.

5.3.2 Cantilever assemblies

5.3.2.1

Wood joists shall not be cantilevered more than 400 mm in the case of joist sizes up to 38 mm x 184 mm and not more than 600 mm in the case of joist sizes up to 38 mm x 235 mm, except as specified in Clauses 5.3.2.2. and 5.3.2.3.

5.3.2.2

When a manufactured home unit does not exceed 4.3 m in overall width, 38mm x 184 mm joists of not less than No. 2 Grade may be cantilevered up to 1165 mm, provided that the joists are spaced not more than 400 mm on centre (oc) and the subfloor is fastened to the joists with a suitable adhesive product to provide composite action

5.3.2.3

Cantilevered joists may exceed the limits specified in Clauses 5.3.2.1 and 5.3.2.2 when it can be demonstrated by calculations or tests that the cantilevered portion, when subjected to the design roof load transferred through the side walls, plus 0.5 kPa uniform floor load, will not deflect more than L/240, where L is equal to twice the cantilever length as measured from the outer edge of the cantilever support.

5.4 Anchorage of home

5.4.1

Anchorage requirements shall be determined by calculation as specified in CSA Z240.10.1 and take into account the geographical location of the manufactured home. Structural anchorage details shall be provided by a professional Structural Engineer licensed in the province of Ontario, and details shall be provided to the municipal building official at the time of building permit application.

5.4.2

Provision shall be made for the attachment of anchorage devices to prevent overturning or sliding between the frame and support piers, without deforming the structure.

5.4.3

The manufacturer shall provide printed instructions with every manufactured home specifying the location and required capacity of anchorage devices. When special fittings or fixtures are needed to comply with the instructions, they shall also be supplied.

(5.5.2)
See previous note regarding the vagueness in interpretation of "accepted engineering practice". These requirements need to be more specific.

5.5 Floors

5.5.1 Modules up to 4.3 m wide

For modules up to 4.3 m wide, the floor shall be secured to the support frame in accordance with Table 2.

5.5.2 Modules more than 4.3 m wide

For modules more than 4.3 m wide, floors shall be secured to the support frame in accordance with accepted engineering practice.
Note: The Canadian Wood Council's Engineering Guide for Wood Frame Construction provides acceptable engineering solutions where lateral load design is required.

5.6 Walls

5.6.1 General

5.6.1.1 Load Transfer

The walls shall be of sufficient strength and rigidity to transfer all lateral and vertical loads to the supports.

5.6.1.2 Framing Construction

When wood frame construction is used for walls, the sized and spacing of studs shall be as specified in Table 3.

5.6.2 Framing for openings

When wall studs are used, they shall be continuous and doubled on each side of openings wider than 800mm so that the inner studs extend from the lintel to the bottom wall plate and the outer studs extend from the top wall plate to the bottom wall plate, except that single studs may be used between the top and bottom wall plates for non-load bearing interior walls.

5.6.3 Framing over openings

5.6.3.1 Non-load-bearing stud walls

Openings in non-load –bearing stud walls shall be bridged with at least 38mm of material that is the same width as the studs and securely nailed to adjacent studs.

(5.6.3.2) See previous note regarding the vagueness in interpretation of "accepted engineering practice". These requirements need to be more specific.

5.6.3.2 Load-bearing stud walls

Where the lintels do not support trusses exceeding a 4.9 m span, openings in load bearing stud walls shall be bridged with wood lintels as specified in Table 4. Lintel members shall be fastened together with at least 82 mm nails in a double row, with nails not more than 450 mm apart in each row. Other framing designs may be used if they are in accordance with accepted engineering practice.

5.6.4 Stud wall top plates

Load-bearing walls shall have not fewer than two top plates, each not less than 38mm thick and the same width as the wall studs, except that a single plat may be used where the concentrated loads from the roof are not more than 38 mm to one side of the supporting studs, or where it forms a tie across the lintel. Non-load bearing walls may have a single top plate of 19mm thickness.

(5.6.4) With interior wall assemblies having a total wall thickness of 19mm, this presents significant potential problems related to acoustics, sound transfer and privacy between the different interior spaces.

5.6.5 Stud wall bottom plate

A bottom plate shall be provided and be at least 38 mm thick, except that, in non-load-bearing walls and in load-bearing walls where the studs are located directly over framing members, it may be 19 mm thick.

5.7 Nailing of wood framing

5.7.1

Nails shall be long enough to enable at least half their length to penetrate the second member. Splitting of the wood members shall be minimized by staggering the nails in the direction of the grain and keeping the nails well in from the edges.

5.7.2

Nailing of framing shall meet the requirements of Table 5, except that, where adhesives are used, fasteners or clamps shall be considered sufficient for forming a bond.

5.8 Adhesives used in structural assemblies

Adhesives used in structural assemblies, e.g., wood trusses or beams, shall meet the adhesive requirements specified in CAN/CSA-086. Other adhesives may be used if the connections of the structural assemblies have been designed or tested to meet the specified loads with mechanical fasteners only.

(5.12)
Wall Sheathing is required. It shall be installed on all relocatable buildings and manufactured homes.

(6.4.1)
More specific requirements regarding the insulative values of these buildings is required. Continuous insulation shall be provided to prevent thermal bridging.

5.9 Interior partitions

When an interior partition is designed to serve as a secondary structural member, it shall have structural characteristics adequate for the intended purpose.

5.10 Subflooring

Subflooring shall meet the requirements of Clause 9.23.14 of the *National Building Code of Canada or the Ontario Building Code.*.

5.11 Roof Sheathing

Roof sheathing shall meet the requirements of Clause 9.23.15 of the *National Building Code of Canada or the Ontario Building Code.*.

5.12 Wall sheathing

Where wall sheathing is used, it shall meet the requirements of Clause 9.23.16 of the *National Building Code of Canada or the Ontario Building Code.*.

5.13 Wall sheathing membrane

Wall sheathing membrane shall meet the requirements of Clause 9.23.17 of the *National Building Code of Canada or the Ontario Building Code.*

6 Construction

6.1 Roofing

6.1.1

Roofs shall be protected with roofing, including flashing where necessary, installed with corrosion resistant fasteners to prevent rain and melting snow from entering the roof.

6.1.2

Roofs shall meet the applicable requirements of Clause 9.26 of the *National Building Code of Canada or the Ontario Building Code.* .

6.2 Siding

Exterior walls shall be protected with siding and flashing in accordance with the applicable requirements of Clause 9.27 of the *National Building Code of Canada or the Ontario Building Code.*, except that siding shall be installed in accordance with Clause 5.7.

6.3 Air leakage and condensation control

Low air permeance and low vapour permeance materials shall be located in accordance with Clause 9.25.1.2 of the *National Building Code of Canada or the Ontario Building Code.*.

6.4 Thermal insulation

6.4.1 General

Sufficient insulation shall be provided in walls, ceilings and floors separating heated space from unheated space or exterior air to prevent moisture condensation on the room side during the winter and to ensure comfortable conditions for the occupants. The minimum thermal resistance of insulation shall be as specified in Table 6. However, the individual areas required to be insulated may vary from the values in the Table 6 provided that the total heat loss through the insulated portions does not exceed the heat loss that would occur if the individual assemblies were insulated to the minimum levels required by Table 6.

(6.4.2)
Every effort shall be made within this minimum standard to provide a more efficient end product which will improve occupant comfort, lower energy use & reduce operation costs while improving the overall durability and life span of the building.

6.4.2 Installation

Installing insulation shall be installed in a manner that ensures that it remains in its proper location.
A layer of continuous rigid thermal insulation shall be provided on all exterior building envelope assemblies including the walls, roof and floor, to ensure the reduction of thermal bridging of these assemblies.

6.4.3 Access hatches

Attic and roof spaces shall be provided with an access hatch in accordance with Clause 9.19.2.1, Part 9, Division B of the *National Building Code of Canada or the Ontario Building Code.*.

6.4.4 Soffit vents

When soffit vents are used, the insulation between ceilings and roofs shall be installed in a manner that does not impede the free flow of air between the soffit vents and the roof spaces.

6.4.5 Fire protection

The fire protection of foamed plastic thermal insulating material shall meet the minimum requirements of the *National Building Code of Canada or the Ontario Building Code.*.

6.5 Interior Surfaces

6.5.1 Walls and ceiling finishes

6.5.1.1 Flame spread rating

Exposed interior wall and ceiling finishes (excluding mouldings, doors, trim, and cabinets) shall be made of a material whose surface flame-spread rating does not exceed 150 when tested in accordance with CAN/ULC-S102.

6.5.1.2 Plywood thickness

The minimum thickness of plywood interior finish shall be specified as in Table 7, except that plywood applied over solid backing may be of any thickness.

6.5.1.3 Grooved Panels

When plywood for interior finishes is grooved, the grooves shall not extend through the face ply and into the plies below the face ply unless the
(a) groove is supported by framing or furring;
(b) grain of the face ply is at right angles to the supporting members; or
(c) thickness of the plywood exceeds the applicable value specified in Table 7 by an amount equal to at least the depth of penetration of the grooves into the plies below the face ply.

(6.5.1.4)
The minimum thickness of gypsum board shall be increased, and in addition to a layer of gypsum, additional non-combustible material finish such as tile or metal shall be provide within a specific offset of the range or any other heating element.

6.5.1.4 Non-plywood finishes

Non-plywood interior wall and ceiling finishes shall be installed in accordance with the following requirements of Division B of the *National Building Code of Canada:*
(a) gypsum board: Clause 9.29.5, except that specialty gypsum products less than 9.5 mm (eg. Vinyl-faced gypsum board) may be used if it can be shown that the finish material will perform at least equivalent to 9.5 mm regular gypsum board;
(b) hardboard: Clause 9.29.7;
(c) insulating fibreboard: Clause 9.29.8;
(d) paricle board and waferboard: Clause 9.29.9 and
(e) wall tile: Clause 9.29.10.

6.5.2 Fire protection around fuel-fired furnaces and water heaters

Fire protection around fuel fired furnaces and water heaters shall comply with Clause 9.10.10, Division B, of the *National Building Code of Canada* *or the Ontario Building Code*.

(6.6)
Quality and durability of exterior finish material shall be such that ingress of rodents is not an issue.

6.5.3 Fire protection around gas and electric ranges

6.5.3.1 Vertical Clearance

Except as specified in Clause 6.5.32., a vertical clearance of at least 750 mm shall be provided above the elements or burners of electric and gas-fired domestic ranges.

6.5.3.2 Cabinets

Cabinets shall meet the requirements specified in Clause 9.10.22, Part 9, Division B of the *National Building Code of Canada* *or the Ontario Building Code*.

6.5.3.3 Wall-framing members

Combustible wall-framing members within 150 mm of the area where the range is to be located shall be protected above the level of the heating elements by material providing fire resistance at least equivalent to 7.9 mm thick gypsum board.

6.5.4 Floor coverings

Floor coverings shall meet the requirements of Clause 9.31, Division B, of the *National Building Code of Canada* *or the Ontario Building Code*.

6.6 Rodents

Exterior surfaces shall be effectively sealed to prevent the entrance of rodents. Surfaces shall be of sufficient durability and constructed of a material appropriate to prevent rodents from chewing / scratching thought the material to gain access to the space from the exterior.

6.7 Light and Ventilation

6.7.1 Windows

6.7.1.1 General

Windows shall meet the specifications of
(a) CAN/CSA-A440-00/A440.1-00 (R2005); or
(b) AAMA/WDMA/CSA 101/I.S.2/A440 and A440S1, *Canadian Supplement to AAMA/WDMA/CSA 101/I.S.2/A440.*

6.7.1.2 Installation

Windows shall be installed
(a) in accordance with the manufacturer's instructions; and
(b) plumb and true, with neat, well-fitted, weathertight joints.

6.7.2 Ventilation and mechanical air change installations

Ventilation and mechanical air change installations shall meet the requirements of Clause 9.32, Part 9, Division B, of the *National Building Code of Canada* *or the Ontario Building Code*.

6.7.3 Attic ventilation

6.7.3.1 General

Every attic or roof space above an insulated ceiling shall be ventilated with openings to the exterior.

6.7.3.2 Natural ventilation

Where natural ventilation is used, the unobstructed vent area shall be not less than 1/300 of the insulated ceiling area, except that where the roof slope is less than 1:6, the unobstructed vent area shall be not less than 1/150 of the insulated ceiling area.

6.7.3.3 Vent types and distribution

Vents shall be roof type, ridge type, eave-type and/or gable end type. Where necessary, two or more types shall be used in combination to ensure uniform ventilation of the roof space. Vents shall be uniformly distributed on opposite sides of the home or unit

(6.7.3.4)
Need for automatic shutdown of ventilation system critical in a high-hazard industrial setting.

6.7.3.4 Powered ventilation

When powered ventilation is used, the ventilator-vent combination shall provide ventilation of the roof space equivalent to that required by Clause 6.7.3.2.
Where buildings are used in an industrial application, capacity to automatically shut-down exterior ventilation must be provided along with necessary gas and toxin detection devices as applicable to the specific industry, and specific site where the unit is to be located.

Note: *Examples of some acceptable designs include*

(a) eave vents (soffits) in combination with a ridge vent or roof vents (i.e., on-quarter of the required vent area in each eave vent and one-half of the are in the ridge vent or roof vents);

(b) two gable end vents of equal area in combination with a centrally located powered ventilator; and

(c) gable or soffit end vents in combination with a powered ventilator at the other end of the home.

(6.8.3)
Hallway widths shall not be reduced on the basis of having only bedrooms served by the hallway.

6.8 Rooms, hallways, and spaces

6.8.1 Measurement

Unless otherwise specified in this Standard, whenever the dimensions of a room or space need to be measured, they shall be measured between finished wall surfaces and between finished floor and ceiling surfaces.

6.8.2 Heights of rooms and spaces

(6.9.1)
Doors are required on all water closets including within a bedroom.

The minimum heights of rooms or spaces shall be as specified in Clause 9.5.3, Division B, of the *National Building Code of Canada* (see Table 8).
Areas in rooms or spaces over which ceiling height is not less than the minimum specified in Table 8 shall be contiguous with the entry or entries to those rooms or spaces.

6.8.3 Hallway width

The unobstructed width of a hallway shall be at least 860 mm, except that the minimum hallway width shall be 710 mm where

All entry doors (including secondary entrances) shall be of the same quality and thickness as the primary entrance door

(a) only bedrooms and bathrooms are located at the end of the hallway farthest from the living area ; and

(b) a second exit is provided in

(i) the hallway, near the end farthest from the living area; or

(ii) each bedroom served by the hallway.

6.9 Doors

6.9.1 General

Every home shall be provided with at lease one entrance door. Every room containing a

water closet shall be provided with a door.
Note: *If a door is installed in the doorway to a bedroom, a door need not be provided at the entrance to a water closet room within the bedroom.*
Doorway openings shall be designed to accommodate the minimum door sizes specified in Table 9.

(6.9.2.1) Barrier Free requirements shall be addressed and accommodated within the design and construction of all new manufactured homes and relocatable building units.

6.9.2 Exterior doors

6.9.2.1 Wood doors

Wood doors shall meet the requirements of CAN/CSA-0132.2 (for solid core doors) or CSA 0132.5 (for stile and rail doors). They shall be at least 45 mm thick, except that doors for secondary entrances may be 35 mm thick if of solid wood, solid core or stile and rail construction.
Where doors are installed in a wall assembly with a fire resistance rating, doors shall provide the necessary coordinating Fire Rating as per the local Provincial Building Code.

6.9.2.2 Sliding glass doors

Sliding glass doors shall meet the requirements of CAN/CGASB 82.1

6.9.2.3 Storm or combination doors

Storm or combination doors shall be at least 35 mm thick (wood doors) or 25 mm thick (metal doors).

(6.9.2.8) Exterior Door requirement for insulation shall meet the current standards of Part 9 of the Ontario Building Code, and shall not be reduces for Manufactured Homes or Relocatable Buildings.

6.9.2.4 Weatherstripping

Weatherstripping made of metal, plastic, rubber, wood, fabric, or a combination of such materials shall be installed at the perimeter of exterior door openings.

6.9.2.5 Additional protection

Where an exterior door opening is not completely protected from wind-blown snow or rain, it shall be provided with a sill that slopes to the exterior. The sill shall be caulked with suitable caulking to prevent the entry of water.

6.9.2.6 Wood door frames

Wood door frames shall meet the requirements of Clauses 5.1.1 to 5.1.4 of CAN/CSA-A440.

6.9.2.7 Steel door frames

Steel door frames shall be painted with a rust inhibiting paint or otherwise suitably treated before erection to prevent corrosion. Such frames shall incorporate a thermal break to prevent a through-metal path from the interior to the exterior.

6.9.2.8 Thermal resistance

When the January design temperature (2.5% basis) is less than -15*C,
(a) exterior doors shall provide thermal resistance of at least RSI 0.7; and
(b) openings shall be double glazed unless a storm door is provided.

6.9.3 Door hardware

6.9.3.1 Hinges for exterior doors

6.9.3.1.1

Hinges for exterior doors shall consist of
(a) "18-8" stainless steel, brass, or bronze of a type that complies with CAN/CGSB 69.18/ANSI/BHMA A156.1, and be equipped with ball bearings;
(b) steel plated with 0.013 zinc or cadmium and chromate treated; or

(c) steel pre-treated and primed for painting in accordance with CAN/CGSB 69.18/ANSI/BHMA A156.1.

6.9.3.1.2
Exterior doors shall be hung with at least three 89 mm x 89 mm solid butt hinges at least 2.5 mm thick.

6.9.3.2 Hinges for interior doors
6.9.3.2.1
Hinges for interior doors shall be as specified in Clause 6.9.3.1.1, except that
(a) they may consist of steel plated with chrome, brass, bronze, nickel or cadmium in accordance with CAN/CGSB 69.18/ANSI/BHMA A156.1; and
(b) bronze and brass hinges need not be of the ball-bearing type.

(6.9.3.3) Wording shall reflect the changes to improve barrier free accessibility to all buildings. Door Knobs will not be an acceptable type of door hardware in these types of construction. All door hardware shall be provided with Lever Style handles

6.9.3.2.2
Interior swing-type doors shall be hung with at least two 76mm x 76 mm solid butt hinges at least 2 mm thick.

6.9.3.3 Other hardware
Screws, bolts and other fastening devices for use with door hinges shall be made from materials compatible with and having the same finish as the door hinges.
All doors shall be equipped with lever handles in accordance with section 3.8 of the *National Building Code of Canada* and the *Ontario Building Code*. Barrier Free requirements shall be addressed and accommodated within the design and construction of all new manufactured homes and relocatable building modules.

6.9.3.4 Locks
The entrance door to a home shall be fitted with devices capable of locking the door from either side and of unlocking the door from the inside without the use of a key. However, exterior doors in addition to the entrance door specified in Clause 6.9.1 need not be lockable from the outside.

6.9.3.5 Doorstops
Doorstops shall be provided wherever necessary to prevent damage to interior wall finishes.

6.9.4 Glass in doors
6.9.4.1 Safety glass usage
6.9.4.1.1
Except as specified in Clause 6.9.4.2, glass side lights wider than 500 mm that could be mistaken for doors, glass in storm doors, and glass in sliding doors within a unit or at every entrance shall be safety glass that meets the requirements of CGSB CAN/CGSB 12.1.

6.9.4.1.2
Glass in entrance doors, other than the entrance door specified in Clause 6.9.1, shall be safety glass where the glass area exceeds 0.5m2 and extends to less than 900 mm from the bottom of the door.
Safety glass shall be permanently marked to indicate the name of the manufacturer and to indicate that it is safety glass.

6.9.4.2 Doors mirrored with glass

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(6.10)
Remove references to Door Knobs. All Door Hardware shall be Lever style or an appropriate style to accommodate Barrier Free Requirements of the Ontario Building Code

(6.12)
CO detectors as well as Smoke alarms are required in all Ontario Buildings

(6.13)
Quality and durability of under-floor sheathing is critical.

Doors mirrored with glass may be used only at the entrance to clothes closets. Such doors shall be reinforced with hardboard, plywood, or particleboard at least 6 mm thick. This material shall be securely fastened to the back of the mirror unless the glass is laminated or tempered safety glass.

6.10 Exits

Every manufactured home shall have at least an exit doorway located not more than 1.5m above ground level. Doors installed to serve as exterior doors shall be designed for exterior use and be openable from the inside by operation of a single knob or lever. To prevent ice buildup making a door inoperable, metal doors and jambs shall have a thermal break between their exterior and interior parts. Fuel fired appliances shall be located at least 1.5 m from the exterior door.

6.11 Bedroom windows

Bedroom windows shall meet the requirements of Clause 9.7.1.2, Division B, of the *National Building Code of Canada or the Ontario Building Code*.

6.12 Smoke alarms

Smoke alarms shall be installed in accordance with Clause 9.10.19, Division B, of the *National Building Code of Canada or the Ontario Building Code*.
Carbon monoxide detectors with alarms shall be installed in all units in accordance with the *Ontario Building Code.*

6.13 Underfloor sheathing

The bottoms of floor assemblies shall be sheathed to protect the assembly during transit. Underfloor sheathing shall have a puncture resistance of at least 5.5 J and be capable of being patched, in the event of damage to meet the required puncture resistance. Instructions for such patching shall be included in the manufacturer's instructions. Underfloor sheathing shall be securely fastened to the floor assembly so that it will not be dislodged during transit.
Underfloor sheathing must be made of or covered by a material that is suitable for exposure to exterior elements and resistant to the ingress of weather, moisture, rodents, insects and other pests.

6.14 Installation of solid fuel-fired appliances

6.14.1 General

6.14.1.1

Solid-fuel-fired appliances shall be certified in accordance with Clause 6.14.2 or 6.14.3 and installed in accordance with the manufacturer's installation instructions and CAN/CSA-B365/ Except as permitted by the regulatory authority, installation shall be carried out in the factory where the manufactured home is constructed.

6.14.1.2

Solid-fuel-fired appliances installed in manufactured homes with an interior floor area of 93 m2 or less shall be designed and installed so that all combustion air is supplied through suitable ducting directly from the outdoors.

6.14.2 Fireplaces

Solid-fuel-fired factory built fireplaces installed in manufactured homes shall meet the requirements of Part A of CAN/ULC-S610. If they are installed in manufacture homes with an interior floor area of 93 m2 or less, they shall also meet the requirements of Part B of CAN/ULC-S610.

6.14.3 Space heaters

Solid-fuel-fired space heaters installed in manufactured homes shall meet the requirements of Part A of CSA B366.2. Solid fuel-fired space heaters installed in manufactured homes with an interior floor area of 93 m2 or less shall also meet the requirements of Part B of CSA B366.2.

7 Roof trusses test

7.1 General

Roof trusses shall be tested in accordance with Clauses 3 to 7 of CSA S307 (with exception of Clause 7.7 of CSA S307). Where access into the roof space is not provided, the design load on the bottom chord specified in Clause 6.4 of CSA S307 shall be based on the calculated dead load only.

7.2 Acceptance criteria

7.2.1 General

Trusses shall be acceptable if they meet the applicable deflection requirement in Clause 5.3.1.1 at 1-1/3 times the design roof snow load after 1h and sustain 2 – 2/3 times the design roof snow load for 24 h without failure.

7.2.2 Failure criteria – Single trusses

If the trusses are tested singly and both trusses fail to meet the requirements of this Standard, the design shall be considered unacceptable. If only one of the two trusses meets the requirements, two additional trusses may be tested. If either of the two additional trusses fails to meet the requirements, the design shall be considered unacceptable.

7.2.3 Failure criteria – Truss pairs

If the trusses are tested as a pair and only one truss fails to meet the deflection requirements of this Standard or collapse occurs, two additional trusses may be tested. If either of the two additional trusses fails to meet the deflection requirements or collapse occurs, the design shall be considered unacceptable.

8 Floor assemblies test

8.1 General

The test specified in Clause 8 shall apply to floor assemblies where the joists or trusses span transversely the length of the home. Where steel outriggers are considered to add to the strength of the floor system the test specified in Clause 8 may be followed by testing both the floor and chassis assemblies and taking into consideration the spacing of outriggers and the number of trusses or joists associated with each outrigger. Alternatively, the completed structure may be loaded in accordance with Clauses 8.3.2.3 and 8.3.2.4 to determine the contribution of the outriggers to the stiffness of the floor.

8.2 Test set-up

When the effect of outriggers is not considered, the trusses or joists shall be tested in pairs, spaced 400 mm oc, and supported on two supports in such a way that the bearing length shall be the same as that actually provided with the longitudinal steel members of the chassis and the span between supports is equal to that between the same members. The test trusses or joists shall be assembled with a 38 mm thick side plate of the same depth as the trusses or joists and end nailed to each end of each truss or joist with four 82 mm nails. The entire assembly shall be covered with the decking material intended for use in construction, using the intended method of fastening. When the combined floor and chassis assembly is being tested, the main longitudinal steel frame members shall be supported along their full length by a material as wide as the steel frame members. The supporting materials shall be of sufficient height to prevent the outrigger members from toughing the supports under loaded conditions. The test assembly, including supports shall sit on a non-yielding floor base.

8.3 Testing procedure

8.3.1 Centre span procedure

8.3.1.1 Measuring deflection

The centre span between supports shall be measured and the midspan locations marked at convenient reference points, e.g., at the top of the particleboard. Deflections shall be measured from the reference points with a graduated scale reading to 1 mm. Other methods for measuring deflection may be used if they provide equivalent accuracy.

8.3.1.2 Load test

A uniformly distributed load equal to 1.4 kPa or 1.9 kPa, whichever is applicable (see Clause 5.2.1), shall be applied at a steady rate to the centre span between the supports (see Figure 2(a)). Deflections at the centre of the span shall be recorded 5 min after load application. The load shall then be removed.

8.3.2 Cantilever span procedure

8.3.2.1

A simulated side-wall assembly at least 600 mm high shall be installed at each cantilever en of the floor assembly and shall be secure to the floor assembly in the manner intended for actual installation.

8.3.2.2

An assembly simulating a pair of roof trusses spaced 400 mm oc shall be placed on the supporting sidewall assembly and anchored to it with one 90 mm nail.

8.3.2.3

The zero load readings shall be taken at tow reference points on each cantilever end of the floor assembly. A uniformly distributed load equal to 0.5 kPa shall be applied over the entire centre and cantilever spans of the floor.

8.3.2.4

a uniformly distributed load equal to the design snow load specified in Clause 5.2.2 shall be applied to the top of the roof truss assembly at a steady rate (see Figure 2(b)). The deflection of the cantilever reference points shall be measured after the complete assembly has sustained the load for 10 min. The load on the top of the roof truss shall be increased to 2-2/3 times the design snow load and shall be maintained for 24 h (see Figure 2(c)).

8.4 Acceptance criteria

Floor assemblies shall be considered acceptable if they meet the deflection requirements of Clause 5.3 at the design loads for 10 min and the requirements of Clause 8.3.2.4 without failure.

9 Deformation resistance test

(9.1 (c))
All Manufacture Homes and Relocatable Buildings shall be provided with a continuously sealed air / vapour barrier which shall be subject to inspection as other buildings are.

Note: *This test may be used to determine the suitability of buildings for installation on surface foundation systems meeting the requirements of CSA Z240.10.1 where differential soil movement due to frost action is likely.*

9.1 Test procedure

The following procedure shall be used for the deformation resistance test:

(a) The home's doors and windows shall be closed, following which the home shall be made level and its support on piers installed at intervals in accordance with the manufacturer's installation instructions. The length of top-surface bearing, parallel to the length of the building, shall be 300 mm.

(b) The home shall be lifted from on of its piers a height of at least 75 mm by jacking at the centre of a pier located nearest one of the home's corners.

(c) The home's exterior and interior wall surfaces and floor and ceiling surfaces shall be inspected for damage or deformation that could compromises the operation of elements such as doors and windows or (if applicable) the integrity of the air barrier.

(9.1(g))
Blower Door Tests shall be implemented if possible to ensure adequate sealing of the building to prevent air infiltration.

(d) The home shall then be lowered and the procedures specified in Items (b) and (c) repeated by jacking in turn at the piers nearest the other three corners of the building.

(e) The home shall then be lowered and, after at least 30 min have passed, reinspected in accordance with Item (c).

(f) The damage or deformation (if any) shall be recorded and the record retained by the tester.

(g) Blower door testing of units both in the factory setting and again upon installation at the site, shall be performed to ensure that adequate air-tightness of the building envelope is achieved.

9.2 Acceptance criteria

Homes shall be deemed to have met the deformation resistance criteria if, after re-leveling and settling, all doors and windows operate properly without binding and there is no identifiable damage that could adversely impact the operability of the home.

10 Markings and set-up instructions

10.1 Markings

Interior markings shall be marked on the interior of the manufactured home in accordance with Clause 6 of CSA Z240.0.1.

10.2 Set-up instructions

Instructions shall be provided in accordance with Clause 7 of CSA Z240.0.1.

2012 Building Code Compendium

Volume 1

January 1, 2015 update
(Containing amendments)

*** Note from Author:**
The following proposed OBC Amendment is directly adopted and modified from existing sources including the OBC 2012 Parts 3, 9, and 10 and ABC 2006 Part 10. The author makes no claims to the originality of the content in Black ink in this section, rather her contributions are constituted only of those sections and subsections written in red ink and the larger argument as to why such amendments are required and should be adopted by the Province of Ontario.

Part 3
Fire Protection, Occupant Safety and Accessibility

Section 3.9. Portable Classrooms

3.9.1. Scope

3.9.1.1. Application

(1) Except as provide in this Section, the requirements in this Division apply to portable classrooms.

3.9.1.2. Heating Systems

(1) Heating systems and equipment in a portable classroom shall be designed and installed in accordance with Section 6.2.

(3.9.3.2)
The minimum Spatial Separation, of Portable Classrooms to be exempt from the requirement for fire resistance rating shall be 10m in keeping with other parts of this code.

Preferably all Portable classrooms shall provided with a minimum fire resistance rating of not less than one hour and to be rated from both the interior and exterior of the wall assembly.

3.9.2. Interior Finish

3.9.2.1. Flame-Spread Ratings

(1) Interior finish material used on a wall or ceiling of a portable classroom shall have a flame spread rating of 150 or less.

3.9.3. Application (See Appendix A.)

3.9.3.1. Building Areas

(1) A single portable classroom shall be not more than 100m2 in building area, and not more than 1 storey in building height.
(2) For the purposes of Subsection 3.2.2., where the horizontal distance between portable classrooms is less than 6 m, a group of portable classrooms may be considered as a single building with a building area equal to the aggregate area of the portable classrooms.

3.9.3.2. Spatial Separations

(1) The requirements in Subsection 3.2.3. need not be provided between individual portable classrooms where the distance between the classrooms is 6 m or more.
The requirements in Subsection need not be provide between individual portable classrooms where the distance between the classrooms is 10m or more.
(2) The requirements in Subsection 3.2.3. need not be provided between individual portable classrooms within a group where,
(a) the portable classrooms are in groups where,
- **(i)** the distance between the classrooms is less than 6 m,
- **(ii)** the number of classrooms in a group is not more than 6, and
- **(iii)** the distance between groups of classrooms is 12 m or more, or

(b) the portable classrooms are in groups where,
- **(i)** the means of egress for each classroom within a group is by a common corridor or passageway,
- **(ii)** the number of portable classrooms in a group is not more than six, and
- **(iii)** the distance between groups of portable classrooms is 12 or more.

(3.9.3.3)
There shall not be a minimum number of portables in order to trigger the requirement for fire alarm systems. ALL portable classrooms shall be tied into the primary Fire Alarm System of the main School building, and have working Fire Alarm and Emergency Lighting and Egress Signage, and all other basic Fire and Life Safety provisions as required else where in this code PRIOR to occupancy of a portable classroom.

3.9.3.3. Fire Alarm Systems

(1) Except as provided in Sentence (2) and (3), the fire alarm system in the main school building shall be extended to portable classrooms with a separate zone indicator on the annunciator.

(2) The requirements in Sentence (1) need not be provided where there are not more than 12 portables on a site and where,
(a) Reserved
(b) the distance between the portable classrooms is less than 6m and the requirements of Subsection 3.2.3. are applied between classrooms, or
(c) the portable classrooms are in groups where,
(i) the distance between the classrooms is less than 6 m,
(ii) the number of classrooms in a group does not exceed six,
(iii) within a group of classrooms, the facing walls have a fire-resistance rating of 45 min, rated from inside the classroom, and
(iv) the distance between groups of classrooms is 12m or more.

(3) The requirements in Sentence (1) need not be provided where the distance between portable classrooms is 6 m or more.
(4) Regardless of proximity to one another, or number of portable classrooms to be installed, all individual portable classrooms shall be connected back to the primary fire alarm system annunciator panel.

(3.9.3.4)
Provisions for Firefighting apply to all portable classrooms

3.9.3.4. Provisions for Firefighting

(1) The requirements in Articles 3.2.2.10. and 3.2.5.1 to 3.2.5.7. need not be provided where there are not more than 12 portable classrooms on a site and where,
(a) the distance between portable classrooms is 6m or more,
(b) the distance between portable class rooms is less than 6 m and the requirements of Subsection3.2.3. are applied between the classrooms, or
(c) the portable classrooms are in groups conforming with either Clause 3.9.3.2(a) or (b).
(d) These requirements are required for any number of portable classrooms to be installed on a site.

(3.9.3.7)
All Fuel Fired Appliances shall be separated from the remainder of the classroom space with a fire Separation of not less than 1hr. This requirement shall match that of service spaces required elsewhere in this code.

3.9.3.5. Portable Fire Extinguishers

(1) A fire extinguisher, in accordance with Article 3.2.5.17., shall be installed in each portable classroom.

3.9.3.6. Means of Egress

(1) Except as required in Sentence 3.9.3.7.(1), a portable classroom shall be provided with *means of egress* conforming to sections 3.3. and 3.4.

3.9.3.7. Fuel Fired Appliances

(1) Where there is only one egress door from a portable classroom, a fuel-fired *appliance* shall be separated from the remainder of the classroom by a *fire separation* with a *fire-resistance rating* of not less than 45 min. In any portable classroom, a fuel-fired appliance shall be separated from the remainder of the classroom by a fire separation with a fire resistance rating of not less than1HR
(2) Except as provided in Sentence (3) and (4), if a portable classroom contains a fuel-fired appliance, the appliance shall be separated from the remainder of the classroom by a fire separation having a fire-resistance rating not less than,
(a) 1.5 h where the horizontal distance between the portable classrooms is 1.5 m or less and
(b) 45 min where the horizontal distance between portable classrooms is more than 1.5m.

(3.9.3.8) Given the increased reliance of Schools, and School Boards on the use of Portable Classrooms in order to provided the necessary instructional space for fluctuating enrollment, a review of all related amenities – not only the classroom space itself – shall be incorporated with the decision to provide and install Portable Classrooms. Among These issues is the number and proximity to Washroom Facilities as well as the provision of Barrier Free access to these units. It is not acceptable to prevent a teacher or student from joining a class on the basis that there is not appropriate ramps or accessibility provisions.

(3) If the horizontal distance between portable classrooms is 6 m or more, a fuel-fired *appliance* need not be separated from the remainder of the classroom by a *fire separation* provided,
(a) there is not more than one *appliance* per portable classroom, and
(b) the *appliance* is located not less than 4.5m from an egress doorway or and *exit* from the portable classroom.

(4) Fuel-fired appliances with sealed combustion located in a portable classroom are not required to be separated from the remainder of the classroom,
(a) if there are not more than four portable classrooms in a group, and
(b) if the appliance is located not less than 4.5 m from an egress doorway or an exit from the portable classroom.
All Portable Classrooms shall be provided with a *fire separation* with a *fire resistance rating* not less than 1 HR, between the fuel fired appliance and the primary educational space in conformance with the definition of a service room in other parts of this same code.

3.9.3.8. Washroom Facilities

(1) Washroom facilities need not be provided in a portable classroom where facilities in the main school building comply with the requirements of Subsection 3.7.4. for the total occupant load of the main school building and the portable classrooms, and
(2) The washrooms are located within _____m of the entrance to the portable classroom.
(3) Where washroom facilities are not located within the required distance of the portable classroom, new washrooms shall be installed in accordance with Subsection 3.7.4. and Section 3.8.

3.9.3.9. Barrier-Free Access

(1) The requirements of Section 3.8. for barrier-free access need not be provided for a portable classroom provided that the main school building complies with the requirements of Section 3.8.
(2) The requirements of Section 3.8 for barrier free access shall be provide for all portable classrooms.
(3) Barrier-free access to the classroom shall be provided by ramps in accordance with section____

3.9.3.10. Installation of Exit Signage

(1) Regardless of proximity to one another, or number of portable classrooms, Exit signage and emergency lighting shall be provided at all designated exits.

3.9.3.11. Provision of Entry Vestibules

(1) All portable classrooms installed in the Province of Ontario shall be designed and installed to provide a proper air-lock entry vestibule.

3.9.3.12. Windows and Natural Daylighting

(1) All portable classrooms shall provide operable windows and natural daylighting to the extent that is feasible on the school site in a manner that

3.9.3.13. HVAC requirement

(1) All Portable classrooms shall be provided with HVAC equipment that meets the requirements of ASHRAE 90.1.

(2) All Portable classrooms shall have noise reducing duct insulation to limit the transfer of excess noise and vibration into the classroom.

Part 9
Housing and Small Buildings

(9.1.1.9 (3))
While housing is not part of the focus of this research or proposal, Part 9 still plays an important role for relocatable buildings of non-residential typologies.

Section 9.1. General

9.1.1. Application

9.1.1.1. Scope

(1) The scope of this Part shall be as described in Subsection 1.1.2. of Division A.

9.1.1.9. Site Assembled and Factory Built Buildings (See Appendix A)

(1) Except as provided in Sentence (2), a manufactured building intended for residential occupancy is deemed to comply with this Code if it is designated and constructed in compliance with

(a) CSA-Z240.2.1, "Structural Requirements for Manufactured Homes", if the building is constructed in sections not wider than 4.88 m or

(b) CSA A277, Procedures for Factory Certification of Buildings".

(2) The requirements of this Code shall apply to,

(a) building components designed and constructed outside the place of manufacture, and

(b) site installation of such buildings

(3) The requirements of this Code shall apply to all manufactured buildings intended for any use other than single-family residential occupancy.

Including: Office, Mercantile, Industrial, Assembly, Care… etc…

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(9.5.1.1 (2))
It is necessary for the Building Code to acknowledge and address the increasing number of uses that Site Assembled and Factory Built Buildings have taken in recent years, and modify the regulations and requirements around these varied typologies accordingly.

Section 9.5. Design of Areas, Spaces and Doorways

9.5.1. General

9.5.1.1. Application

(1) Except as otherwise specified in this Part, this Section applies only to dwelling units that are intended for use on a continuing or year-round basis as the principal residence or the occupant.

(2) This section shall apply to all dwelling units, including those used on a temporary basis – especially in the context of short-term occupancy by migrant or remote workers

9.5.1.2. Method of Measurement

(1) Except as otherwise specified in this Part, the areas, dimensions and heights of rooms or spaces shall be measured between finished wall surfaces and between finished floor and ceiling surfaces.

9.5.1.3. Floor Areas

(1) Minimum floor areas specified in this Section do not include closets or built-in bedroom cabinets unless otherwise indicated.

9.5.1.3. Floor Areas

(1) Minimum floor areas specified in this Section do not include closets or built-in bedroom cabinets unless otherwise indicated.

9.5.1.4. Combination Rooms (See Appendix A.)

(1) Two or more areas may be considered as a combination room if the opening between the areas occupies the larger of 3m2 or 40% or more of the wall measured on the side of the dependent area.
(2) Where the dependent area is a bedroom, direct passage shall be provided between the two areas
(3) The opening required in Sentence (1) shall not contain doors or windows.

9.5.2 Barrier Free Design

9.5.2.1. General

(1) Except as provided in Sentence (2) and Article 3.8.1.1., every building shall be designed in conformance with Section 3.8
(2) The requirement of Section 3.8 need not be provided for houses including semi-detached houses, duplexes, triplexes, townhouses, row houses and boarding or rooming houses with fewer than 8 boarders or roomers.

(9.9.4) These amendments shall recognize the underlying objective to increase the overall fire-safety and minimize potential fire exposure of relocatable buildings. Given that relocatable buildings are often sited incrementally on an as-needed basis, the full scope and number of units is not always know at the outset of installation. By providing FRR from both sides of the wall assembly, the flexibility of placement is increased, as well as the safety of the units' occupants.

9.9.4. Fire Protection of Exits

9.9.4.1. Application

(1) Except as provided in Articles 9.9.4.4 and 9.9.4.6., this Subsection applies to the fire protection of all *exits* except *exits* serving a single *dwelling unit.*

9.9.4.2. Fire Separation for Exits

(1) Except as provided in Sentence (5) and Article 9.9.8.2., every exit other than an exit doorway shall be separated from each adjacent floor area or from another exit by a *fire separation* having a *fire resistance rating* not less than that required for the floor assembly above the floor area

9.9.4.6. Openings Near Exit Doors

(1) This Article applies to,
(a) exit doors serving other than single *dwelling units*, and
(b) exit doors serving single dwelling unites where there is no second and separate exit from the *dwelling unit*.
(1) Where an exterior *exi*t door described in Sentence (1) in one *fire compartment* is within 3 m horizontally of an unprotected opening in another fire compartment and the exterior walls of these *fire compartments* intersect at an exterior angle of less than 135*, the opening shall be protected with wired glass in fixed steel frames or glass block conforming to Articles 9.10.13.5 and 9.10.13.7. or with a rated closure conforming to Table 9.10.13.1 with respect to the rating of the *fire separation* between the two compartments.

9.9.5. Obstructions and Hazards in Means of Egress

9.9.5.1. Application

(1) This Subsection applies to obstructions and hazards in every means of egress except those within a dwelling unit or serving a single *dwelling unit*.

9.9.5.2. Occupancies in Corridors

(1) Where a corridor contains an occupancy, the occupancy shall not reduce the unobstructed width of the corridor to less than the required width of the corridor.

9.9.5.3. Obstructions in Public Corridors

(1) Except as permitted in Sentence (2), obstructions located within 1980mm of the floor shall not project horizontally more than 100 mm into exit passageways, corridors used by the public or public corridors in a manner that would create a hazard for persons with no or low vision travelling adjacent to walls.

(2) The horizontal projection of an obstruction in Sentence (1) is permitted to exceed 100 mm where the obstruction extends to less than 680 mm above the floor.

9.9.5.4. Obstructions in Exits

Modify requirements to apply to all buildings in a place of employment especially those having a night shift.

(1) Except as permitted in Subsection 9.9.6 and Article 9.8.7.6., no fixture, turnstile or construction shall project within the required width of an *exit.*

9.9.5.5. Obstructions in Means of Egress

(1) No obstructions such as posts or turnstiles shall be placed so as to restrict the width of a required *means of egress* from a floor area to less than 750 mm unless an alternate unobstructed *means of egress* is provided adjacent to and plainly visible from the restricted *egress*.

9.9.5.9. Ancillary Rooms

9.9.6.7. Door Latching, Locking & Opening Mechanisms

(1) Principal Entrance doors and doors to suites, including exterior doors to dwelling units and other doors in an access to exit shall:

(a) be openable from the inside or in travelling to an exit without requiring keys, special devices or specialized knowledge of the door opening mechanism, or

(b) in the case of exit doors, be controlled by electromagnetic locking mechanisms in accordance with section 3.4.6.16 (4)

(2) Except for doors serving a single dwelling unit and doors to accessory buildings and to garages serving a single dwelling unit, door release hardware on doors in a means of egress shall be operable with one hand and the door shall be openable with not more than one releasing operation.

(3) Door release hardware on doors in a means of egress shall be installed not more than 1200 mm above the finished floor

(4) Except hotels…

9.9.8. Exits from floor Area

9.9.11. Signs

9.9.11.1. Application

(1) This subsection applies to all exits except those serving not more than one dwelling unit.

9.9.11.2. Visibility of Exits

(1) Exits shall be located so as to be clearly visible or their locations shall be clearly indicated.

9.9.11.3. Exit Signs

(1) Except as required in Sentence (7), every exit door shall have an exit sign placed over it or adjacent to it if the exit serves:

(a) a building that is 3 storeys in building height

(b)a building having an occupant load of more than 150, or

(c) a room or floor area that has a fire escape as part of a required means of egress.

Section 9.10. Fire Protection
9.10.1. Definitions and Application
9.10.1.1. Support of Noncombustible Construction
(1) Where an assembly is required to be of *noncombustible* construction and to have a fire-resistance rating, it shall be supported by *noncombustible* construction.

9.10.2. Occupancy Classification
9.10.2.1. Occupancy Classification
(1) Every building or part of it shall be classified according to its major occupancy as belonging to one of the groups or divisions described in Table 9.10.2.1.

9.10.3. Ratings
9.10.3.1. Fire-Resistance and Fire-Protection Ratings
(1) Where a *fire-resistance* or a *fire-protection rating* is required in this Section for an element of a building, such rating shall be determined in conformance with the test methods described in Part 3, or in accordance with MMAH Supplementary Standard SB-2, "Fire Performance Ratings" or MMAH Supplementary Standard SB-3, "Fire and Sound resistance of Building Assemblies". (See Appendix A)

(9.10.3.3) These amendments shall recognize the underlying objective to increase the overall fire-safety and minimize potential fire exposure of relocatable buildings. Given that relocatable buildings are often sited incrementally on an as-needed basis, the full scope and number of units is not always know at the outset of installation. By providing FRR from both sides of the wall assembly, the flexibility of placement is increased, as well as the safety of the units' occupants.

9.10.3.2. Flame-Spread Rating
(1) Where a *flame-spread rating* is required in this Section for an element of a building, such rating shall be determined in accordance with the test methods described in Part 3, or in accordance with MMAH Supplementary Standard SB-2, "Fire Performance Ratings".

(2) Unless the *flame-spread rating* is referred to in this Part as a "surface *flame-spread rating*", it shall apply to any surface of the element being considered that would be exposed by cutting through it as well as to the exposed surface of the element.

9.10.3.3. Fire Exposure
(1) Floor, roof and ceiling assemblies shall be rated for exposure to fire on the underside.
(a) Except for factory assembled buildings, which will require *fire resistance ratings* to be designed for fire exposure from both inside the building as well as from outside the building.

(2) Exterior Walls shall be rated for exposure to fire from inside the building, except that such walls need not comply with the temperature rise limitations required by the standard tests referred to in Article 9.10.3.1 if such walls have a limiting distance of not less than1.2m, and due allowance is made for the effects of heat radiation in accordance with the requirements in Part 3.
(a) Except for factory assembled buildings, which will require *fire resistance ratings* to be designed for fire exposure from both inside the building as well as from outside the building.

(3) *Firewalls* and interior vertical *fire separations* required to have fire resistance ratings shall be rated for exposure to fire on each side.

9.10.3.4. Suspended Membrane Ceiling

(1) Where a ceiling construction has a suspended membrane ceiling with lay-in panels or tiles that contribute to the required *fire-resistance rating*, hold down clips or other means shall be provided to prevent the lifting of such panels or tiles in the event of a fire.

9.10.9. Ratings

9.10.9.1. Fire

9.10.9.2. Continuous Barrier

(1) Except as permitted in Article 9.10.9.3, a wall or floor assembly required to be a *fire separation* shall be constructed as a continuous barrier against the spread of fire.

(2) The continuity of a fire separation shall be maintained where it abuts another *fire separation*, a floor, a ceiling, a roof or an exterior wall assembly.

9.10.9.3. Openings to be Protected With Closures

(1) Except as permitted in Article 9.10.9.5 t 9.10.9.7., openings in required *fire separations* shall be protected with *closures* conforming to Subsection 9.10.13.

9.10.9.4 Due to ease of access to the underside of relocatable buildings, and inconsistent installation of proper skirting, fire separation of the floor assembly is essential to allowing adequate time for occupants to escape the building in the event of a fire.

9.10.9.4. Floor Assemblies

(1) Except as permitted in Sentences (2) to (4), all floor assemblies shall be constructed as *fire separations.*

(2) Floor assemblies contained within *dwelling units* need not be constructed as *fire separations.*

(3) Floor assemblies for which no *fire resistance rating* is required by Subsection 9.10.8 and floors of *mezzanines* not required to be counted as storeys in Articles 9.10.4.1 and 9.10.4.2 need not be constructed as *fire separations*.

(4) Where a crawl space is not required by Article 9.10.8.9 to be constructed as a *basement*, the floor above need not be constructed as a *fire separation*.

(5) Where a crawl space is part of a relocatable building, the floor above is required to be constructed as a *fire separation* with a *fire resistance rating* of not less than 1 HR

9.10.9.5. Interconnected Floor Spaces

(1) Except as permitted by Article 9.9.4.7., *interconnected floor spaces* shall conform to the requirements of Subsection 3.2.8.

9.10.9.6. Penetration of Fire Separations

(1) Piping, tubing, ducts, *chimneys*, wiring, conduit, electrical outlet boxes and other similar service equipment that penetrate a required fire separation shall be tightly fitted or fire stopped to maintain the integrity of the separation. (See Appendix A, OBC 2012)

(2) Penetrations of a *firewall* shall be sealed at the penetration by a *fire stop* that, when subjected to the fire test method in CAN/ULC-S115, "Fire Tests of Firestop Systems", has an FT rating not less than the f*ire-resistance rating* for the fire separation.

(3) Except as provided in Sentences (4) to (12) and Article 9.10.9.7., pipes ducts, electrical outlet boxes, totally enclosed raceways or other similar service equipment that partly or wholly penetrate an assembly required to have a *fire resistance rating* shall be noncombustible unless the assembly has been tested incorporating such equipment.

(4) Electrical wires or other similar wiring enclosed in *noncombustible* totally enclosed raceways are permitted to partially or wholly penetrate an assembly required to have a *fire resistance rating* without being incorporated in the assembly at the time of testing as required in Sentence (3).

(5) Single conductor metal sheathed cables with combustible jacketing that are more than 25 mm in overall diameter are permitted to penetrate a fire separation required to have a fire resistance rating without being incorporated in the assembly at the time of testing as required in Sentence (3), provided the cables are not grouped and are spaced a minimum of 300 mm apart.

(6) Electrical wires or cables, single or grouped, with combustible insulation or jacketing that is not totally enclosed in raceways of non-combustible material, are permitted to partly or wholly penetrate an assembly required to have a fire-resistance rating without being incorporated in the assembly at the time of testing as required in Sentence (3), provided the overall diameter of the wiring is not more than 25 mm.

(7) *Combustible* totally enclosed raceways that are embedded in a concrete floor slab are permitted in an assembly required to have a *fire resistance rating* without being incorporated in the assembly at the time of testing as required in Sentence (3), where the concrete provides at least 50mm of cover between the raceway and bottom of the slab.

(8) *Combustible* outlet boxes are permitted in an assembly required to have a fire resistance rating without being incorporated in the assembly at the time of testing as required in Sentence (3), provided the opening through the membrane into the box does not exceed 160 cm2

(9) *Combustible* water distribution piping is permitted to partly or wholly penetrate a fire separation that is required to have a *fire resistance rating* without being incorporated in the assembly at the time of testing as required in Sentence (3), provided the piping is protected with a fire stop in conformance with 3.1.9.4.(4).

(10) *Combustible* sprinkler piping is permitted to penetrate *fire separation* provided the *fire compartments* on each side of the *fire separation* are sprinklered.

(11) Sprinklers are permitted to penetrate a fire separation or a membrane forming part of an assembly required to have a fire-resistance rating without having to meet the fire stop requirements of Sentence (1), provided the annular space created by the penetration of a fire sprinkler is covered by a metal escutcheon plate in accordance with NFPA 13, " Installation of Sprinklers"

(12) *Combustible* piping for central vacuum systems is permitted to penetrate a *fire separation* provided the installation conforms to the requirements that apply to *combustible* piping in Sentences 9.1.9.7.(2) to (6)

(13) Fire dampers are permitted to penetrate a fire separation or a membrane forming part of an assembly required to have a fire resistance rating without having to meet the fire stop requirements of Sentence (1), provided the fire damper is
(a) installed in conformance with NFPA 80, "Fire Doors and Other Opening Protectives," or (b) designed specifically with a fire stop.

9.10.9.7. Combustible Piping

(1) Except as permitted in Sentences (2) to (6), combustible piping shall not be used where any part of a piping system partly or wholly penetrates a fire separation required to have a fire resistance rating or penetrates a membrane that contributes to the required fire resistance rating of an assembly.

(2) *Combustible* piping, not located in a vertical shaft is permitted to penetrate a fire separation required to have a fire resistance rating or a membrane that forms part of an assembly required to have a fire resistance rating, provided the piping is sealed at the penetration by a fire stop that has an F rating not less than the fire resistance rating required for the fire separation.

(3) The rating referred to in Sentence (2) shall be based on CAN/ULC-S115, "Fire Tests of Fire stop Systems", with a pressure differential of 50 PA between the exposed and unexposed sides, with the higher pressure on the exposed side.

(4) *Combustible* drain piping is permitted to penetrate a horizontal fire separation or a membrane that contributes to the required fire resistance rating of a horizontal fire separation, provided it leads directly from a noncombustible water closet through a concrete floor slab

(5) *Combustible* piping is permitted,

(a) on one side of a vertical fire separation provided it is not located in a vertical shaft, and

(b) to penetrate a vertical or horizontal *fire separation* when the *fire compartment* on each side of the *fire separation* is *sprinklered.*

(6) In buildings containing 2 dwelling units only, combustible piping is permitted on one side of a horizontal *fire separation*

9.10.9.8. Collapse of Combustible Construction

(1) *Combustible construction* that abuts on or is supported by a *noncombustible fire separation* shall be constructed so that its collapse under fire conditions will not cause the collapse of the *fire separation.*

9.10.9.9. Reduction in Thickness of Fire Separation by Beams and Joists

(1) Where pockets for the support of beams or joists are formed in a masonry or concrete fire separation, the remaining total thickness of solid masonry and /or grout and/or concrete shall be not less than the required equivalent thickness shown for Type S monolithic concrete in Table 2.1.1. of MMAH Supplementary Standard SB-2, “Fire Performance Ratings”, for the required *fire-resistance rating.*

9.10.9.10. Concealed Spaces Above Fire Separations

(1) Except as provided in Sentence (2), a horizontal service space or other concealed space located above a required vertical fire separation shall be divided at the fire separation by an equivalent fire separation within the space.

(2) Where a horizontal service space or other concealed space is located above a required vertical fire separation other than a vertical shaft, such space need not be divided as required in Sentence (1) provided the construction between such space and the space below is constructed as a fire separation having a fire resistance rating not less than that required for the vertical fire separation, except that where the vertical fire separation is not required to have a fire resistance rating greater than 45 min, the fire resistance rating of the ceiling is permitted to be reduced to 30 min.

9.10.9.11. Separation of Residential Occupancies

(1) Except as provided in Sentences (2) and (4), residential occupancies shall be separated from all other major occupancies by a fire separation having a fire-resistance rating of not less than 1 h.

(2) Except as provided in Sentences (3), a major occupancy classified as residential occupancy, including live/work units, shall be separated from other major occupancies classified as mercantile or medium hazard industrial occupancies by a fire separation having a fire-resistance rating of not less than 2 h.

(3) Where not more than 2 dwelling units or live/work units are located in a building containing a *mercantile occupancy*, such *mercantile occupancy* shall be separated from the dwelling units or *live/work units* by a *fire separation* having not less than 1 hr *fire-resistance rating*.

(4) The requirement for fire separations between *major occupancies* in Sentence (1) is waived for the occupancies allowed within *live/work units.*

9.10.9.12. Residential Suites, Live/Work Units and Industrial Buildings

(1) Except as provided in Sentence (2), not more than 1 suite of residential occupancy shall be contained within a building classified as Group F, Division 2 major occupancy.

(2) Except where a Group F Division 2 major occupancy is directly related to live/work units, not more than one suite of residential occupancy shall be contained within a building classified as Group F, Division 2 major occupancy.

9.10.9.13. Separation of Suites

(1) Except as required in Article 9.10.9.14 and as permitted by Sentence (2), each suite in other than *business and personal services occupancies* shall be separated from adjoining suites by a *fire separation* having a *fire resistance rating* of not less than 45 min.

(2) In sprinklered buildings, suites of *business and personal service occupancies* and *mercantile occupancy* that are served by public corridors conforming with Sentence 3.3.1.4 (4) are not required to be separated from each other by *fire separations*.

(9.10.9.14) Camps for housing workers referred to in section 9.10.21.2 shall not be afforded less protection from fire than other residential occupancies.

9.10.9.14. Separation of Residential Suites

(1) Except as provided in Sentences (2) and (3) and Article 9.10.21.2., suites in *residential occupancies* shall be separated from adjacent rooms and *suites* by a *fire separation* having a *fire resistance rating* of not less than 45 min.

(2) Sleeping rooms in boarding, lodging or rooming houses where sleeping accommodation is provided for not more than 8 boarders or lodgers shall be separated from the remainder of the floor area by a fire separation having a fire resistance rating of not less than 30 min where the sleeping rooms form part of the proprietor's residence and do not contain cooking facilities.

(3) Dwelling units that contain 2 or more storeys including basements shall be separated from the remainder of the building by a fire separation having a *fire resistance rating* of not less than 1h.

9.10.9.15. Separation of Public Corridors

(1) Except as provided in Sentences (2) and (3), public corridors shall be separated from the remainder of the building by a *fire separation* having not less than a 45 min *fire resistance rating*.

(2) In other than residential occupancies, no *fire-resistance rating* is required for *fire separations* between a public corridor and the remainder of the building if,
(a) the floor area is sprinklered,
(b) the sprinkler system is electrically supervised in conformance with Sentence 3.2.4.10(3), and
c) the operation of the sprinkler system will cause a signal to be transmitted to the fire department in conformance with Sentence 3.2.4.8 (4).

(3) In other than residential occupancies, no fire separation is required between a public corridor an the remainder of the building if,
(a) the floor area is sprinklered,
(b) the sprinkler system is electrically supervised in conformance with Sentence 3.2.4.10(3),
c) the operation of the sprinkler system will cause a signal to be transmitted to the fire department in conformance with Sentence 3.2.4.8 (4), and
(d) the corridor exceeds 5 m in width.

9.10.10.7) Emergency Power Systems complete with back up generator shall be provide for all relocatable buildings in industrial settings.

9.10.10.7. Emergency Power Installations

(1) Where a generator is intended to supply emergency power for lighting, fire safety and life safety systems is located in a building, it shall be located in a room that:

(a) is separated from the remainder of the building by a *fire separation* with a *fire resistance rating* not less than,

(i) 1hr, if the floor assembly is not required to have a *fire resistance rating* of more than 1 hr, and

(ii) 2hr, if the floor assembly is required to have a *fire resistance rating* of more than 1 hr

(b) contains only the generating set and equipment that is related to the emergency power supply

9.10.14. Spatial Separation Between Buildings

9.10.14.1 Application

(1) Except as permitted in Subsection 9.10.15., this Subsection applies to *all buildings.*

9.10.14.2 Area and Location of Exposing Building Face

(1) The area of an exposing building face shall be,

(2) Taken as the exterior wall area facing in one direction on any one side of a *building*, and

(a) calculated as,

(i) the total area measured from the finished ground level to the uppermost ceiling, or

(ii) the area for each *fire compartment*, where a building is divided into fire compartments by *fire separations* with *fire resistance ratings* not less than 45 min.

(9.10.21.1) Camp for Housing Workers:

(9.10.21.2) Workers in construction camps shall not be afforded any less protection from fire by their buildings than other similar occupancies.

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9.10.21. Fire Protection for Construction Camps

9.10.21.1 Application

(1) Except as provided in Articles 9.10.21.2 – 9.10.21.9, camps for housing of workers shall conform to Subsections 9.10.1 – 9.10.20

Provisions of this section shall apply to all occupancies of construction camps, including office areas, and assembly occupancies for example and not only residential type occupancies.

9.10.21.2 Separation of Sleeping Rooms

(1) Except for sleeping rooms within *dwelling units*, sleeping rooms in a *building* in a *camp for housing workers* shall be separated from each other and from the remainder of the building by a *fire separation* having not less than 30 min *fire-resistance rating.*

(2) Fire separations having not less than 45min Fire Resistance Rating shall be provided between sleeping rooms in accordance with other sections of this same code. See Section 9.10.9.14(1) for reference.

9.10.21.3 Floor Assemblies between 1st and 2nd Storey

(1) Except in a dwelling unit, a floor assembly in a *building* in a *camp for housing workers* separating the 1st and 2nd storey shall be constructed as a *fire separation* having not less than 30 min. FRR.

(2) Fire separations having not less than 1HR Fire Resistance Rating shall be provided for floor assemblies between floors of occupancies containing dwelling units in accordance with other sections of this same code. See Section 9.10.9.14(3) for reference.

9.10.21.4 Walkways Connecting Buildings

(1) *Walkways* of *combustible construction* connecting *buildings* shall be *fire separated* from each connected *building* by a *fire separation* having not less than a 45 min *fire-resistance rating*.

(2) Fire separations having not less than 1HR Fire Resistance Rating shall be provided between exterior walls and exterior connecting walkways in accordance with other sections of this same code. See Section

9.10.21.5 Spatial Separations

(1) *Buildings* in a *camp for housing workers* shall be separated from each other by a distance of not less than 10m unless otherwise permitted in Subsection 9.10.4.

9.10.21.6 Flame Spread Ratings

(1) Except in *dwelling units* and except as provided in Sentence (2), the surface *flame spread rating* of wall and ceiling surfaces in corridors and walkways, exclusive of doors, shall not exceed 25 over not less than 90 percent of the exposed surface area and not more than 150 over the remaining surface area.

(2) Except within *dwelling units*, corridors that provide access to exit from sleeping rooms and that have a *fire resistance rating* of not less than 45 min shall have a *flame-spread rating* conforming to the appropriate requirements in Subsection 9.10.17.

9.10.21.7 Smoke Detectors

(1) Except in dwelling units, corridors providing *access to exit* from sleeping rooms in every *building* in a *camp for housing workers* with sleeping accommodations for more than 10 people shall have a *smoke detector* connected to the building alarm system.

(2) Carbon Monoxide Detectors shall be provided in accordance with Ontario Provincial Laws.

9.10.21.8 Portable Fire Extinguishers

:

(1) Each *building* in a *camp for workers* shall be provided with portable fire extinguishers in conformance with the provisions of the Fire Code made under the Fire Protection and Prevention Act, 1997.

9.10.21.9 Hose Stations

(1) Every building in a camp for housing workers providing sleeping accommodations for more than 30 persons shall be provided with a hose station that is protected from freezing and equipped with a hose of sufficient length so that every portion of the building is within range of the hose stream.

(2) Hose stations required in Sentence (1) shall be located near an exit.

(3) Hose size referred to in Sentence (1) shall be not less than 19mm inside diam and shall be connected to a central water supply or a storage tank having a capacity of at least 4500 L with a pumping system capable of supplying a flow of at least 5 L/s at a gauge pressure of 300kPa.

Part 10
Relocatable (Industrial Accommodation) Buildings
(Adapted from Part 10, Alberta Building Code 2006)

10.1. Application
10.1.1. General
10.1.1.1. Responsibility for Compliance
1) The *owner* of a *building* regulated by this Part is jointly responsible with any operator or lessor for the building's compliance with this Code.
2) During construction of a *building* regulated by this Part, the constructor is jointly responsible with the owner for compliance with this Code.
3) The manufacturer of a relocatable structure is jointly responsible with the installation contractor and the owner for compliance with this Code and for informing the owner of all necessary permitting, required for the building's installation.

10.1.1.2. Application
1) Except as specifically varied in this Part, Parts 1 to 9 apply to a *building* regulated by this Part.
2) Except as provided in Sentence (3), this Part applies to a *building* providing accommodation for an industrial work force living and working in a temporary location, but does not apply to *manufactured homes*, prefabricated single family *dwelling units*, or other types of prefabricated manufactured *buildings*.
This section shall apply to other buildings including the following relocatable structures: Disaster Relief Housing, Portable Classrooms, Construction Trailers, Temporary Condo Show Rooms, Mercantile Occupancies in Relocatable structures, etc….
3) This Part also applies to Group D and Group F Division 3 *occupancies* for a workforce working in a temporary location.
This section also applies to Group D, & Group F, Division 3 occupancies for workforces in permanent locations.

10.1.1.3. Scope
1) This part applies to
a) a one *storey building*
i) without sleeping accommodation, that is not more than 1200m2 in *building area*, and if sprinklered, is not more than 2400m2 in *building area* and
ii) with sleeping accommodation, that is not more than 600m2 in *building area*, and if *sprinklered*, is not more than 1200m2 in *building area,* and
b) a two storey building
i) without sleeping accommodation, that is not more than 600m2 in *building area*, and if *sprinklered*, is not more than 1200m2 in *building area*, and
ii) with sleeping accommodation, that is not more than 300m2 in *building area*, and if *sprinklered*, is not more than 600 m2 in *building area*.
2) A *building* described in Sentence (1) is permitted to consist of one or more transportable modules specifically designed to be readily relocatable and usable without permanent *foundation*.

(Part 10)
It is the suggestion of the author that this Part should apply to all relocatable buildings, not solely those intended for industrial accommodations.

(10.1.1.1(3))
This addition shall require that the manufacturer have an increased role and responsibility in the assurance that the requirements of this code, and all affiliated regulatory requirements are met. This is necessary, as the building owner or purchaser is not necessarily well versed in the requirements of the Building Code.

(10.1.1.2)
There are a wide range of types and occupancies of prefabricated manufactured buildings and relocatable buildings. This industry is no longer limited to manufactured housing, and the regulations need to reflect the changing uses and occupancies, and the resultant implications from these changed.

(10.1.1.4)
These are suggested dates and would be subject to review based on feasibility of adoption and implementation of this Part into the larger OBC Document.

10.1.1.4. Renovation Requirement of Existing Units

1) Sections 10.6 and 10.7 apply to

a) a *building* constructed on or after 02 January 2016, and

b) except, as varied by Sentence (2), a building constructed before 02 September 2007 at the time of relocation.

2) Units built between 01 March 1977 and 02 January 2016 shall comply with the requirements of Part 10 of the Code in effect at the time of construction and to Sections 10.6 and 10.7 of this code upon relocation.

3) A *building* referred to in Sentences (1) and (2) must be constructed or renovated by a *constructor* certified by the *Chief Building Administrator* and must carry the appropriate Ontario label.

4) A *building* regulated by this Part that is constructed in or relocated into Ontario after 02 January 2016 shall conform in all respects to this Code.

(10.1.1.5)
Installation of Relocatable Building shall require Recognition of Site Plan Control Jurisdictions, and adherence to all local requirements and regulations regarding the siting of these structures.

10.1.1.5. Temporary Facilities

1) A *building* to which this Part applies shall not stay at one site for more than 5 years, except as permitted by the *authority having jurisdiction*.

2) Where a temporary facility is being installed in an area to which Site Plan Control applies, such permits and agreements must be completed with the *authority having jurisdiction* prior to installation of the building.

10.1.1.6. Combined Activities

1) A *building* containing sleeping accommodations is permitted to include spaces for other uses not exceeding 100 m2 each in area, and if more than 50 m2 in area, each space shall be separated from the remainder of the *building* by doors and a wall conforming to Sentence 10.4.1.3(3) and Article 10.4.5.1.

2) Separation of certain types of activities and occupancies shall be in accordance with Part 3.

(10.2.1.1 & 10.2.1.2) All location and jurisdiction references in the modified and adopted Part 10 to be added to the OBC shall list "Ontario" specific organizations and locations.

(10.2.2.3) Due to the fact that relocatable buildings are used for more occupancies than solely Business and Personal Services (Group D) or Single Family Dwellings, the Occupancy of the Relocatable Building shall be determined and all structural loads designed in accordance with Part 4 – specific to the intended use – not just generically.

(10.2.3.2) Tie-Down Devices Shall be provided for all Relocatable Buildings regardless of intended duration of Occupancy. "If" Shall be removed from Clause 1.

10.2. Structural Requirements

10.2.1. General

10.2.1.1. Structural Design

1) Structural design shall be in accordance with Part 4 and, in addition, the design criteria shall allow for the effects of forces due to transportation and frequent relocation.

2) Structural design of loadbearing assemblies shall be done by a *professional engineer*, licensed in the province of Ontario.

10.2.1.2. Foundations

1) A *building* referred to in this Part is permitted to have a permanent or a temporary foundation. Either foundation must be a structurally sound, engineered and stamped solution by a Professional Engineer Licensed in the Province of Ontario.

10.2.2. Design Loads

10.2.2.1. Snow Loads

1) Roof *live loads* shall be ground snow load and associated rain load, and is permitted to be modified by a coefficient but shall be not less than 2 kPa.

2) Roof design shall allow for the effects of drifting snow.

10.2.2.2. Wind Loads

1) Design *live load* due to wind shall be based on reference velocity wind pressure not less than 0.7 kPa.

10.2.2.3. Floor Loads

1) Design floor loads in Group D *occupancies* shall be not less than 2.4 kPa.

2) Design floor loads in all other occupancies to comply with requirements of Part 4 of this code.

10.2.3. Stability

10.2.3.1. Design

1) If the resistance to overturning, calculated as the sum of the stabilizing moment of *dead load* only, is less than twice the overturning moment due to the *live loads* acting on the *building*, provision for the attachment of tie-down devices shall be made in the construction of the modules.

10.2.3.2. Tie-Down Devices

1) If tie-down devices are required,Tie-down devices are required on all relocatable buildings and the manufacturer shall provide tie-down instructions with each module specify the location, required capacity and anchoring of recommended tie-down devices.

2) If special fittings, fixtures or provisions are needed to comply with the tie-down instructions, they shall be supplied with the module.

3) The tie-down instructions shall be provided for a specific site only and shall be printed on a label and affixed to the module in a visible location.

(10.3.1.1)
2.1 m does not meet the minimum height requirements for room sizes within Part 9 or Part 3 of this code. In order to ensure more occupant friendly conditions, room heights of 2.1 m should be minimized to a specific size and type as outlined in this proposed revision, while the remainder of the relocatable unit's conditioned space shall provide 2.3 m minimum ceiling heights which meet expectations outlined in other parts of this code.

(10.4.1.3)
Sleeping Rooms given that these are essentially treated as separate tenants shall be provided an equivalent level of FRR as is expected from other types of multi-unit residential dwellings.

10.3. Heights and Areas

10.3.1. Size Requirements

10.3.1.1. Heights

1) Except as permitted by Sentence (2), the clear ceiling height shall be not less than 2.1m.

The clear ceiling height comply with Table 9.5.3.1 Room Ceiling Heights and shall not be less than 2.1m, with a clear height of 2.3m over at least 75% of the required floor area for living, dining, kitchen or office space.

2) In a module specifically produced to be transported by aircraft, the clear ceiling height shall be not less than 2m over at least 90% of the *floor area* and shall be not less than 1.9 m over the remaining *floor area*.

10.4. Fire Safety

10.4.1. Fire-Resistance Rating and Fire Separations

10.4.1.1. Fire-Resistance Rating

1) The fire-resistance rating required for a wall by other Parts of this Code is waived if the membranes on the wall contribute to the fire-resistance rating of the wall a membrane protection value not less than those specified in Articles 10.4.1.3 to 10.4.1.5.
a) when rated in accordance with Appendix D, or
b) when tested in accordance with Section 15 of CAN/ULC-S101, "Fire Endurance Tests of Building Construction and Materials."

10.4.1.2. Membrane Protection

1) The values of membrane protection in Articles 10.4.1.3 to 10.4.1.5 apply only if the wall or ceiling is framed with wood members not less than 38 x 64 mm spaced not more than 400 mm oc.

2) If a wall framing system with stud dimensions less than those specified in Sentence (1) is used, the membrane values required in Article 10.4.1.3 to 10.4.1.5 shall be increased by 10 min.

3) Prefinished wall paneling not less than 4.2 mm thick applied over plywood paneling, waferboard or oriented strandboard not less than 7.5 mm thick shall be considered to provide a 5 min. protection.

10.4.1.3. Sleeping Rooms

1) Each face of a wall separating a sleeping room from another room shall have not less than a 5 min membrane protection.

2) Except as required by Sentence (3), a corridor shall be separated from the remainder of the building by a wall having not less than a 5 min membrane protection on each face.

3) Except as permitted by Sentence (4), the face on the sleeping room side of a wall separating a sleeping room from a corridor or from a space referred to in Article 10.1.1.6. shall have not less than a 10 min membrane protection.

4) The rating of the membrane protection required by Sentence (3) need not be more than 5 min if the wall cavity is filled with mineral wool produced from glass, slag or *rock*.
a) having a density not less than 14 kg/m3
b) compressed to 75% of its normal thickness, and
c) completely filling the cavity.

(10.4.1.4)
Service Rooms shall be provided with continuous fire separations from all adjoining space of not less than 1hr FRR.

(10.4.1.5)
Exterior Wall must have a fire separation of not less than 1hr FRR, rated for fire exposure from both the interior AND the exterior. All Exterior Walls shall be class with non-combustible exterior cladding.

The membrane protection shall apply to all units, even those placed in isolation, or those with low occupancy loads. These issues are always subject to future changes due to staffing or other considerations, and seldom if ever do building owners return to existing relocatable buildings with the intension of upgrading the FRR of the Wall Assemblies unless forced by the Authority having Jurisdiction. And even then seldom do such upgrades occur.
FRR shall be considered a basic function of the structure, and such requirements shall not be waived under any circumstances.

10.4.1.4. Service Rooms

1) Wall faces in a *service room* shall have not less than a 30 min membrane protection.

2) The ceiling of a *service room* shall have not less than a 30 min membrane protection.

1) Wall Assemblies of Service Rooms shall provide a 1 HR FRR in accordance with Part 3 __

10.4.1.5. Exterior Wall Requirements

1) Except as permitted by Sentence (2) and (3), exterior walls shall have not less than a 5 min membrane protection from the inner face and shall have noncombustible exterior cladding.

(1) Combustible Cladding shall not be used regardless of proximity to trees.

2) A single module place more than 15 m from trees, shrubs or other modules may have combustible cladding. Relocatable Building Modules shall be provided with appropriate FRR of Exterior Wall, Roof and Floor Assemblies (min. 1hr FRR) to allow for landscaping and trees to be planted in close proximity to the buildings.

3) The membrane protection value in Sentence (1) does not apply in a single module if the occupant load is not more than 10 and the module is placed not less than 10m from any other building. Membrane protection shall apply to all relocatable buildings.

10.4.1.6. Fire Separations

1) In a two *storey building*

a) the floor assembly of the second *storey* shall be a fire separation having a 45 min *fire-resistance rating*, Floor assemblies for all relocatable buildings shall have a 1 HR minimum fire resistance rating.

b) the exit stairways from the second storey shall be separated from the remainder of the building by a fire separation having a 45 min *fire-resistance rating*, and
Exit stairways shall be separated from the remainder of the building by a fire separation having a 1HR minimum fire resistance rating.

c) the loadbearing walls, columns and arches supporting the floor assembly of the second storey shall have a 45 min *fire-resistance rating*.
Load bearing walls, colums and arches supporting the floor assembly of the sectond storey shall have a minimum 1 HR fire resistance rating.

10.4.2. Service Spaces

10.4.2.1. Service Room

1) A fuel-fired *appliance* placed in a *building* containing sleeping accommodation shall be placed in a *service room*.

10.4.2.2. Fire Dampers

1) An opening through the wall of a *service room* for the passage of a duct shall be protected with a *fire damper* having not less than a 45 min *fire-protection rating*. 1HR minimum fire protection rating.

10.4.2.3. Fire Stopping

1) An opening through the ceiling of a *service room* for the passage of a *chimney flue* shall be protected with fire stopping.

2) The joist space through which a *chimney flue* penetrates must have solid blocking not less than 38 mm thick on each side of the *chimney flue* and not less than 25mm from the *flue* separating the *flue* space from the joist space.

10.4.3. Flame-Spread Rating

10.4.3.1. Flame-Spread Rating

1) Except as otherwise required by this Subsection, the *flame-spread rating* of interior wall and ceiling finishes including 90% of the surface area of cupboards and built-in furniture, shall be no more than 150.

2) The *flame-spread rating* in a corridor and in an exit stairway from a second storey shall be not more than 25 on

a) 90% of the ceiling surface area, and

b) 90% of the wall surface area.

3) The *flame-spread rating* on the floor shall be not more than

a) 300 in a corridor, and

b) 150 in an *exit* stairway from a second *storey*.

10.4.4. Windows and Means of Egress

10.4.4.1. Windows

1) For each sleeping room, a window capable of serving as an emergency *means of egress* shall be provided with an unobstructed openable area not less than 0.35 m2 with no dimension less than 380 mm, and with a sill height not more than 1150 mm above the inside floor. A window shall not provide the primary means of egress from any building.

2) A window with non-breakable glazing or that is not openable shall not be used in a sleeping area unless the window is designed and permanently marked as being of a knock-out type.

10.4.5. Doors

10.4.5.1. Fire-Protection Rating

1) Doors listed and labeled as having not less than a 20 min fire protection rating or as conforming to CAN4-S113, “Wood Core Doors Meeting the Performance Required by CAN4-S104-77 for Twenty Minute Fire Rated Closure Assemblies,” shall be used

a) as smoke doors, and

b) between any part of a building and

- i) a corridor,
- ii) an exit stair, or
- iii) a service room.

2) A door frame that has not been tested and labeled by a testing agency may be used for a door required to have a 20 min fire-protection rating if the frame is rabbeted from solid wood stock and the final thickness is not less than 32 mm.

3) A door referred to in Sentence (1) shall be equipped with a latching mechanism.

10.4.5.2. Closers

1) A door equipped with an automatic closer shall be used between any part of a *building* and a) a *service room*,

b) an *exit stair*, or

c) a washroom facility.

10.4.5.3. Service Room Doors

1) A door to a *service room* may open outward from the *service room*.

10.4.5.4. Smoke Doors

1) Every corridor more than 55 m in length, shall be subdivided by smoke doors.

2) A smoke door shall be equipped with an automatic closer actuated by *smoke detectors*, and shall be designed and installed to retard the passage of smoke.

10.4.6. Exits

10.4.6.1. Number of Exits and Travel Distance

1) Except as permitted by Sentence (2), every *floor area* shall be served by not less than 2 *exits*.

2) A module is permitted to be served by one exit provided
a) the module is free standing and placed not less than 10 m from another *building*, and
b) the travel distance from any point in the module to the *exit* does not exceed 15m.
c) the module is provided with FRR of Exterior floor, wall and roof assemblies of 1 hr or more.

10.4.6.2. Travel Distance

1) Exits shall be located so that the travel distance from any part of the building to at least one exit is not more than
a) 25 m if the *building* is not *sprinklered*, or
b) 40 m if the *building* is *sprinklered*.

10.4.7. Fire Suppression

10.4.7.1. Standpipe and Hose System

1) If a *building*, or aggregate of *buildings*, containing sleeping accommodation at one site, serves 60 or more persons and is not *sprinklered*, each *building* shall be provided with a standpipe and hose system conforming to Sentences (2) to (7).

2) A firefighting water supply of not less than 13.5m3 for each *building* shall be supplied but the total water supply at one site need not be more than 27m3.

3) At least one hose cabinet shall be provided that contains a 38 mm diam. hose not more than 30m in length, capable of reaching all parts of the *building* with a water system.

4) In determining the location of a hose cabinet, allowance for spray shall be made only from the door of a bedroom to the back corner of the bedroom.

5) A hose shall be equipped with a nozzle that is adjustable from fog to a straight stream.

6) The minimum residual pressure at the hydraulically most remote hose station shall be 300 kPa, with a flow rate of not less than 5 L/s.

7) The firefighting water system is permitted to be combined with the domestic system, however, the water storage required for firefighting shall not be depleted by the domestic system.

8) Requirements for a *building* that has separate waterlines for hose and standpipe systems, are permitted to be established by the *authority having jurisdiction*.

9) An aggregate of *buildings* as referred to in Sentence (1) shall be considered as being a group of *buildings* that
a) function a one unit and are not more than 10 m from each other, or
b) are physically connected to each other by corridors, *walkways* or other facilities through which fire or smoke could spread.

10.4.7.2. Sprinkler System

1) If a sprinkler system is installed, it shall be designed by a professional engineer in conformance with NFPA 13, “Installation of Sprinkler Systems,” or NFPA 13R, “Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height.”

10.4.7.3. Portable Extinguishers

1) Portable extinguishers shall be installed in conformance with the Ontario Fire Code, latest Ed.

10.4.8. Electrical

10.4.8.1. Specific Electrical Requirements

1) Not less than 2 duplex receptacles shall be installed in each sleeping room.

10.4.9. Foamed Plastic

10.4.9.1. Foamed Plastic

1) *Foamed plastic* shall not be exposed in any part of a building.

2) Sentence (1) applies to the space beneath the module and to a roof space in addition to other parts of the building.

3) *Foamed plastic* shall have a flame spread rating not more than 25.

4) The surface of *foamed plastic* shall be protected from interior spaces in the *building* by 12.7mm gypsum board or by a *thermal barrier* complying with CAN4-S124-M, "Test of the Evaluation of Protective Coverings for Foamed Plastic," Classification A.

10.5. Health Requirements

10.5.1. Heating and Ventilation

10.5.1.1. Design

1) Heating equipment shall be capable of maintaining a temperature of 20*C within a *building* when the outside temperature is -45*D and the wind velocity is 25 km/h

(2) Heating equipment shall comply with the standards of ASHRAE 90.1

(10.5.1.2) Improved insulation levels for all units shall be required in order to improve the occupant comfort, lower energy use and reduce operating costs while improving the durability of the units.

10.5.1.2. Insulation

1) All exterior wall and roof cavities shall be completely filled with insulation having a resistance to heat flow not less than that provide by glass fibre batts, but the resistance need not be more than RSI 2.1. less than R13 + R7.5 continuous insulation

2) A floor assembly above an unheated space shall include thermal insulation with a thermal resistance not less than RSI 2.1. R-30

3) Installation and fastening of insulation shall ensure that it cannot be displaced during transportation.

4) All exterior roof cavities shall be completely filled with insulation having a resistance to heat flow not less than that provide by glass fibre batts, but the resistance need not be less than R38

5) Continuous layer of rigid insulation shall be provided on all exterior building envelope assemblies including walls, floor and roof, to prevent thermal bridging of the assemblies.

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10.5.1.3. Ventilation

1) Ventilation requirements shall be in accordance with ANSI/ASHRAE 62, "Ventilation for Acceptable Indoor Air Quality."

10.5.1.4. Circulation

1) In a *building* to which this Part applies, air may be circulated provided

a) supply and return air systems are ducted, and

b) 100% of the supply air is exhausted and not returned from

i) washroom facilities
ii) clothes drying areas, and
iii) kitchens and other areas containing cooking facilities.

10.5.1.5. Forced Air System

1) A forced air heating system shall be provided with air filters, which are to be checked and changed on a routine basis in conjunction with the manufacturer recommendations.
(2) Auto shutdown capacity of HVAC systems for buildings located in industrial settings complete with gas detection and monitoring shall be supplied and installed in conjunction with specific site requirements for all industrial relocatable buildings.

10.5.1.6. Ducts

1) All ducts for a heating system and for a ventilation system shall be constructed of galvanized steel.
2) Except as required by Article 10.4.2.2 for a wall of a *service room*, an air duct is permitted to penetrate a wall with a membrane protection without installing a *fire damper* at the penetration.

10.5.1.7. Vapour Barrier

1) If a *vapour barrier* is cut for openings for items such as electrical outlets and junction boxes, ducts, windows or doors, the integrity of the *vapour barrier* around the opening shall be maintained.

10.5.1.8. Screens

1) A *building* used for eating, cooking or sleeping shall have screens over all doors, windows and other openings to the exterior to prevent the entrance of flies and other insects.

10.5.2. Plumbing Facilities

10.5.2.1. Number of Fixtures

1) The fixtures in each washroom shall be based on the number of persons using that washroom, shall conform to Sentences (2) and (3) and, if persons of each sex are to be accommodated, a separate washroom shall be provided for each sex.
2) A *building* with sleeping accommodation shall be provided with
a) water closets on the basis of 1 unit for every 5 persons or part thereof up to 15 persons and 1 unit for every 15 persons or part thereof in excess of 15 persons,
b) lavatories on the basis of 1 unit for every 5 persons of part thereof,
c) showers or tub baths on the basis of 1 unit for every 11 persons or part thereof,
d) urinals in washrooms for males on the basis of 1 unit for every 25 persons or part thereof, and
e) laundry facilities
3) Water closets and lavatories in a building not covered by Sentence (2) shall conform to Part 7 and Part 3.7

10.5.2.2. Piping

1) Piping in corridor walls and in walls separating sleeping rooms shall be *noncombustible.*

10.5.2.3. Heat Tape

1) If heat tape is used on *combustible* drain, waste and vent pipes, it shall be provided with devices to ensure that it will not exceed temperatures recommended by the *combustible* pipe manufacturer and it shall be installed in accordance with the manufacturer's recommendations and instructions, except that a heat tape shall not be closer than 50mm to any other *combustible* material.

(10.5.2.4) Changes to the references listed shall be made to reflect the appropriate Ontario body, organization or regulation.

10.5.2.4. Sewage Disposal

1) Waste water from plumbing fixtures shall be discharge to a public sewage system if a system is available, otherwise it shall be discharged to a *private sewage disposal system* or to a sewage holding tank in accordance with the plumbing and drainage regulations made pursuant to the Safety Codes Act.

10.6. General Safety

10.6.1. Spatial Separation

10.6.1.1. Spatial Separation

1) Except as permitted by Article 10.6.1.2. and Subsection3.2.3., the spatial separation between buildings shall be not less than 10m dependent upon the FRR of the exterior wall assemblies.

10.6.1.2. Walkways or Corridors

1) The spatial separation between the end walls of modules containing sleeping accommodation may be less than 10 m if the end walls adjoin a *walkway* or corridor that
a) is not less than 3m in width,
b) is *sprinklered*,
c) is separated from any adjoining module or *building* by a *fire separation* with *a fire-resistance rating* not less than 45 min that extends through any crawl space to the ground, and
d) contains no *combustible* piping.

10.6.1.3. Proximity to Vegetation

1) A *building* shall be located not closer than 15 m to any bushes, trees or similar vegetation unless the unit is provided with appropriate FRR of the exterior wall assemblies. .

10.6.1.4. Proximity to Process Areas

1) A *building* shall be located not closer than 15m to any industrial process area.

2) Relocatable Structures located within Process areas, with no know blast risk shall provide 2 HR FRR for all assemblies including Walls, Roof and Floor Assemblies.

10.6.1.5. Proximity to Blast Zones

1) Relocatable Structures, including washroom facilities, which are not specifically designed for blast resistance, shall **not** be installed within an area with known potential blast risk.

2) Where the potential for such risk is present but not clear, blast risk analysis shall be carried out by the owner with a qualified consultant experience in Blast Risk Analysis prior to the installation of a relocatable structure.

10.6.2. Skirting

10.6.2.1. Skirting

1) Except as permitted by Sentence (2), skirting on a module, if installed, shall be *noncombustible*, or have *noncombustible* cladding.

2) When a single module is 15 m or more from trees or shrubs or similar vegetation, the skirting, if installed is permitted to be *combustible*.

3) Skirting shall be installed if the wall of a module is less than 15 m form the wall of another module or from another wall of the same module that forms an included angle of less than 135*.

4) Skirting shall be installed on that portion of the space beneath the module that is more than 750 mm in height measured at the exterior face of the module and measured between the ground surface and the underside of the module.

(10.6.1.1) The Ontario Building Code needs to be modified to recognized potential external hazards including Explosion, Fire and Toxic Hazards as may be present at a wide range of industrial facilities including but not limited to the Oil and Gas Sector. While there are voluntary industry standards and guidelines, which companies may choose to follow, the current regulations around buildings in these environments is vague at best and mute at worst.

(10.6.1.4 & 10.6.1.5) Specific Requirements shall be adopted from industry standards and best practices to reduce the inappropriate siting of relocatable structures in high-risk areas.

(10.6.2.1) This section addresses the potential fire hazard of adjacent vegetation, but remains mute on more probable sources of ignition and hazards.

(10.6.2.2(1)) Annotation of the changes that are proposed specifically to Re-number the existing Part 10 Change of Use to Part 13, and Subsequently to adopt the model of the existing Part 10 " Relocatable Buildings" as adapted from the existing Alberta building Code

10.6.2.2. Underside of Units

1) All exposed undersides of floor assemblies shall be clad with non-combustible, water-resistant, rot-resistant, and pest-resistant cladding, fastened and sealed continuously to the underside of the Floor Assembly.

10.6.3. Fire Alarms

10.6.3.1. Fire Alarm Systems

1) A fire alarm system shall be installed in accordance with CAN/ULC-S524, " Installation of Fire Alarm Systems, " in a *building*
a) providing sleeping accommodation for more than 10 persons,
b) providing dining facilities for more than 100 persons,
c) providing recreational facilities for more than 100 persons,
d) if required by other Parts of this Code, except as varied by Clauses (a), (b) and (c).

2) The fire alarm system required by Sentence (1) shall be tested to ensure satisfactory operation in conformance with CAN/ULC-S537, "Verification of Fire Alarm Systems," except that the verification may be done by an electrician: qualified in the maintenance of fire alarm and detection systems.

10.6.3.2. Manual Stations

1) If a fire alarm system is required by Sentence 10.6.3.1. (1), a manual station conforming to CAN/ULC-S528-M, "Manual Pull Stations for Fire Alarm Systems," shall be located adjacent to each exit so that no person can leave the *building* through an *exit* without passing a manual station.

10.6.3.3. Heat Detectors

1) If a fire alarm system is required by Sentence 10.6.3.1 (1), *heat detectors* conforming to CAN/ULC-S530, "Heat Actuated Fire Detectors," shall be placed in each service room, storage room, kitchen and clothes drying area.

10.6.3.4. Smoke Detectors

1) If a fire alarm system is required by Sentence 10.6.3.1 (1), *smoke detectors* conforming to CAN/ULC-S529, "Smoke Detectors for Fire Alarm Systems," shall be installed in every corridor serving rooms containing sleeping accommodation.

10.6.3.5. Smoke Alarms

1) A smoke alarm conforming to CAN/ULC-S531, "Smoke Alarms," shall be installed on the ceiling of every room providing sleeping accommodation.
2) The smoke alarm in Sentence (1)
a) shall be installed by permanent connection to an electrical circuit,
b) shall be equipped to show that it is in operating condition,
c) shall have no disconnect switches between the overcurrent device and the smoke alarm, and
d) is permitted to be tied into the *building* fire alarm system.

10.6.3.6. Carbon Monoxide Detectors

1) A carbon monoxide detector shall be installed in every room providing sleeping accommodations in accordance with Ontario Laws

10.6.4. Kitchen Ventilation

10.6.4.1. Cooking Equipment Ventilation System

1) Except as provide in Article 10.6.4.2., every kitchen containing commercial cooking equipment used in processes producing smoke or grease-laden vapours shall be equipped with a mechanical exhaust system conforming to NFPA 96, " Ventilation Control and Fire Protection of Commercial Cooking Operations."

(10.6.4.2) Provisions for separation distances of key elements shall not be modified by change of materials.

10.6.4.2. Kitchen Hoods, Canopies and Exposed Exhaust Ducts

1) Ducts for a kitchen exhaust system shall be constructed of 0.84 mm minimum thickness stainless steel.

2) A demountable exhaust extension may be used if the connection is exposed and is grease-tight.

3) The airflow in and around a canopy or hood shall be in accordance with good engineering practice and each design shall be submitted to the *authority having jurisdiction* for review.

(10.6.4.3) The Exception for Existing Modules section shall be phased out over a period of 5 years, in order for the market to adopt these new standards. After a 5 year transition period, all existing modules shall be required to be fully upgraded to meet current standards if they are have continued occupancy and use.

4) The required clearance from the exhaust duct to *combustible* material may be waived if a 25 mm air space, having no materials in it, separates the exhaust duct from a *noncombustible* material backed by not less than 25 mm of mineral wool insulation, which protects the *combustible* material.

5) The required clearance from the hood or canopy to *combustible* material may be waived if a 50 mm air space, having no materials in it, separates the hood from a *noncombustible* material backed by not less than 25mm of mineral wool insulation, which protects the *combustible* material.

6) A sidewall fan may be used.

7) A fan shall be rated for continuous use as a commercial exhaust fan.

10.6.4.3. Exceptions for Existing Modules

1) A canopy or hood installed before June 30, 1985, is permitted to have other than welded joints and seams.

2) In modules constructed before June 30, 1985, the kitchen mechanical exhaust and fire suppression system is considered acceptable provide

a) the canopy completely covers all commercial cooking appliances and is complete with filters,

b) an automatic fire suppression system is located in the canopy, and

c) the system provides mechanical exhaust sufficient to remove grease-laden vapours.

3) All older models of relocatable buildings must be updated to meet current fire safety requirements if there is a change in ownership or if they are be relocated from their current installation.

(10.6.5.1) No exception based on intended occupancy levels shall remove the requirement to furnish modules with full functioning emergency lighting.

10.6.5. Lighting

10.6.5.1. Emergency Lighting

1) Emergency lighting shall be provided to average levels of not less than 0 lx at floor or tread level in all corridors and in areas serving as *access to exit* from all *buildings* having an *occupant load* more than 20.

Emergency Lighting shall be provided in all building units, regardless of anticipated occupancy levels at the time of initial construction.

10.6.5.2. Exit Signs

(10.6.5.2)
No occupancy exception shall remove the requirement for modules to be provided with all necessary Exit signs to meet a necessary requirements outline in other parts of this code.

1) An illuminated *exit* sign shall be installed at each exit location serving all *building* having an *occupant load* more than 20.
Exit Signs shall be provided in all building units, regardless of anticipated occupancy levels at the time of initial construction.

10.6.6. Doors

10.6.6.1. Exit Door Hardware

1) Every *exit* door from a *building* containing sleeping, dining or recreational facilities shall be equipped with plunger type hardware or hardware listed and labeled by a testing agency, that will release and allow the door to swing open if a force not exceeding 90N is applied to the hardware in the direction of *exit* travel.

10.7. Identification

10.7.1. Labeling

10.7.1.1. Identification Plate

1) Each building module conforming to this Part shall be clearly and permanently identified with a plate showing
a) the date of construction,
b) the name of the constructor, (manufacturer)
c) the address of the constructor,
d) the Model Number and Serial Number, and
e) the structural and mechanical design parameters.

(10.7.1.1)
Dates provided are suggestions only and shall be modified to suit a feasible timeframe based on the projected adoption and implementation of these changes.

2) The identification plate shall be fixed to the module in a location that is visible when the unit is complexed or standing alone.
3) In the case of a building module constructed after January 02, 2016, the identification plate required by Sentence (2) shall be affixed at the time of construction.
4) In the case of a building module constructed before January 01, 2016, the identification plate required by Sentence (1) shall be affixed before relocation to a new site.

10.8. Objectives and Functional Statements

10.8.1. Objectives and Functional Statements

10.8.1.1. Attribution to Acceptable Solutions

1) For the purpose of compliance with this Code as required in Clause 1.2.1.1(1)(b) of Division A, the objectives and functional statements attributed to the acceptable solutions in this Part shall be the objectives and functional statements listed in Subsection 4.2.8. of Division A. (See A-4.1.2.1.(1) in Appendix A of Division A.)

APPENDIX C

EXTENDED ACKNOWLEDGEMENTS

I would like to extend my thanks to all of the following people who were part of the North House Project:

Faculty Team: Geoffrey Thun, Kathy Velikov, David Lieberman, Dr. John Straube, Philip Beesley, Donald McKay, Rick Haldenby & Dr. Michael Collins (University of Waterloo)
Dr. Alan Fung (Ryerson University)
Dr. Lyn Bartram & Dr. Rob Woodbury (Simon Fraser University)

Core Architectural Student Team: Lauren Barhydt, Chris Black, Maun Demchenko, Natalie Jackson, Jen Janzen & Bradley Paddock.

Core Engineering Student Team: Sebastien Brideau, Brent Crowhurst, Ivan Lee, Bart Lomanowski, Andrew Marston, Toktam Saied & Humphrey Tse.

Interaction Design Student Team: Rob Mackenzie, Kevin Muise & Johnny Rodgers.

Additional Student Team: Fabio Almeida, Wade Brown, Eric Bury, Aya Dembo, Brittany Hanam, Andrew Haydon, Andrea Hunniford, Davis Marques, Lindsey Nette, Matt Peddie, David Schellingerhoudt, Sonja Storey-Fleming, Jamie Usas & Allan Wilson.

MCM 2001 Inc. Fabrication Team: Jack Debski, Gregory Rybak, Sean Baldwin, Witek Jasinski, Mikola Minzak, Krzystof Banasek, Piotr Dabrowski, Zbigniew Gembora, Adam Golaszewski, Ryszard Goryl, Wladyslaw Iwaniec, Oleg Izvekov, Philip Lesniak, Maks Matuszewski, Pawel Noga, Richard Pelly, Danny Pietrangelo, Krzystof Plaza, Jan Sawczak, Luke Statkiewicz & Lukasz Szczepanek.

Structural Engineer: Cory Zurell

Red Electric Team: Dan Pelkman, Robin Sanders & Nicolas Stroeder.

Mechanical Team: Al Davies (Eco-Options Geosolar), Steve Davies (Ecologix Heating Technologies), Aaron Goldwater (Goldwater Solar Services) & Gord Walsh (Slatus Air).

Controls Design: Chris Brandson (Vertech Solutions) & Reid Blumell (Embedia Technologies)

Mackie Moving Systems: John Fyfe & Fred Taphouse.

Bulthaup Canada Kitchen Systems: Antje Bulthaup & Stefan Sybydlo.

Figure A-10 & A-11: North House Exterior Perspective – Day & Night

APPENDIX D

A BRIEF OVERVIEW OF THE NORTH HOUSE PROJECT

The North House is a proof-of-concept, prefabricated, solar-powered home designed for northern climates, developed as part of a research project initiated in Fall 2007 at the University of Waterloo School of Architecture. The development and design of the project involved a broad collaboration between faculty and students at the University of Waterloo, with Ryerson University and Simon Fraser University. This thesis originates from this faculty-directed research project for which I was a primary member of the graduate student team. Many of the concepts, and details, described in this work were developed by the team. In the greater context of the project, however the discussion & analysis of the landscape strategy of the North House within the context of the broader movement of urban agriculture and experiential exterior learning spaces are representative of the unique contributions that I have made to the larger project team.

With a focus on high-performance architecture, responsive systems and interactive technologies, the house was designed for use as a public demonstration project, where it could showcase a wide range of new applications of technology and promote an energy conscious lifestyle. It is also intended for use as a research laboratory, for the long-term monitoring of the systems in the house, and to house subsequent iterations of its systems and components. The house was fabricated by MCM 2001 Inc.: a custom millwork and components manufacturer located in Toronto, Ontario.

North House was one of twenty projects selected as finalists to compete in the 2009 Solar Decathlon, sponsored by the United States Department of Energy (DOE) and the National Renewable Energy Laboratory (N.R.E.L.). The houses of all twenty finalists were erected on the National Mall in Washington D.C. during the month of October 2009, where they competed against one another through a series of ten specific contests structured to both qualitatively and quantitatively assess their design and performance. North House placed fourth overall in the competition.

The house is organized into two basic zones. The first is a highly insulated north service zone called the 'densepack', which constitutes the building's primary structural module and contains all mechanical and electrical components, wet services and storage. The second zone is an open flexible and reconfigurable living and sleeping space, clad on three sides in the DReSS layered façade system which partners large areas of glazing with responsive exterior shading. Outside of the conditioned space, a carefully choreographed constructed landscape was erected to facilitate public accessibility & viewing as well as to illustrate the Holistic Solar concepts established by the team.

DESIGN OBJECTIVES

Five design objectives were established by the team at the outset of the North House project and remained consistent throughout the 18-month design and construction process. These objectives and their manifestation in the built project are outlined here:

A House for Climate Extremes

Beyond meeting the design challenges of a cold climate, North House is designed to perform in an extreme climate with broad fluctuations, such as that of Southern Ontario, Canada, where it is common to experience hot, humid summers, and cold, dry winters, ranging between +30°C and 15°C.[1] The house is designed to respond quickly to these fluctuations using a layered façade system called the DReSS system, outlined below.

The power generating elements, of the house, comprise a set of technologies intended to perform in a variety of conditions. While horizontally oriented photovoltaic panels located on the project's roof perform optimally in the summer, vertically mounted building integrated photovoltaic panels on solar-exposed façade locations allow for power production in winter when sun angles are low. These panels combined comprise a 14kW solar array, which over the course of an annual cycle, and when grid tied, is designed to produce almost twice the energy that the house consumes. Solar thermal collectors on the roof provide hot water for both domestic use, and space conditioning through a three-tank cascading heat system. Operable insulated casement panels provide passive ventilation in the spring and fall seasons, while maintaining the integrity of the thermal envelope when in the closed position.

DReSS (Distributed Responsive System of Skins)

The DReSS System is a layered system of building skins in which each layer performs a specific function yet where the overall system is intended to constitute an envelope that responds dynamically to changes in exterior environmental conditions, the interior state of the home, and the desires of its occupants. The ratio of solid insulated wall assembly to the DReSS system assembly was carefully balanced using energy modeling software to maximize the capacity for passive heating, while providing adequate insulation to retain that heat. The layers of the system include: automated exterior venetian blinds, high performance glazing in a custom designed wood curtain-wall system, and motorized interior shades. The system combines active and passive technologies in order to be both energy-efficient and highly responsive.

The exterior venetian blinds are used to block solar radiation, before it reaches the glazing and begins to heat the building's interior. When passive heating is desired they can be fully retracted to maximize passive solar gains. Between these two extreme operational states, the blinds are capable of subtle variations appropriate to mediate solar exposure with a range of fine-grained configurations. Salt hydrate, an encapsulated phase change material (P.C.M.) in the floor allows for both ambient capture and diurnal heat storage. The control system for the blinds was developed by the project team to outperform existing manufacturer controls which operate at fixed predetermined states based on typical weather patterns for a given geographic location. Rather, solar irradiation and wind sensors track the sun's actual performance in real time, so that facades are only shaded as required, leaving ample glazing exposed for daylight and views to the exterior.

The insulated glazing units (I.G.U.s) were selected for their R-value, solar heat gain coefficient and visual transmittance. The IGUs manufactured by Serious Materials have an R-value of 12, a U-value of 0.472, a solar heat gain coefficient of 0.438 and visual transmittance of 0.585. They have semi-insulating spacers, which balance R-value and structural capacity allowing for the manufacture of large, high-performance units. Three low emissivity (low e) coatings are located on surfaces facing the exterior to control radiant heat. Units are comprised of a quad-layer system, with two Mylar films suspended between two panes of glass, the interior cavities of which are krypton filled. The wood curtain-wall system uses materials and detail configurations that pursue a thermally inert objective by using rubber caps, anchored to a friction-fit clip, pre-installed on the face of the mullion. Large IGUs, combined with the design of the wood curtain-wall system, minimizes the frame effect, in which heat is lost primarily through the edges of the IGUs. Due to time constraints, the friction-fit clip was manufactured in steel for the prototype, but can be replaced with a thermally inert material such as fibreglass or high-density plastic. The interior shades can be individually controlled to provide privacy and reduce glare. They allow the occupant to control their environment in a way that will not compromise the critical performance of the building envelope.

ALIS (Adaptive Living Interface System)

The Adaptive Living Interface System is a digital interface through which the occupants of the North House can control the active systems within the North House. Three touch screens within the house allow for the intuitive control of lights, shades and the interior climate through a set of gradient-based switches. The interface provides direct feedback in terms of how selected settings affect performance, energy consumption, energy cost, etc. These same controls can also be accessed online or through a smart phone, providing maximum flexibility to the occupants.

Another feature of the A.L.I.S. system is the ‘ambient canvas,’ an LED display embedded in the kitchen backsplash informing occupants of their energy and water consumption, as well as their progress with regard to predetermined goals. This ambient feedback is more abstract in its nature, and is linked to psychological research examining occupant behavior that suggests that subconscious, non-information based cues form a critical dimension to the shaping of behavior, in this case, domestic behavior and the development of ‘sustainable practices’ through non-information based reinforcement. Providing residents with cues, about the building’s function, is key to their involvement in its efficient operation. This kind of subtle feedback display, combined with the building’s smart controls, gives residents a sense of agency, which will help to foster their commitment to sustainable living.

Holistic Solar Living

Holistic solar living incorporates solar resource into occupant lifestyle in ways much broader than just photovoltaic power generation. Many aspects of the design of North House encourage its occupants to embrace the seasonal extremes of one’s locale. The functioning of the house, notably the DReSS façade system, responds to climatic variation in a way that characterizes the interior space of the home, encouraging an occupant lifestyle, which varies with the seasons. Daylighting and visual connections to the outdoors are maximized especially in colder months when occupants tend to spend less time outdoors. In warmer months, the occupants of North House can enjoy a range of outdoor amenities, including a very generous deck, with space for dining and entertaining, vegetable gardens for food production, and an extensive outdoor counter with a sink, for canning or drying food grown on site. While ornamental and native grass species selections, incorporated into the landscape design, also serve to highlight changing botanical characteristics associated with the passing months. All of these factors encourage the occupants of North house to live a lifestyle in tune with solar and seasonal conditions.

Customizable Components

North House is a prefabricated, factory-built housing prototype, which is comprised of independent components. The project was designed anticipating the potential for mass production and mass customization, insofar as its constituent elements might be reconfigured to produce a range of housing types, and sizes. Although the house is capable of being used in its prototype state to support two occupants, this is not intended to declare an optimal final design solution, but rather, a prototype for the components, systems, and approaches that would inform a broader set of designed products for market. The prototype house is comprised of a series of independent components that allow the house to be assembled and disassembled with ease, and for individual components or entire systems to be swapped out and replaced by alternates. The component-based design of North House allows it to function as a laboratory for testing alternate systems an technologies as they are developed. The components, systems, and approaches of North House can also be applied to a wider range of building projects. For example the DReSS system, tested on the North House prototype could be used in buildings of various scales and programs.

While these five objectives were maintained throughout the duration of the design process, they were not the only parameters that shaped the project. Since the house was to participate in the 2009 Solar Decathlon, it also needed to be designed for a range of exigencies linked to the rules, regulations, and conditions of the U.S Department of Energy's competition, and the specific limitations of construction on the National Mall in Washington D.C.. This included at a broad level, transportation constraints, ease and rapidity of assembly and disassembly, limited structural loading to the ground condition, and the logics of limited staging areas during on site work.

THE SOLAR DECATHLON

The Solar Decathlon is a biannual competition hosted by the United States Department of Energy and the National Renewable Energy Laboratory. From a range of applicants' proposals, the D.O.E. selects 20 finalists. These teams build their 100% solar-powered house in the months leading up to the competition, and then transport it in pieces to Washington DC where they reassemble it over a period of seven days on the National Mall. The objectives of the competition did not specifically include developing prefabricated building techniques, but due to these particular competition constraints, it was something that all teams needed to consider. Prefabricated building technique was a specific focus for our team, but the competition added additional constraints, which would influence the design of the North House.