

## WINTER: PUBLIC ENEMY #1 FOR ACCESSIBILITY EXPLORING NEW SOLUTIONS

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**Abstract:** Winter is expensive. For countries situated in the northern hemisphere, closer to the north pole, such as Canada, Russia and Scandinavia, winter requires the acquisition of special clothing, car tires, and sports equipment, snow removal or plowing from the streets, and is associated with the presence of ice patches, along with accidents and illnesses associated with cold weather. Fall-related injuries due to winter conditions have been estimated to cost the Canadian health care system \$ 2.8 billion a year. However, the greatest cost snow entails every year is the social isolation of seniors as well as wheelchair and walker users. This results from the lack of accessibility, as it is difficult to circulate on snow-covered streets even for the able-bodied. Social isolation has been associated with other negative consequences such as depression and even suicide. This exploratory pilot study aimed at finding possible and feasible design solutions for improving the accessibility of sidewalks during winter conditions. For this project we used a Co-Design methodology. Stakeholders (City of Quebec representatives, designers, urban planners, occupational therapists, and adults with motor, visual and aural disabilities) were invited to participate in the design process. In order to meet the objectives, two main steps were carried out: 1. Conception of the design solutions (through Co-design sessions in a Focus-group format with seniors, designers and researchers); and 2. Validation of the design solutions (consultation with experts and stakeholders). The results are a wide variety of possible and feasible solutions, including the reorganisation of the snow-removal procedure and the development of heated curb cuts. This project was funded by the City of Quebec in partnership with the Centre

interdisciplinaire de recherche en réadaptation et intégration sociale (CIRRIIS). Ultimately, the project sought to explore possible solutions to be implemented, if feasible, in the future by the municipal government.

**Keywords:** Winter, urban accessibility, co-design methodology, universal design

## Introduction

Snow is a major problem for accessibility and current snow removal procedures are both expensive and inadequate to provide the accessibility required for people with disabilities. The low temperatures and snow precipitations experienced in countries situated in the northern hemisphere, such as Canada, Russia and Scandinavia greatly influence the everyday life of all individuals. For example, winter conditions imply acquiring special clothing, car tires, and sports equipment, as well as snow removal or plowing from the streets, and the existence of ice patches, along with accidents and illnesses associated with cold weather. Indeed, walking in winter conditions can be dangerous. Fall-related injuries due to ice or snow are an important and serious problem, especially in an aging society. They have been estimated to cost the Canadian health care system \$ 2.8 billion a year (Miller, Wightman, Rumbolt, McConnell, Berg, Devereaux, & Campbel, 2009). According to Environment Canada (2010), Quebec City is the third most important major Canadian city (metropolitan areas with over 150,000 inhabitants) to have received the greatest annual quantity of snow with 316 cm, behind St. Johns, Newfoundland, in 2<sup>nd</sup> place with 322 cm, and Saguenay, Quebec, in 1<sup>st</sup> place with 342 cm. It is estimated that Canada spends approximately \$ 1 billion on snow removal every year. The City of Quebec spent \$ 13.6 million in 2008 for this purpose.

However, the greatest cost snow entails every year in Quebec and in most northern countries is the social isolation of seniors as well as of wheelchair and walker users. These results from the lack of accessibility due to winter

conditions, as, for these individuals, it is almost impossible to circulate in snow-covered streets. Although there are several factors involved in the process of social isolation (Brennan, Moore, & Smith 1995; Edelbrock, Buys, Creasey, & Broe, 2001; Gardner, Brooke, Ozanne, & Kendig, 1999; Hall & Havens, 1999), adults with physical disabilities might prefer to stay home rather than go out, because of the challenges which will certainly be encountered. Social isolation, in turn, has been associated with other negative consequences such as depression (Gutzmann, 2000; Silveira & Allebeck, 2001) and even suicide (Conwell, 1997; Rapagnani, 2002).

Current efforts to make urban centers more accessible, such as the "Access City Awards" in Europe and the WHO's "Age Friendly Communities" all over the world, do not take into consideration the impact of winter as a major accessibility problem. This particular subject has received little academic attention. Toronto Rehab is one of the few groups that has studied the impact of winter on seniors and individuals with motor disabilities. Its activities focus on the development of winter clothing and footwear along with walking patterns in cold weather. However, the problem is vast and the list of different aspects that require immediate attention is significantly long. **The aim of this project was to explore and to define some possible and feasible solutions to improve accessibility to urban centers in winter conditions.**

### **Current practices for snow removal and alternative strategies**

In Canada, as in other northern countries, snow removal is most commonly done by mechanical means (snowplows, shovels, etc.), usually includes the use of chemicals (salt, sand, etc.) and generally involves three steps. The main actor of the first step is the salt spreader which removes snow and spreads salt. This chemical enhances snow melt and the granular nature of the salt contributes to providing better traction. Then, once the storm has subsided, the "front-end loaders" and "graders" push the snow to the edge of the road. Finally, the "snowplows" or "snow blowers" transfer the accumulated snow into a "dump truck", which then takes the snow to a designated snow dump.

Despite the popularity of this technique, evidence suggests that there are many disadvantages associated with its use, namely the damage done to street furniture and the long term high maintenance costs for citizens as well as for public and private organizations. For example, salt damages the pavement, trees, and grass, as well as corroding automobiles and has severe effects on ground water, water bodies and roadside vegetation (Demers & Sage, 1990; Mayer et al., 1999; Remakrishna & Viraraghavan, 2005). These effects have led many scientists to believe that smaller amounts of chemicals could be used, which in turn would also be cheaper (Nixon, 1993). In addition, salt and sand spreading is generally performed once precipitations are finished. Thus, security measures are neglected since safety concerns are present before complete snow removal (Chen, 2011). Many hazardous accidents are associated with these conditions, as well as with the machinery used for snow removal. According to the Canadian Institute for Health Information (CIHI), the most serious injuries (excluding motor vehicles) are, by far, falls on ice. They led to 7138 hospital admissions in 2010-2011 within Canada, nearly 10 % more than in 2006-2007 (CIHI, 2011). Walking on icy and snowy surfaces is very dangerous. Finally, due to the fact that de-icing chemicals have negative impacts such as concrete corrosion and environmental pollution, it could be beneficial to diversify our methods for snow removal (Chen, 2011; Nixon, 1993; Wang, 2010). To address these problems, snow-melting alternative systems have been proposed in the past years such as hydronic and electrical asphalt-heating systems.

### [Hydronic systems](#)

Hydronic heating systems use a circulating pump to deliver heated fluid (water and antifreeze) through pipes embedded near the upper surface of the pavement to melt snow and ice. Freeze protection is essential since most of these systems are operated intermittently in subfreezing weather. The pipe material in the deck is usually either cross-linked or high-density polyethylene. The pipe can be arranged so that it is simply clipped to the steel reinforcement before the concrete or the asphalt is poured. This type of system is warmed by kerosene, gas or a geothermal source (Chen, 2011:

3241-3242). The hydronic system technology requires special planning in the spacing and layout of the pipe. Despite the limited geographical environments where this technology can be used effectively as well as the amount of planning and work involved, several countries use hydronic systems, including Argentina, Finland, the United States, Japan and Iceland (Kinya & Shigeyuki, 2000; Lund, Rees, & Spitler, 2002).

### Electrical systems

As an alternative strategy, electric snow-melting systems are more popular. They are composed of three basic components: a heating cable, a control unit and an activation device. The piping is buried in the pavement and is powered by electrical cables. The cables are inside the piping, and the heat output is determined by the resistance of the electric cables used and the imposed voltage. The power can be generated by a standard electrical system, wind turbine or solar system. The radiating heat from the electric cables warms up the entire surface of the material in which the piping is embedded. The same technology is used in underfloor heating systems. Several recent studies (Kinya & Shigeyuki 2000; Rees & Spitler, 2002) analyzed the pipe mappings and heat distribution needed to adapt this system for snow melt. Like the hydronic system, the electric snow-melting system needs careful organization of the pipes to avoid unnecessary heat loss and additional construction costs.

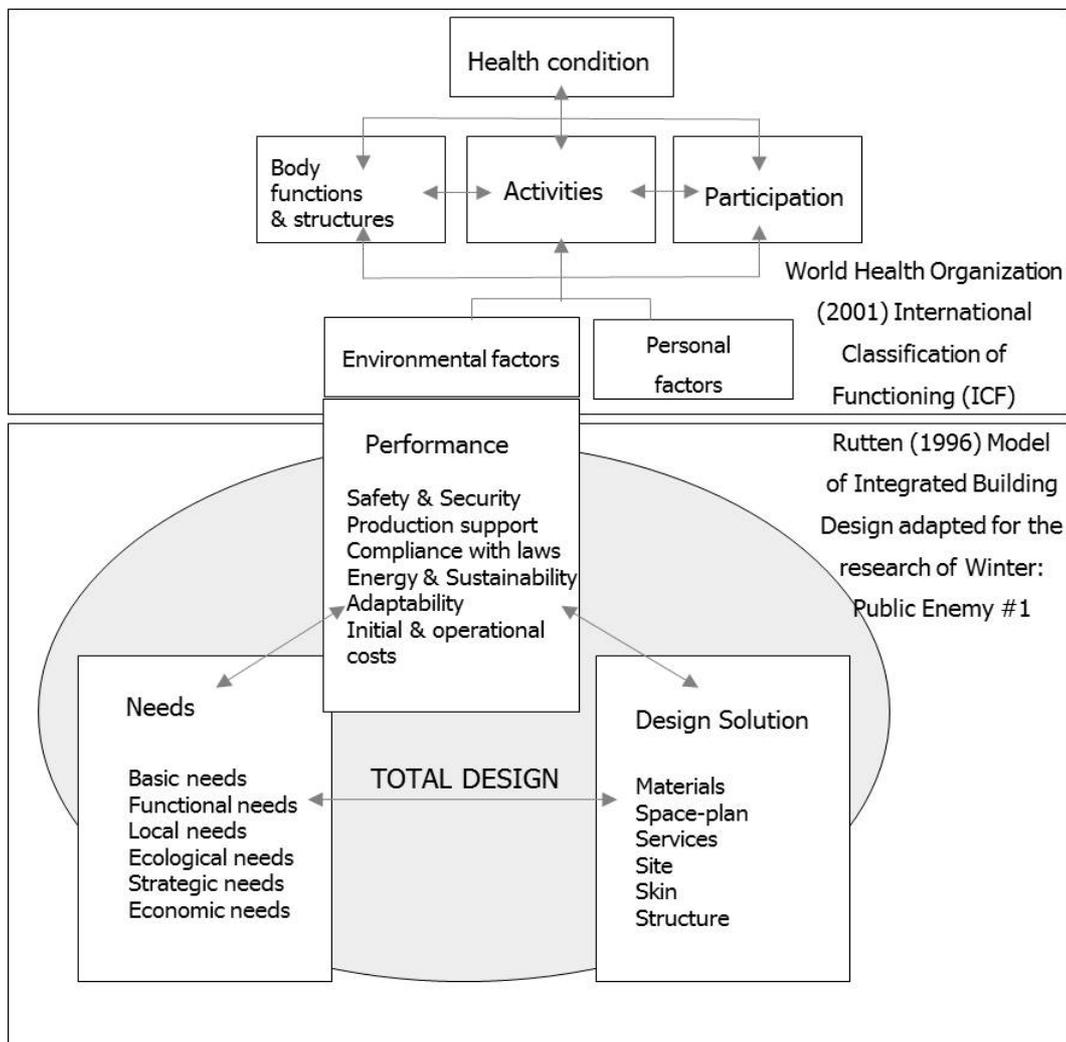
The combination of conventional and alternative methods for snow removal could lead to the creation of an innovative design solution which would match our climate and be in line with the Office des personnes handicapées du Québec (OPHQ)'s political initiative for access and social participation for all citizens (OPHQ, 2009).

### **Theoretical Framework**

When looking for the most appropriate framework to describe the needs of the different actors relevant in the design process of an urban-accessible solution, we used a combination of two models, the International Classification of Functioning model (ICF) (WHO, 2001) and the Model of Integrated Building Design (MIBD) (Rutten, 1996), which were first combined

by Van Hoof and colleagues (2010). Despite the fact that Rutten did not elaborate much on his model, Van Hoof published several articles based on this model (ICF-MIBD-model). Moreover, we have successfully used this approach in the past (Huissman & Morales, 2012) and have adopted it here.

Figure 1. IFC/MIBD Model adapted to the research on Winter: Public Enemy #1



In Figure 1, in the ICF model, the built environment can be seen as an environmental factor influencing individuals in their everyday performances. The most important feature of this model is the clear and comprehensive structure which encompasses every aspect of the design process in a project. The needs of the different actors or stakeholders involved in a health or accessibility-related project are therefore taken into consideration in the design solution for individuals to have the best possible performance. In the

ICF-MIBD framework, the individuals' relationship with accessible environments is viewed from different perspectives and dynamically described in the MIBD model as a triangular interaction and co-dependant relationship between Needs, Performance and the Design Solution. The following paragraphs provide a general description of these three elements.

### Needs

To respond to their needs, the different actors involved in the development of design solutions (stakeholders) define the importance and usefulness they attribute to these needs. There are six types of needs: Basic, Functional, Local, Ecological / Sustainable, Strategic and Economic. Each of these responds to the needs of different stakeholders participating in the creation of a design solution, such as the accessibility requirements for individuals with or without disabilities (basic need), the workers' needs for structured management of municipal activities to keep the city clean and functional (functional need), the city management staff's requirements (strategic need), the city leaders' needs (economic need), the community's requirements in terms of accessibility (local need), and the ecological impact of the design solution during construction and thereafter (ecological need).

### Performance

Performance is the capacity of the design solution to meet the values or needs of the different stakeholders. It also includes the created expectations towards the design solution in relation to its contribution to improve the city's accessibility. Performance is divided into the following components: Safety & Security, Production support (infrastructure provided), Compliance with laws, Energy & Sustainability, Adaptability of the solution to different contexts, Initial and Operational costs.

### Design Solution

The design solution is the group of components that forms and shapes the design itself. It includes all elements relevant to the design process of an urban-accessibility design solution. The building system is based on the 6 S's

(Brand, 1994): Stuff (Materials), Space Plan, Services (if it requires electricity, hydro-sanitary network, etc.), Skin (finishing), Structure of the design solution and Site (place where it will be built or implemented).

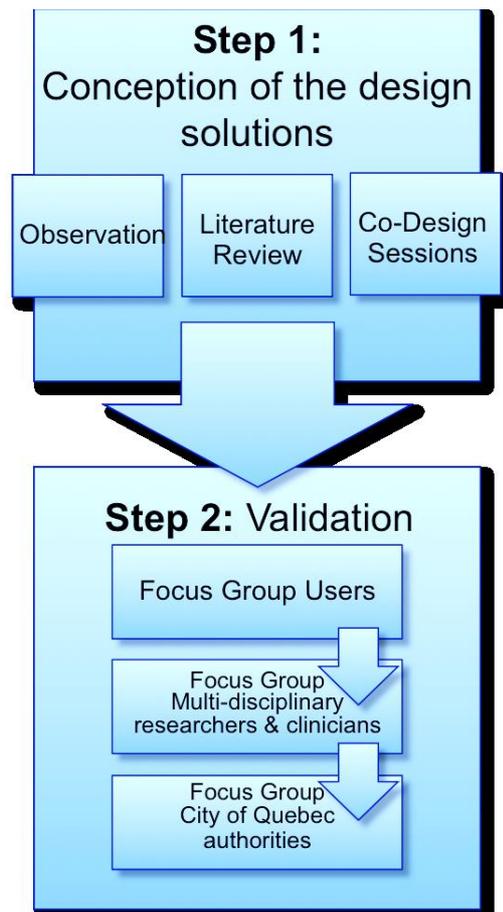
The different elements of this model, as presented in the previous paragraphs, provided a structural framework for the development of the Co-Design process we implemented. Particular emphasis was placed on the “Needs” and the “Design Solution” elements. For example, in the individual co-design sessions and group co-design sessions with users, the *basic needs* of people with motor, visual and aural disabilities were discussed in order to suggest new ideas or to improve earlier ones we presented. In the co-design group session with the Quebec City’s representatives, the ideas were discussed in terms of the *functional needs* of municipal activities and the action plan for snow ploughing, along with some local, strategic and economic needs. Moreover, the environmental implications (ecological needs) were also brought up as a very important element. All these elements influenced the development of design solutions with regard to their dimensions, materials, location, etc., in order to try to predict their performance in terms of safety, security, compliance with municipal laws, energy and sustainability.

## **Methodology**

Co-Design methodology was used in which the stakeholders were invited to participate in the creation of design solutions and/or new strategies to improve accessibility in winter conditions. Recently, several authors (Ivey & Sanders, 2006; Sanders & Stappers, 2008; Sleeswijk, Visser, Stappers, Van der Lugt & Sanders, 2005) have redefined and extended the limits of participative design and promoted a new process known as co-design. Co-design refers to the act of collective creativity shared by two or more people, where the user is an “expert in his own experience” (Morales et al. 2012). In order to answer our questions and meet the objectives, this project was divided into two main steps:

1. Conception of a design solution or strategy
2. Validation via consultation with experts (See Figure 2).

Figure 2. Co-Design Methodology



The following paragraphs describe each step in detail:

**Step one: Conception of the design solution or strategy.**

The main objective of this step was to understand the needs (as described in the IFC/MIBD Model), along with the performance of existing technical aids in winter conditions. The design process was organized into three main phases: an observation activity, a literature review and the co-design sessions per se.

- **Observation:** Second-year students from the School of Architecture of Laval University in Quebec City took photographs and videos of accessibility restraints due to snow on sidewalks. In addition, these students were asked to use wheelchairs and walkers to test their performance and to increase their awareness of mobility limitations in winter conditions. Students had to choose a relevant location along with the nearest bus stop and street crossing; then, they analysed this

environment in terms of accessibility during the month of February 2013 in Quebec City. This phase provided data in terms of specific difficulties, related to the winter season, found in the urban context for wheelchair and walker users (i.e. snow accumulation in a street corner, among others).

- **Literature review:** A scoping review (Arksey & O'Malley, 2005; Levac et al. 2010) to understand the state of art of the problem and some potential needs was performed using keywords from two main themes:
  - Snow removal: (snow ploughing OR plowing) AND (action plan for snow removal OR snow removal strategies) OR (processus de déneigement OR priorités de déneigement) AND (Scandinavian roads in winter OR snow ploughing in Scandinavia)
  - Accessibility: (Winter accessibility OR accessibility with snow) AND (universal design for winter conditions OR inclusive design in winter) OR (Scandinavian design in winter OR accessibility in Scandinavian winter)

For the gray literature, websites on European accessibility measures were consulted such as:

- <http://eo-guidage.com/>
  - <http://www.universaldesign.ie/>; among others.
- 
- **Co-Design sessions:** In order to respond to some of the needs identified as well as to address the poor performance of technical aids as revealed during the observation phase and the literature review, five co-design sessions with individuals were organized: two at the University of Montreal and three at Laval University in Quebec City. Based on the literature review and the observation activity, several important elements were identified as more problematic such as curb cuts, inclined streets, street crossings, bus stops and access to shops and restaurants. Each of these elements was discussed in all

sessions. The average duration of each session was 1.5 hours, with individual sessions organized for a subset of urban planners, architects, designers and experts in accessibility. All sessions were recorded and organized according to the same format. The research project was explained with the help of a PowerPoint presentation by the first author and then a period of questions helped clarify certain aspects of the project. Following this, the first author opened the session for suggestions or ideas to improve accessibility, with special focus on the previously identified elements (curb cuts, etc.). Other elements suggested by the participants were also welcomed and discussed. The first author then sketched the participants' ideas based on their description (graphic data). He then exchanged ideas with the participants until they reached at least three possible design solutions. For example, the first author asked open questions such as, how do you imagine we can increase the accessibility of curb cuts? Participants would then suggest something, such as "melting the snow". Then, the first author would ask, how would you materialize/conceptualize the snow melting idea? There followed exchanges with the participants until the idea had a more solid form and foundation. Particular emphasis was given to respecting the different elements of the IFC/MIBD Model (Van Hoof, 2010), addressing the needs within the proposed design solution as well as trying to imagine how to maximize performance. The analysis of the sessions' recordings allowed the first author to ensure full consideration of all the details and definition of the design solutions. The ideas collected during session one were presented at the end of session two; both the ideas gathered during sessions one and two were presented at the end of session three and so on. These ideas were presented only after the participants gave their own ideas. The objective of showing them to all the participants was to improve, combine or eliminate different ideas as appropriate. No individuals with disabilities participated in this first set of sessions as we aimed for a basic idea which could further be developed and expanded during step two of this study, through a focus group with users (adults

with motor, visual and aural disabilities) as the experts of their own experience.

### **Step two: Validation (consultation with experts).**

The different ideas and design proposals resulting from the individual co-design sessions were presented to, enriched and validated by a variety of stakeholders. The key feature of this research project was precisely the gathering of different points of view regarding a common objective in order to better grasp all the elements that must be taken into consideration. What we call "validation", in this case, is a filtering process, a research strategy to "purify" and enhance the design solutions and to set some parameters for the never-ending process of creation in order to achieve more realistic, viable and sensible solutions. A focus group is a methodological technique which allows "listening to people and learning from them" (Morgan, 1988, p.9). In order to meet our objectives in this study, it was pertinent to use this technique in order to learn from the "experts" in the process of creating design solutions. Three focus group sessions were organized.

The first focus group brought together an odd number (Morgan, 1988) of adults with motor, visual and hearing disabilities (n=5). Since, these individuals represent the main users of the proposed designs, they were the first ones whose opinion was sought. The participants were recruited through the Regroupement des organismes de personnes handicapées de la région 03 (ROP 03), a non-profit social organization representing people with disabilities. This focus group was particularly challenging and at the same time it was one of the most productive sessions. The ideas developed in the individual co-design sessions were represented via cardboard models for the blind participants so that they could grasp the architectural concepts discussed. For example, one idea proposed in the co-design session was to create a reservoir or trough underneath the sidewalks of a whole city block. The idea was to install these at strategic points throughout the city. This reservoir would be covered with a metallic grating for the snow to fall through. At the bottom there would be an electric source of heat for snow melting and the resulting water from the snow melt would be disposed of in the storm sewers. A cardboard model was fabricated to illustrate the

buildings, sidewalk, street and the reservoir covered with a “metallic-grating-like” surface. The reaction of the blind participants was very enthusiastic, as they clearly understood the idea when the first author guided their hands to each of the elements and explained the idea. This was repeated with most of the other ideas.

The second focus group brought together members of the Unis-vers-Cité research team (n=7). This multidisciplinary group includes researchers from many disciplines such as engineering, geomatics, occupational therapy, nursing, architecture, physiotherapy, and sociology working on accessibility issues. The main objective in this case was to assess and to improve the design proposals from a multidisciplinary perspective.

The third focus group gathered municipal representatives from the City of Quebec (n=7), such as employees from the departments of urban planning (Service de l'aménagement du territoire) and transportation and public services (Travaux publiques). The main objective of this group was to evaluate the feasibility and economic implications of implementing the “improved solutions” resulting from the first and second focus groups.

The reason for having three different focus groups was to differentiate distinct perspectives that can be used to examine each proposed solution, keeping in mind a holistic vision of the applicability of the design solutions. All three 3-hour sessions were based on a similar co-design and brainstorming format. All sessions were divided into two parts. The first consisted of the presentation and explanation of the project to the participants with a PowerPoint presentation. A question period took place after a break halfway during the session. Then, the different design proposals were presented and explained in a PowerPoint presentation. The proposals were discussed and suggestions to improve, combine or eliminate them were presented by the participants. The first author sketched the participants' suggestions according to the description they gave (graphic data). These suggestions were also discussed until unanimity was reached. Then another element was discussed (i.e. curb cuts, inclined streets, street crossings, bus stops, access to shops and restaurants), and so on. Other aspects were also openly discussed to find solutions.

Each co-design session and focus group session was recorded, and these recordings as well as the drawings resulting from the co-design sessions provided a backup description of the participants' suggestions. An evaluation and review of the recordings of each session (individual or group) along with the graphic data gathered during the session was performed after each session. This process allowed the first author to define and describe the different design solutions exhaustively.

## **Results & Discussion**

As mentioned earlier, from the literature review and observation activity several important elements were identified as more problematic, such as curb cuts, inclined streets, street crossings, bus stops and access to shops and restaurants. Other discussions on different aspects or suggestions, besides the ones mentioned previously, were also welcomed. Conducting individual co-design and then group co-design sessions considerably improved the development and evaluation of the feasibility of the ideas. For example, in the first group session, an idea proposed in an individual co-design session to create a reservoir or trough underneath the sidewalks of a whole city block was taken up, but it was suggested to elaborate such a strategy only for curb cuts. The first group session gathered users only, people with motor, visual or hearing disabilities. It was argued that it was really this section of the sidewalk which required particular attention since snow always accumulates there. Therefore, in this session, a significant amount of time was invested to improve and solve technical problems for this particular suggestion. In addition, within the group session, new elements not discussed in the previous steps emerged, such as the inefficiency of the snow removal action plan by the City's authorities. This element was discussed in the two other session groups, particularly the one involving the City representatives.

Throughout the co-design and focus group sessions, themes and ideas were grouped and organized. Three main themes emerged:

1. Improve snow removal processes;
2. Incorporate new technology in the urban context to improve snow removal
3. Provide additional public transportation during winter months.

Due to the great number of elements discussed during the co-design and focus group sessions, not all suggested ideas are presented in this article. However, the most relevant ones, those which most drew our attention, are presented below.

### **1. Improve snow removal processes.**

This necessarily includes rethinking the type of machinery and chemicals used in the snow removal process. As mentioned earlier, significant damage can be done to street furniture due to the machinery used for snowplowing. The use of new design solutions regarding the machinery needs to be considered in order to improve their performance and the efficiency of the snow removal procedures. Moreover, the de-icing chemicals currently used damage the pavement, trees and grass, corrode automobiles and pollute water supplies. New products should be developed to limit the adverse ecological impacts of the snow removal process. For example, on some highways in the province of Quebec, there have been scattered initiatives to use beetroot juice mixed with 50 % of the regular amount of salt used for de-icing. There are some limitations regarding the minimal temperature at which this product is efficient, since it freezes at  $-14^{\circ}\text{C}$  without salt and at  $-28^{\circ}\text{C}$  with salt (Proulx, 2012). However, this method reduces pollution by half and the stains induced by the beetroot juice are reported to be easily removed.

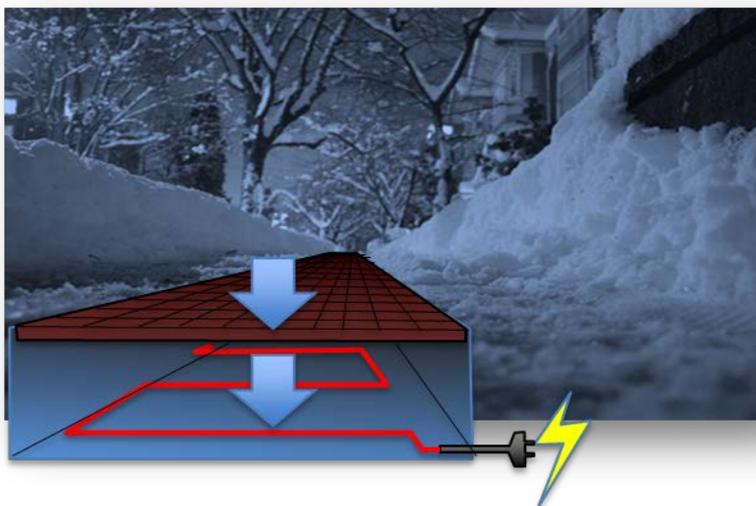
Other aspects of the procedure for snow removal also need to be reassessed. In the province of Quebec for example, the priority is given to vehicular circulation first, then to sidewalks and bus stops. Additional research needs to be done in order to consider having a better working understanding of the process, the priorities used to identify which infrastructures of the network should be cleared first, the users' needs and constraints, and the persons

responsible to carry out the city's snow removal procedure in order to demonstrate the benefits of modifications. Moreover, this procedure should be in agreement with an action plan on eco-friendly public transportation.

## 2. Incorporate new technology in the urban context to improve snow removal.

This point addresses sidewalks and curb cuts to melt snow and facilitate snow removal. This involves using an electrical system for snow-melting purposes. Particular attention was also given to curb cuts because most of them are inclined to facilitate wheelchair access. However, during winter months, this incline actually favors the accumulation of snow as well as water, rendering the snow removal process tedious. Due to the prioritization of snow removal for vehicular transportation, sidewalks remain often neglected, snow is plowed onto the sidewalk and accumulations are especially important at street corners, making walking very difficult for individuals without any disability and almost impossible for individuals with motor or visual disabilities (see Figure 3).

*Figure 3. Solution for melting snow in sidewalks*



The implementation of a 30 cm-deep reservoir or through the width of the curb cuts' incline is proposed. This reservoir would be covered with a metallic grating for the snow to fall through. The proposed configuration for the metallic grating is a trellised section with 1,5 cm by 1,5 cm holes and a

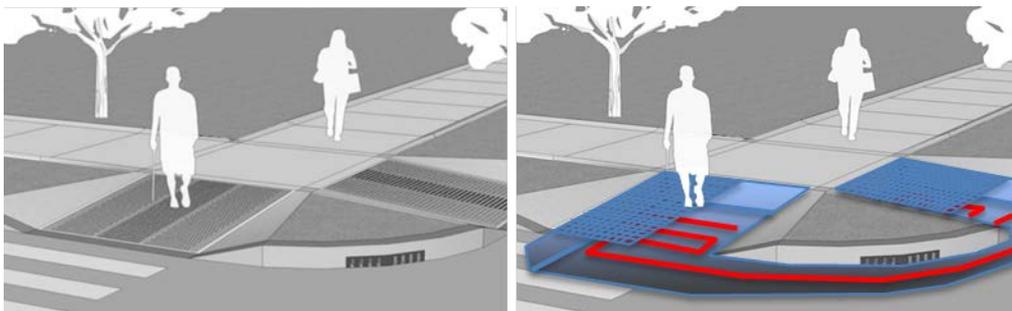
20 cm solid strip in the center of the grating, allowing women wearing high heels to circulate safely. At the bottom there would be an electric source of heat for snow melting purposes. The resulting water from the snow melting process would be disposed of in the storm sewers (see Figure 4). Again, different possible sources for the energy could supply the resistor, including public lighting and solar panels.

*Figure 4. Curb cut during winter months in Quebec City*



For strategically selected sidewalks, the suggested design solution was to excavate a 30 cm-deep channel or trough, approximately 50 cm wide. As for the curb cuts, a 30 cm deep trough could be cut along the sidewalk, using a similar electric resistor heat source and also connected to the public storm sewers (see Figure 5). Again, different sources of energy to supply the resistor could be used. This solution will be evaluated in terms of cost/energy efficiency, in order to determine whether or not it will be implemented in Quebec City.

Figure 5. Solution to improve accessibility in street corners



### 3. Provide additional public transportation during winter months.

One of the main accessibility problems during winter months involves bus stops. This includes getting on and off the bus, the frequency at which the buses pass and the waiting time in cold weather. This could be improved if, during this period, additional routes could be used to take people with motor disabilities to strategic points, such as supermarkets, drug stores and community centers. The main financial problem of the City of Quebec's public transportation agency, as for many others in the world, would then lie in the additional bus drivers' salary. It was proposed to incorporate driver-free electric transportation systems, which have already been implemented in France (see CATS project - City Alternative Transportation System, [www.parc-innovation-strasbourg.eu/CATS-project](http://www.parc-innovation-strasbourg.eu/CATS-project), and <http://induct-technology.com/produits/navia-2>). These vehicles follow a pre-programmed route and are equipped with sensors which identify obstacles and make the vehicle stop if any is present.

Another possibility is to develop a scooter rental program adapted to winter conditions, similar to the BIXI system, a public bicycle-rental system in Montreal. The BIXI system is an alternative means of urban transportation, with many bicycle-rental stations all over the city situated at key destinations. The stations are installed progressively in the spring, starting at the beginning of April, depending on weather conditions. Stations are kept in service until mid-November, before being removed from the streets for the winter months. The proposal was to replace the bicycles with scooters adapted to winter conditions in order to provide another transportation option. This idea has major repercussions in terms of investment and

political will, and its use could be out of the question for many countries. Nevertheless, these suggestions clearly exemplify the complexity of the problem and the diversity of solutions for improved accessibility during winter months.

## **Conclusions**

Winter is expensive and the solutions given in this paper are not “cost-free”. However, walking in snow-covered streets during winter months is dangerous and fall-related injuries due to ice and snow are on the rise every year, proof that the way this problem is currently being addressed is far from optimal. This project provides some possible solutions to address this problem. Research grants will be sought in two areas: rethinking the snow-removal procedure to identify better snow-removal priorities for pedestrians and develop the curb cut prototype as outlined previously.

This project is clearly positioned under the umbrella of the global movement of “Age-Friendly Communities” and while winter is not a global problem, it does concern the northern countries of the world and the problems remain unsolved or badly addressed. The repercussions of being imprisoned for three or four months of the year for seniors and individuals with physical disabilities are very serious. This document is intended to be understood as a starting point for the development of additional studies seeking a better understanding of the person-environment interaction, with tangible results in the form of better design solutions.

## **Limitations of the study**

This project could have had included seniors in its development. However, the focus of our recruitment was to gather adults with motor, visual and hearing disabilities; age was not considered a limitation. Moreover a cost/energy investment study of the solutions proposed has not been developed yet. Nevertheless, such a study will be carried out in the near future.

## Acknowledgements

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## References

- [1] American National Standards Institute. (1992). *Accessible and usable buildings and facilities*. Retrieved October 24, 2007, from <http://www.ansi.org/>
- [2] Brennan, P. F., Moore, S. M., & Smyth, H. A. (1995). The effects of special computer network on caregivers of persons with Alzheimer's disease. *Nursing Research, 44*, 166-172.
- [3] Chen, M., Shaopeng, W., Hong, W., Jizhe, Z. (2011). Study of ice and snow melting process on conductive asphalt solar collector. *Solar Energy Materials & Solar Cells, 95*, 3241-3250.
- [4] CIHI. (2011). *National Trauma Registry Minimum Data Set*, Canadian Institute for Health information.
- [5] Conwell, Y. (1997). *Management of suicidal behavior in the elderly*. *Psychiatric Clinics of North America, 20*, 667-683.
- [6] Daniel, W. W. (2005). *Biostatistics*. Hoboken, NJ: John Wiley & Sons, Inc.
- [7] Demers, C. L. and Sage, W. R.: 1990, 'Effects of road deicing salt on chloride levels in Four Adirondack streams', *Water, Air and Soil pollution* 49, 369-373.
- [8] Edelbrock, D., Buys, L., Creasey, H., & Broe, G. A. (2001). Social support, social networks and social isolation: The Sydney older persons' study. *Australian Journal of Ageing, 20*, 173-178.
- [9] Environment Canada (2010). Meteorological Service of Canada. Canadian Climate Normals. 1981-2010 Climate Normals & Averages. Retrieved December 10, 2013, from: <ftp://ftp.tor.ec.gc.ca/Pub/Normals/English/>

- [10] Erin Miller, Elizabeth Wightman, Karla Rumbolt, Sara McConnell, Katherine Berg, Moira Devereaux, Fiona Campbel (2009) Management of Fall-Related Injuries in the Elderly: A Retrospective Chart Review of Patients Presenting to the Emergency Department of a Community-Based Teaching Hospital. *Physiotherapy Canada* 26-37 10.3138/physio.61.1.26
- [11] Gardner, I., Brooke, E., Ozanne, E., & Kendig, H. (1999). *Improving social networks, a research report: Improving health and social isolation in the Australian veteran community*. Lincoln Gerontology Centre, La Trobe University, Melbourne.
- [12] Gutzmann, H. (2000). Diagnosis and therapy of depression in advanced age. *Therapeutische Umschau*, 57, 95-99.
- [13] Hall, M., & Havens, B. (1999). *The effects of social isolation and loneliness on the health of older women*. Research Bulletin, Centres of Excellence for Women's Health, 2.
- [14] <http://induct-technology.com/produits/navia-2> - visited in February 2014
- [15] Huisman, E.; Morales, E., van Hoof, J., Kort, H., (2012) Healing Environments : a systematic review of the meaning of physical environmental factors on patient, family, carers (PFC) and staff outcomes. (Journal of Building & Environment) doi:10.1016/j.buildenv.2012.06.016.
- [16] Ivey, M. & Sanders, E. (2006). Designing a physical environment for co-experience and assessing participative use. Presented at Wonderground, Design Research Society International Conference, November 1-4, 2006, Lisbon, Portugal.
- [17] Kinya, I., Shigeyuki, N. (2000). Prospects of snow melting systems using underground thermal energy Storage in Japan. *Proceedings of Annual Conference of the Society of Heating*, Japan, 154-160.
- [18] Mayer, T., Snodgrass, W. J. and Morin, D.: 1999, 'Spatial characterization of the occurrence of road salts and their environmental concentrations as Chlorides in Canadian surface waters and Benthic sediments', *Water Quality Research Journal of Canada* 34(4), 545-574.
- [19] Morales, E.; Rousseau, J. (2010) Which Areas of the Home Pose Most difficulties for Adults with Motor Disabilities? *Physical & Occupational Therapy in Geriatrics Journal*, June 2010, Vol. 28, No. 2, Pages 103-116
- [20] Morgan, D. L. (1988). *Focus groups as qualitative research*. London: Sage.

- [21] Office des personnes handicapées du Québec(OPHQ), (2009). A part entière: pour un véritable exercice du droit à l'égalité. Gouvernement du Québec Proulx, S. (2012) Déglaçant à la betterave. Emission de téléquébec du 27 mars 2012. <http://vieenvert.telequebec.tv/sujets/713/deglacant-a-la-betterave>
- [22] Rees, S.J., Spitler, J.D. (2002). Transient analysis of snow-melting system performance. *ASHRAE Transactions*, 108, 406-423.
- [23] Régie du bâtiment du Québec. (1995). *Code de construction du Québec, Chapitre 1: Bâtiment et code national du bâtiment du Canada 1995 (modifié)*. Quebec, QC: Institut de recherche en construction, Régie du bâtiment du Québec.
- [24] Remakrishna, D.,M. & Viraraghavan, T., (2005) Environmental Impact of Chemical Deicers - A Review; *Water, Air, and Soil Pollution* (2005) 166: 49-63
- [25] Rutten, P.G.S. (1996) Strategisch bouwen, Inaugural speech (in Dutch). Technische Universiteit Eindhoven, The Netherlands URN:NBN:NL:UI:25-461650-of
- [26] Sanders, E. & Stappers, P. (2008). Co-creation and the new landscapes of design. *CoDesign*, 4, 5-18.
- [27] Siebert, N. & Zacharakis, E. (2010). Asphalt Solar Collector and Borehole Storage: Design study for a small residential building area. Master's Thesis within Sustainable Energy Systems and Structural Engineering & Building Performance Design, Department of Energy and Environment, 147 p.
- [28] Silveira, E., & Allebeck, P. (2001). Mitigation, ageing and mental health: an ethnographic study on perceptions of life satisfaction, anxiety and depression in older Somali men in east London. *International Journal of Social Welfare*, 10, 309-320.
- [29] Sleeswijk Visser, F., Stappers, P. J., van der Lugt, R., & Sanders, E. (2005). Context mapping: Experiences from practice. *CoDesign*, 1, 119-149.
- [30] Van Hoof, J. (2010) Ageing-in-place: the integrated design of housing facilities for people with dementia. Dissertation. Eindhoven University of Technology, Eindhoven, the Netherlands. ISBN 978-90-386-2326-9

- [31] Wang, H., Liu, L., and Chen, Z. (2010). Experimental investigation of hydronic snow melting process on the inclined pavement. *Cold Regions Science and Technology*, 63, 44-49.
  
- [32] WHO (2001) International classification of functioning, disability and health. Resolution WHA54.21 of the fifty-fourth World Health Assembly, ninth plenary meeting, agenda item 13.9, 22 May 2001, A54/VR/9, Geneva, Switzerland, World Health Organization
  
- [33] [www.parc-innovation-strasbourg.eu/CATS-project](http://www.parc-innovation-strasbourg.eu/CATS-project) - visited in February 2014