

APPENDIX D
ALTERNATIVE SOLUTION REPORT

ALTERNATIVE SOLUTION REPORT TIMED-EGRESS ANALYSIS

MORDEN GREENHOUSE AND HEADER BUILDING 101 ROUTE 100, MORDEN, MANITOBA

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Our File: 16-522

1.0 **INTRODUCTION**

This report provides an approach to compliance of the requirements relative to a timed-egress analysis to address the exit travel distances for the Morden Greenhouse and Header Building located at 101 Route 100 in Morden, Manitoba. The request to review the travel distance for the facility is a result of a proposed addition to the south of the existing building.

The information contained in this report is based on drawings provided by KGS Group.

The alternative solution outlined in this report is intended only for the Project, and is not intended to set a precedent for future projects. All references indicated in this report are from the Manitoba Building Code 2011 (MBC), unless noted otherwise.

This report was prepared by LMDG Building Code Consultants Ltd. (LMDG) for KGS Group, and is intended for submission to and review by the Authorities Having Jurisdiction for the Project. The material provided in this report is based on LMDG's best judgment in light of the information available to LMDG at the time of preparation. Any use of this report by third parties, or any reliance on or decisions made based on it are the responsibility of such third parties. LMDG accepts no responsibilities for damages, if any, suffered by any third party as a result decisions made or actions based on this report.

2.0 **PROJECT CHARACTERISTICS**

The following table identifies the characteristics of the building for the purpose of applying the building code.

Applicable building code Part: 3

Building height: 1 storey

Building area: Approximately 1,234 m²

First storey: Level 1

Number of streets facing: 1

Sprinklered: No

Major occupancies: Group F, Division 2

Construction type: Noncombustible

The Project is an existing building that includes a greenhouse located at the south end of the building and laboratories at the north end. An addition will be constructed as an extension of the existing greenhouse at the south end of the building. The building is classified as containing a Group F, Division 2 major occupancy and will include subsidiary offices and service rooms.

The existing building is of noncombustible construction, is not sprinklered, and is equipped with a single-stage fire alarm system.

3.0 SUMMARY OF COMPLIANCE ISSUES

The maximum exit travel distance permitted within the building is based on the requirements applicable to a floor area that is not sprinklered. In accordance with the requirements of Clause 3.4.2.5.(1)(f), the maximum travel distance to an exit measured from any point in a floor area is 30 m. There are locations within the floor area of the building that will exceed this maximum permitted travel distance to an exit following the completion of the addition. The greatest travel distance that will occur will be 33 m. However, it should be noted that the prescriptive travel distance limit of 30 m will be achieved throughout the majority of the floor area.

A reduced architectural floor plan has been provided in **Appendix A** to this report, indicating the exit travel distance measurements throughout the floor area and identifying the specific location where the maximum travel distance to an exit will occur.

For the purposes of determining the occupant load of the building, a factor of 4.6 m²/person has been used for the laboratories, 28 m²/person for the greenhouse space, and an occupant load factor of 9.3 m²/person has been used for the office in accordance with Table 3.1.17.1. As such, the Level 1 occupant load is calculated to be 74 people.

4.0 ALTERNATIVE SOLUTION

The objective-based MBC is made up of two major divisions, Divisions A and B. Division A presents the objectives that the code addresses and the functional requirements (in qualitative terms) that solutions must satisfy. Division B presents the quantitative performance criteria with which solutions must comply (where these are available) and provides deemed-to-comply solutions drawn from the current version of the MBC.

The MBC explains that compliance with the code can be achieved by:

- complying with the applicable acceptable solutions in Division B, or
- using alternative solutions that will achieve at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the applicable acceptable solutions.

With respect to the alternative solutions, the document includes a complete list of objectives statements, categorized as:

- OS—Safety,
- OH—Health,
- OA—Accessibility, and
- OP—Fire and Structural Protection of Buildings.

Included as part of this document is the list of functional statements, which are measures, such as those described in the acceptable solutions in Division B, that are intended to establish the criteria by which the building or its elements may achieve the stated objectives.

Finally, the MBC includes a list of the acceptable solutions attributed to each Division B code requirement in which the objectives and functional statements attributed to each existing code requirement (Division B) are listed with the corresponding code reference.

- **Formulation of an Alternative Solution**

The appendix to the MBC provides guidance for the development of alternative solutions. Firstly, the proponent of an alternative solution must demonstrate that the alternative solution addresses the same issues as the applicable acceptable solutions in Division B, and their attributed objectives and functional statements. Furthermore, effort must be made to demonstrate that an alternative solution will perform as well as a design that would satisfy the applicable acceptable solutions in Division B. In this sense, it is Division B that defines the boundaries between acceptable risks and the unacceptable risks referred to in the objective statements.

When Division B offers a choice between several possible designs, the one providing the lowest level of performance should generally be considered to establish the minimum acceptable level of performance to be used in evaluating alternative solutions for compliance with the code.

4.1 Alternative Solution: Timed-Egress Analysis

As described in **Section 2.0** of this report, there are portions within the floor area of the building that will not comply with the maximum permitted travel distance of 30 m when measured from any point in the floor area to an exit. The maximum travel distance to an exit on Level 1 will be 33 m.

A timed-egress analysis will be used to address the applicable requirements of the MBC on an alternative solution basis. Specifically, the affected areas will be addressed by analyzing the additional time required to reach an exit to determine whether or not the travel distance extension causes a reduction in the performance level for an occupant to reach an exit as it compares to a prescriptively code compliant building (i.e., where exit doors are at their maximum capacity and occupants are within 30 m of an exit when measured from any point in the floor area).

4.1.1 Applicable Building Code Requirements

In accordance with Clause 3.4.2.5.(1)(f), the maximum travel distance from any point in a floor area is required to be not more than 30 m.

In accordance with Sentence 3.4.3.2.(1), the aggregate required width of exits shall be determined by multiplying the occupant load by the appropriate width per person factor provided for level areas, stairs, and ramps.

4.1.2 Intent of Applicable Building Code Requirements

In accordance with Division A, Clause 1.2.1.1.(1)(b), compliance with the MBC is permitted to be achieved by using alternative solutions that will achieve at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the applicable acceptable solutions.

Parts 2 and 3 of Division A outline the objectives and functional statements for all requirements of the building code. The objectives and functional statements from Articles 2.2.1.1. and 3.2.1.1. applicable to the building code requirement noted above are as follows.

Code Requirement	Objectives and Functional Statements
Clause 3.4.2.5.(1)(f)	[F10-OS3.7]
Sentence 3.4.3.2.(1)	[F10-OS3.7]

The detailed description of the applicable objectives and functional statements from Division A are as follows.

Objectives and Functional Statements	Description
F10	To facilitate the timely movement of persons to a safe place in an emergency
OS3.7	To limit the probability that a person in or adjacent to the building will be exposed to an unacceptable risk of injury due to hazards caused by persons being delayed in or impeded from moving to a safe place during an emergency

It is proposed that a timed-egress analysis will provide evidence that the location of exits will meet the intent of the applicable objectives and functional statements of Division A for the noted requirements. An analysis of the specific functional and objectives statements noted above is as follows.

It is intended that occupants will be capable of moving from any point in a floor area to a location that will provide protection from exposure to a fire within an acceptable time period. This period of time has been simplified in the Canadian code documents, including the MBC. In an effort to provide simplified requirements, the MBC prescribes the maximum distance of travel to an exit facility and the minimum effective width of the exit facility. These two measurable values reflect the time required for an occupant to travel to an exit facility and the time required for all occupants to enter the exit facility once arrived (occupant flow through an exit door or other exit threshold), respectively.

4.1.3 Alternative Solution Approach

The following is a comparative analysis of the time for occupants to travel to an exit from the time for occupants to travel to an exit in a scenario that meets the prescriptive requirements of the building code. The analysis will confirm that the extended travel distances within the floor area will meet the attributed objectives and functional statements. In this case, the exit capacity has been determined on the basis of 6.1 mm/person for the exit doors as required by the MBC. On this basis, it will be the flow time of occupants from the floor area to an exit that will determine the total egress time. That is, the period of time required for the last occupant to cross the threshold of the exit door where the doors are at their maximum capacity will be longer than the period of time for the furthest occupant to reach the exit door in the proposed scenario with an extended travel distance.

The first scenario will be based on the proposed condition with the extended travel distances. The time required for occupants to flow through the associated exit doors will be determined on the basis of the number of persons per metre width of the exit door per minute. For the purposes of this analysis, the flow rate for the doors will be 50 persons per door leaf as identified on Page 3-381 of *The SFPE Handbook of Fire Protection Engineering 2008* (refer to **Appendix B** to

this report for further information). Based on the above, the following table indicates the estimated flow rates of occupants for the exit doors.

Proposed Condition					
Exit Door	Door Leaf	Capacity of Occupants at Exit Door ⁽¹⁾	Occupants Utilizing Door ⁽²⁾	Flow Rate at Door	Total Flow Time for Distributed Occupants at Door
1	1	143 persons	18 persons	50 persons/min.	0.36 min.
2	2	285 persons	18 persons	100 persons/min.	0.18 min.
3	2	285 persons	19 persons	100 persons/min.	0.19 min.
4	1	166 persons	19 persons	50 persons/min.	0.38 min.

⁽¹⁾ Based on 6.1 mm/person.

⁽²⁾ Assumes equal distribution at each exit door in order to indicate the shortest anticipated queue time at each exit door.

The time required for occupants to flow through the associated exit doors within a code compliant scenario (i.e., the exit doors will attributed with the maximum permitted exit capacity) will be determined on the same basis as that used in the analysis above. Accordingly, the following table indicates the estimated flow rates of occupants for the exit doors.

Acceptable Solution Condition					
Exit Door	Door Width	Capacity of Occupants at Exit Door ⁽¹⁾	Occupants Utilizing Door ⁽²⁾	Flow Rate at Door	Total Flow Time for Distributed Occupants at Door
1	1	143 persons	143 persons	50 persons/min.	2.86 min.
2	2	285 persons	285 persons	100 persons/min.	2.85 min.
3	2	285 persons	285 persons	100 persons/min.	2.85 min.
4	1	166 persons	166 persons	50 persons/min.	3.32 min.

⁽¹⁾ Based on 6.1 mm/person.

⁽²⁾ Assumes equal distribution at each exit door in order to indicate the shortest anticipated queue time at each exit door

Portions of the floor area that will be more than 30 m but not more than 33 m to an exit were reviewed in terms of the travel time to reach an exit queue relative to a code-complying travel time. For this analysis, the travel speed has been determined as 75 m/min. based on Table 3-12.4 of *The SFPE Handbook of Fire Protection Engineering 2008* (refer to **Appendix B** to this report for further information), using a travel speed on a horizontal surface for occupants without a locomotion disability. Based on this travel speed, an occupant within 30 m of an exit would reach an exit location within 24 seconds. An occupant travelling at the same speed over a 33 m distance will reach the exit location within 26.5 seconds. Since the queue times for the proposed condition will be less than either of this value, the travel time of 26.5 seconds will define the evacuation time for the proposed condition.

However, comparing this to the potential queue time for a code-complying scenario, i.e., 2.85 to 3.32 min as determined above in a code compliant scenario with doors at their maximum capacity, an occupant arriving at an exit door within 24 or 26.5 seconds will be required to wait for the remaining occupants to finish queueing for an additional 124 to 175 seconds prior to exiting the building. In this case, the queue time of 3.32 min (199 seconds) defines the evacuation time for a code complying condition. As such, the additional travel time of 2.5 seconds for the extended travel distance of 33m will not adversely affect the evacuation time of the building occupants in comparison to a code conforming condition.

5.0 CONCLUSION

As determined by the analysis above, it is demonstrated that the extension of the travel distance will result in an exit time that will be less than that permitted by a code complying scenario as described above. As such, the extended travel distance of 3 m will not have an adverse effect on the time required for an occupant to exit the building. Based on these considerations, the extended travel distance for the floor area of the Morden Greenhouse and Header House facility will meet the intent of the objectives and functional statements of the Division B provisions. Specifically, the travel distance to exits within the floor area can be considered to be such that the occupants will be provided with the required protection from exposure to a fire within an acceptable time period on an alternative solution basis.

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APPENDIX A
REDUCED ARCHITECTURAL FLOOR PLAN



APPENDIX B

EXCERPTS FROM SFPE HANDBOOK OF FIRE PROTECTION ENGINEERING 2008

Table 3-12.4 Speed on a Horizontal Surface

Subject Group (number)	Mean (m/s)	Standard Deviation (m/s)	Range (m/s)	Interquartile Range (m/s)
All disabled (n = 107)	1.00	0.42	0.10–1.77	0.71–1.28
With locomotion disability (n = 101)	0.80	0.37	0.10–1.68	0.57–1.02
No aid (n = 52)	0.95	0.32	0.24–1.68	0.70–1.02
Crutches (n = 6)	0.94	0.30	0.63–1.35	0.67–1.24
Walking stick (n = 33)	0.81	0.38	0.26–1.60	0.49–1.08
Walking frame or rollator (n = 10)	0.57	0.29	0.10–1.02	0.34–0.83
Without locomotion disability (n = 6)	1.25	0.32	0.82–1.77	1.05–1.34
Electric wheelchair (n = 2)	0.89	—	0.85–0.93	—
Manual wheelchair (n = 12)	0.69	0.35	0.13–1.35	0.38–0.94
Assisted manual wheelchair (n = 16)	1.30	0.34	0.84–1.98	1.02–1.59
Assisted ambulant (n = 18)	0.78	0.34	0.21–1.40	0.58–0.92

Table 3-12.5 Speed on Stairs

Subject Group (number)	Mean (m/s)	Standard Deviation (m/s)	Range (m/s)	Interquartile Range (m/s)
Ascent				
With locomotion disability (n = 30)	0.38	0.14	0.13–0.62	0.26–0.52
No aid (n = 19)	0.43	0.13	0.14–0.62	0.35–0.55
Crutches (n = 1)	0.22	—	0.13–0.31	0.26–0.45
Walking stick (n = 9)	0.35	0.11	0.18–0.49	—
Rollator (n = 1)	0.14	—	—	—
Without disability (n = 8)	0.70	0.24	0.55–0.82	0.55–0.78
Descent				
With locomotion disability (n = 30)	0.33	0.16	0.11–0.70	0.22–0.45
No aid (n = 19)	0.36	0.14	0.13–0.70	0.20–0.47
Crutches (n = 1)	0.22	—	—	—
Walking stick (n = 9)	0.32	0.12	0.11–0.49	0.24–0.46
Rollator (n = 1)	0.16	—	—	—
Without disability (n = 8)	0.70	0.26	0.45–1.10	0.53–0.90

Table 3-12.6 Time in Seconds to Negotiate Doors

Closing Force (N)	No Aid (n = 63)			Crutch Users (n = 5)		Walking Stick (n = 28)			Walking Frame/Rollator (n = 8)	
	Mean (s)	Standard Deviation	Range (s)	Mean (s)	Range (s)	Mean (s)	Standard Deviation	Range (s)	Mean (s)	Range (s)
Push										
21	3.0	0.8	1.7–4.5	3.7	3.6–3.8	3.7	1.5	2.3–7.4	7.9	2.0–12.8
30	3.5	2.2	1.9–15.0	3.0	2.5–3.2	3.8	1.5	2.5–7.3	6.3	2.2–10.5
42	3.7	1.5	1.6–10.2	3.8	2.9–5.2	4.0	1.6	2.3–7.5	5.2	2.1–10.3
51	4.1	2.4	1.0–14.3	3.6	3.1–3.9	4.3	2.4	1.5–10.7	7.9	2.0–14.3
60	4.0	1.9	1.3–13.0	3.8	3.6–4.1	3.7	1.5	1.7–7.9	5.2	2.0–10.3
70	4.3	2.0	1.7–11.2	3.9	3.3–4.6	4.6	2.1	2.5–11.1	6.2	1.7–11.2
Pull										
21	3.3	1.5	1.5–7.6	2.8	2.2–4.0	3.6	1.4	1.8–7.6	5.7	2.0–8.2
30	3.2	1.0	1.5–5.2	—	—	3.2	0.9	1.8–4.9	5.2	4.3–6.0
42	3.7	1.8	1.4–12.6	4.0	2.9–6.3	3.9	1.4	1.9–6.8	4.7	2.6–6.9
51	3.8	1.6	1.5–10.2	3.6	2.5–4.6	4.6	2.2	1.5–9.5	6.3	2.5–11.2
60	4.1	1.9	1.5–11.4	3.6	2.7–4.7	4.1	1.7	1.4–7.4	8.9	1.9–17.0
70	4.6	2.2	1.5–12.6	4.6	2.6–4.7	4.9	2.3	2.1–9.7	3.2	1.9–6.7

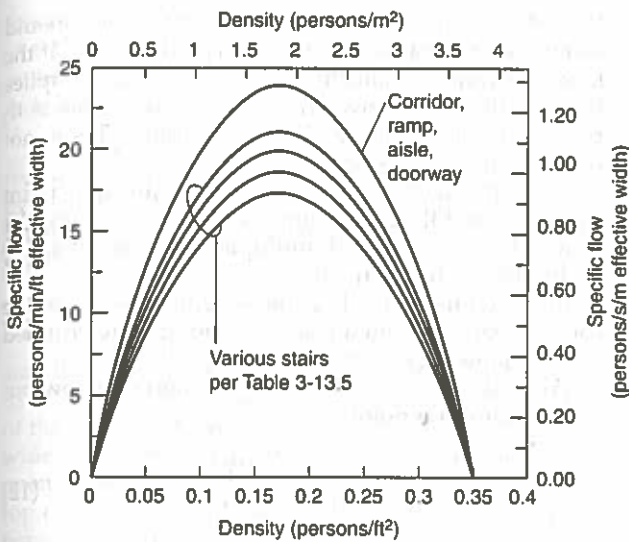


Figure 3-13.8. Specific flow as a function of population density.

Table 3-13.5 Maximum Specific Flow, F_{sm}

Exit Route Element		Maximum Specific Flow	
		Persons/min/ft of Effective Width	Persons/s/m of Effective Width
Corridor, aisle, ramp, doorway		24.0	1.3
Stairs			
Riser	Tread		
(in.)	(in.)		
7.5	10	17.1	0.94
7.0	11	18.5	1.01
6.5	12	20.0	1.09
6.5	13	21.2	1.16

Special consideration for door mechanism. In Table 3-13.5 and Figure 3-13.8 the maximum achievable specific flow rates for corridors and doorways are considered equivalent. This is based on the original calculations made by Nelson and MacLennan.²⁶ However, this is based on the assumption that the entire effective width of the doorway is available and that the passage of the population through the doorway is not influenced by the door mechanism itself. If the door leaf is not mechanically held open, then the traversing population may be forced to hold it open, delaying their passage. These actions have the potential for slowing the evacuees' movement through the opening, producing a reduced flow rate. It may also reduce the width available to the width of a single person (i.e., the width required for the person holding the door and passing through the exit), rather than the full available width of the exit leaf. In this case, the exit width available may be dynamic and reduced even from the calculated effective width.

These factors may act to limit the flow through the doorway. When doors on an egress route are not mechanically held open, these factors should be considered. In such circumstances, where the interaction with the door

leaf influences performance, it may be more conservative to assume a maximum achievable flow rate based on the number of door leaves available rather than the actual width (effective or otherwise) of each door leaf; that is, increasing the door leaf size may not produce a linear increase in the achievable flow, given the need to hold the leaf open and the reduction in the available door width due to the position of the closing leaf. A maximum flow rate of 50 persons/min/door leaf is suggested for doors that are not mechanically held open.^{3,8} Fruin originally noted flow rates between 40 and 60 persons/minute through exits with door leaves; however, the lower flow rate of 40 persons/min was produced during observations involving slow-moving occupants and so is discounted.³

The data used to support the flow rate through doors are several decades old and may not accurately reflect the movement and shape characteristics of current populations; for example, the impact that the increasing levels of obesity in some parts of the world might have on the capacity of egress routes and on movement rates.⁴² In addition, the data from which these relationships were derived were collected from nonemergency pedestrian movement and/or egress drills. The functions described should not be assumed to necessarily provide conservative predictions; the engineer should therefore factor this into the design recommendations made.

Calculated flow, F_c : The calculated flow, F_c , is the predicted flow rate of persons passing a particular point in an exit route. The equation for calculated flow is

$$F_c = F_s W_e \quad (8)$$

where

F_c = Calculated flow

F_s = Specific flow

W_e = Effective width of the component being traversed

Equation 8 is based on the assumption that the achievable flow rate through a component is directly proportional to its width.

Combining Equations 7 and 8 produces

$$F_c = (1 - aD)kDW_e \quad (9)$$

F_c is in persons/min when $k = k_1$ (from Table 3-13.2), D is in persons/ft², and W_e is in ft. F_c is in persons/s when $k = k_2$ (from Table 3-13.2), D is persons/m², and W_e is m.

Time for passage, t_p : The time for passage, t_p , is the time for a group of persons to pass a point in an exit route and is expressed as

$$t_p = P/F_c \quad (10)$$

where t_p is time for passage (t_p is in minutes where F_c is in persons/min; t_p is in seconds where F_c is persons/s). P is the population size in persons.

Combining Equations 9 and 10 yields

$$t_p = P/[(1 - aD)kDW_e] \quad (11)$$