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An experimental research-creation process by models and images

Habitabilité architecturale par les formes climatiques. Un processus expérimental de recherche-création par maquettes et images

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Introduction

1 Climate Form Finding for Architectural Inhabitability is part of a reflection on the theme of "Eroded Landscapes as Architectural Form Givers", which brings together graduate and postgraduate scientific researchers to forge links between architecture and its climatic context "through the process of erosion to create architectural forms adapted to their context associated to the cold climate of Northern America" (Demers & Potvin, 2017). In the academic architecture curriculum, design methodologies developed through "Eroded Landscapes" have provided poetical connectors to environmental fluxes aiming to offer new insights of low energy theories (Demers & Potvin 2017). Shifting from compartmented deterministic disciplines towards a more systemic approach integrating quantitative and qualitative aspects of building performance, the research theme has addressed more speculative explorations through scale models rather than solely relying on digital simulations. "Eroded Landscapes" explored pedagogical practices of environmental sciences integrated to the complexity of low energy architecture theories in graduate architecture design studios. Such integrated knowledge to design requires theoretical and technical skills, but in the architecture design studio, it created sources of intuitive inspiration in relation to simulations whereas "the construction of physical models accelerated this integrated knowledge associated with structural and environmental concepts in early design stage" (Demers & Potvin 2017). Environmentally, "Eroded Landscapes" provides a readily available corpus of morphologies resulting from physical transformations of matter through weatherization by sun, wind and rain" (Demers & Potvin 2017). It addresses environmental adaptability of structures and their

inhabitability through graduate design studios, architectural thesis design projects, and fundamental parametric studies of wind and light. "Eroded Landscapes" was funded by Government of Québec's *Fonds de recherche québécois sur la société et la culture* (FRQ-SC), a 2014-18 research grant obtained by the *Groupe de recherche en ambiances physiques* (GRAP), at Laval University's School of Architecture. The research grant originates from parametric wind eroded design methodologies developed by Potvin (1993), studies on wind shadows by Laplante (2006), and typologies of light through physical modeling developed by Demers (1993, 1997) and Biron (2008). The paper therefore illustrates a design research methodology outcome, specially aimed to integrate the complexity of wind and lighting ambiances into the pedagogy of architectural design studios.

2 Climate Form Finding for Architectural Inhabitability focuses on architecture in the critical conditions of northern climates. The design research addresses the question of how to inhabit Nordicity by designing with a cold climatic environment. Indeed, natural fluxes, such as wind, snow and ice, create undesirable comfort conditions during the cold season. These conditions, combined with new constructive opportunities, raise questions about how today's architects should design the Nordic architecture: Should we "fight" the climate during the design process and therefore deny it? Or can we integrate it into its full potential for form finding and creation? On this issue, Norberg-Schulz (1981, p. 23) suggests to become "friends" with a particular environment, as the "Nordic man has to be friend with fog, ice, and cold winds; [...] he has to experience the poetical value of being immersed in the winter environment" (ibid.). Following this idea, Norbert-Schultz adds that the "more one increases the ability to read and understand the landscape, the more likely one is to make a poetic reinterpretation that stimulates the senses". In that regard, this paper presents the results of an exploratory research which focuses on the poetic and aesthetic qualities of the cold climate as a trigger for inspiration to design architectural forms "through the process of erosion to create architectural forms adapted to their context associated with the cold climate of Northern America" (Demers and Potvin, 2017). It has been shown that the phenomenon of erosion can be formally identified and observed in resulting natural snow or ice formations (Potvin, 1993). Indeed, one can already contemplate a multitude of rounded shapes and atmospheres that may eventually be experienced in architectural spaces, such as bubbles, crevasses, mounds or stalactites. Thus, this design research aims to recreate the "erosion" process, a physical transformation of snow and ice through weatherization by wind and sun, which could be observed in the cold northern climate and can come to create magnificent shapes and winter landscapes. By introducing a combined tactile and numerical approach to creation (Charest, 2015), this natural flow is used to generate a new type of "climatic morphologies".

3 This article presents the outcome of a design process resulting from successive experiments based on cold climatic fluxes using a combined experience of analogue models and simulation tools. This approach suggests that tactile manipulations using analogue models remain easier to perform than any other type of simulation. Indeed, for many architects, such experiences relate to Pallasma's (2013) notion of "thinking hand", model interactions and manipulations expand one faculty to create new forms and spaces. Although there are many parametric software programs that can reproduce complex morphologies (Hensel and Menges, 2006, 2009), form-making designs with analogue simulation tools is favoured, because "the release of the machine also develop

and enrich imagination in the early stages of design and encourages unexpected discoveries" (Agkathidis, Hudert and Schillig, 2011).

4 In addition to proposing a process of creation focusing on the use of analogue models, this approach suggests that photography should serve as a tool of spatial visualization to analyse, imagine and render visual experiences of the newly created spatial morphologies. Photographic approaches using images are widely available and potentially user-friendlier than several simulation tools, especially in early design stages (Demers 1997). Although "analogical tools require time and craftsmanship, they offer unique opportunities for dynamic spatial visualization validation" (Demers and Potvin, 2017). Therefore, photographic images could become the bridge between the reduced analogue model simulation and the generation of an architectural design project, an hypothesis justified by the fact that "physical modelling retains its power to manifest and suggest relationships, scales, and organizational forms that numerical models often do with difficulty" (Agkathidis, Hudert and Schillig, 2011). Moreover, it is recognized that in the design activity, the image is the main communication tool of a project that helps to "visualize architecture" (Hogrefe, 2016). The research argues that an "architectural rendering" should provide an overview of the final mood desired by the designer, where the environment, including elements relative to the surrounding climate and the potential collage of characters digitally added to contextualize the project, could moreover express environmental fluxes related to form finding design objectives. Thereby, such as a projection of the human vision towards an inhabited space, the image allows the study of the potential "inhabitability" of the forms and physical models that are studied. Finally, it is hypothesized that these images, produced as the results of the parametric research, could act as architectural typologies that feed the architectural imagination, inspiring designers to experiment with the cold climatic environment. Ultimately, the process should encourage the creation of new architectural forms and ambiances adapted to the critical challenge of their particular context and climate.

5 In order to follow up on these statements, design research objectives aim to use erosion processes to inspire architectural design in connection with the cold climatic environment. In addition, the purpose is to develop a creative process through different manipulation stages using models, simulation tools and images to design potentially new architectural forms and physical ambiances, where the final goal is to validate ambiances, materiality and potential habitability of new morphologies through diverse representation methods, architectural renderings or digital collage.

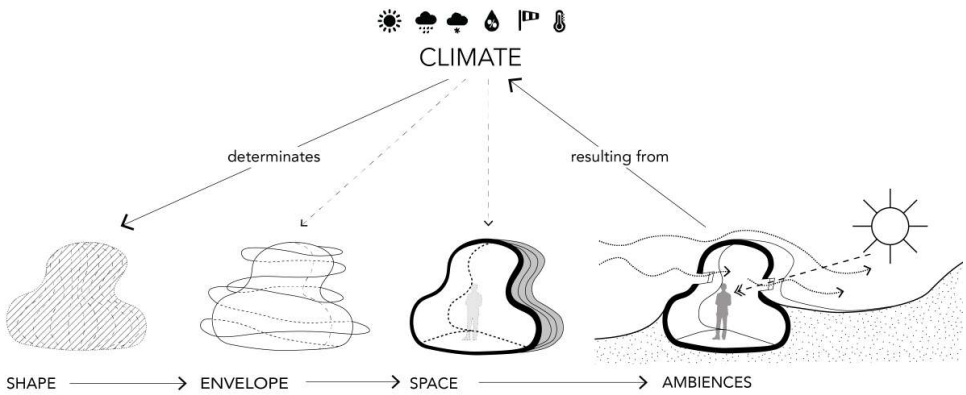
6 This paper is structured under four sections. The methodology describes the design research processes that were involved in obtaining 'inhabited' images. Results are discussed through three stages of creation: form generation, space exploration and transformation, and finally inhabited space creation as architectural ambiance. The conclusion presents advantages and limits of this research-creation process with possible future developments.

Inhabiting Climate: Design stages of the form generation process

7 This project develops an "inhabitability process of form generation", where each stage of model experimentation and their photographic analysis provide glimpses of their

"architectural potential" (Schumacher, 2009). The approach proposes that tactile manipulations put forward the experimental and experiential nature of cold climatic fluxes at several levels of precision and simulation, from inception to final developments. Illustration 1 suggests a narrative process generation, guided in progressive stages of inhabitation at each step by experiences of climatic environmental fluxes. The first step of the process proposes that form generations should conclude in a new ambiance after experimenting an environmentally adapted enveloped (step 2), explored the creation of a corresponding space (step 3), and inhabiting the space (step 4). This last step is connected to the first step (shape), since this process could be re-explored using different environmental fluxes related to climate such as sun, rain, water, wind and temperature. Laplante (2006), Demers and Potvin, (2017), and Charest (2015) proposed similar form finding processes of erosion by wind and water flows. Wind is the most unpleasant flux, causing felt temperatures to significantly drop during the winter season. Therefore, the design process consists in the development of an eroded form mainly created by a climatic wind flow. Subsequently, the design of an envelope, which relates to the record of digital information (Hensel and Menges, 2006, 2009), allows the production and the reading of an interior space model. Finally, this spatial component abstractly evoked through physical models could take a particular significance of its own in the designers' conceptual intentions in relation to architecture applications or programs. The process described in illustration 1 suggests that physical model ambiances have the potential to be partly experienced, or felt by designers during the research activities, relating more closely to potential inhabitants of these structures, due to exposure to light and the action of climate from which they were generated.

Illustration 1: The inhabitability process of form generation by climate



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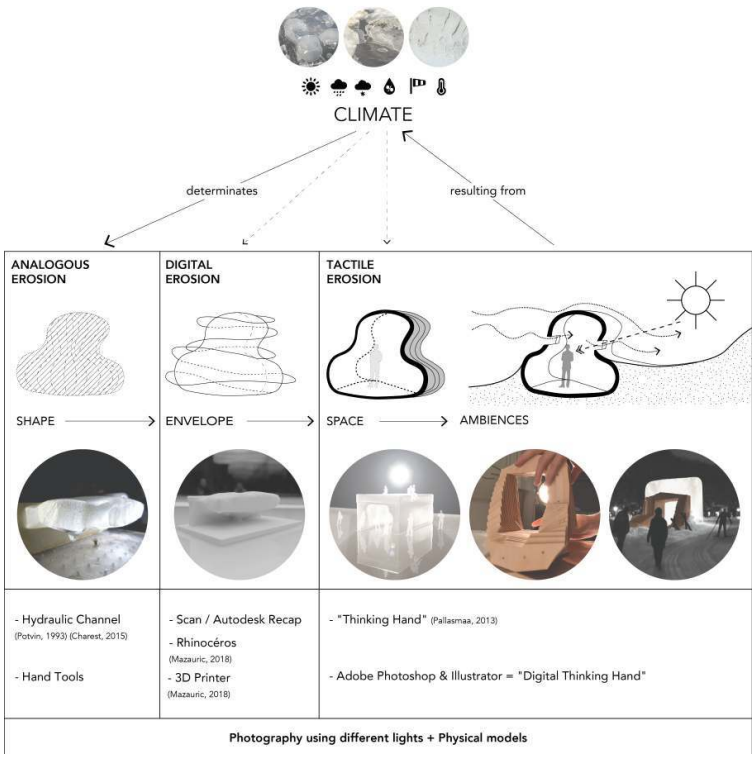
8 Illustration 2 represents an application of the theoretical diagram of the form-finding process from climatic fluxes in relation to early design stages, with corresponding specific tools used and associated resulting model images. The use of photography, as described in the introduction, binds all the stages of the methodology throughout the process. Shaping the first design stage, produces eroded ice shapes resulting from the interaction existing between wind flows and corresponding obstacles, which can be identified as the generated "wind envelope" (Laplante, 2006). The action of the cold northern wind is reproduced by a simulation tool called "hydraulic flume" (Charest, 2015). Besides, according to previous mentioned ideas, as this first stage favours the use

of analogue experimentations, this part of the design process is nicknamed: “analogue erosion”. In Envelope, or the second stage, the eroded shapes have been digitized with a scanner to capture the generated volume’s tri-dimesional contours. The digital file from the envelope scan always occasioned translation variables, or “errors” such as holes or approximate volume reconstruction, that were numerically corrected with a parametric design software, before being digitally printed with a three-dimensional printer. Therefore, this part of the design process was nicknamed: “digital erosion” because shapes were also intentionally altered, modified and redesigned using the software. During these first two stages, models are assessed with a mirror-box type of artificial sky to simulate the diffuse light of an overcast sky, as well as a heliodon in a photo studio to simulate sunlighting. At that experimential stage, the research goal was to generate a bank of eroded envelope typologies (Demers, 1997) and observe the form’s potential for architectural program uses, which required a more neutral diffuse light source.

9 Conversely, the final design stage, relating space and ambiances, assesses the inhabitability potential of produced spaces by using outdoor photography of the models to integrate the full spectrum of light and true colours obtained under natural lighting conditions. Winter climatic conditions were chosen as surrounding environments to better convey the contextuality of the project. Reminding Pallasmaa’s notion of “thinking hand” (2013) during the photographic analysis, tactile handlings allowed spatial exploration and ambiance discoveries by moving, rotating and observing the model in every way (image 2.D). In addition, this part of the process involves digital manipulation, where the images obtained during previous transformations are used as a basis for the production of collages (image 2.C) or architectural renderings (image 2.E), made using an image editing software to “visualize” a potential inhabitability of the models (Hogrefe, 2016). The concept of the “thinking hand” can also be applied to this digital manipulation, which is also intentional in the design process. Finally, this design stage was nicknamed “tactile erosion”, because it aims the potential habitability and intentionally modifies the shape or the orientation of models.

Illustration 2: The different photographic experiments of the models through erosion stages



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Results

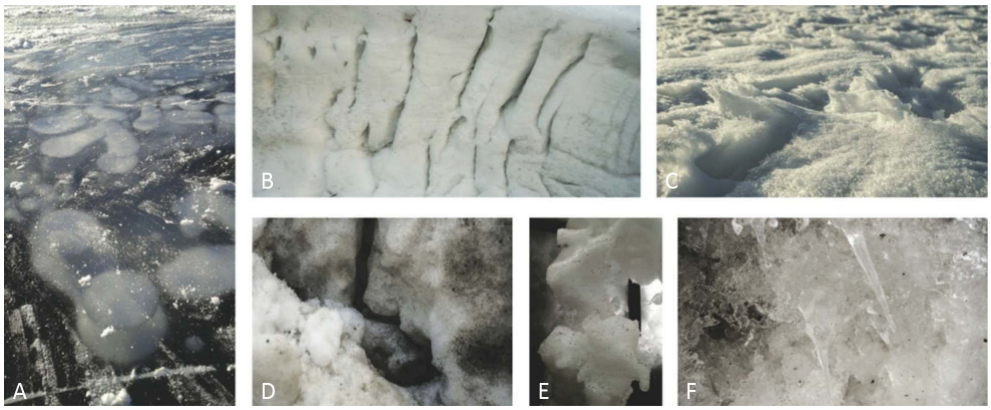
10 Through the different design stages described in illustration 2, photography images of models' experimentations are analysed and architecturally discussed and interpreted. As an introduction to the previously described systematic approach of form generation, a series of images selected from the observation of those expressed conditions of the existing cold climatic environments related to the site serve as inspirations and moods for the design process. Each design stage adds and completes additional information needed for architectural applications: firstly, to identify the typologies of the produced shapes, and, secondly, to "inhabit" the resulting images of those spaces to visualize their architectural potential.

The Climate as a Trigger for Inspiration

11 Natural fluxes, such as wind, snow and ice, create undesirable comfort conditions during the cold season. However, the phenomenon of erosion can be formally identified and observed in resulting natural snow or ice formations. Indeed, one can already contemplate a multitude of rounded shapes and atmospheres that may eventually be experienced in architectural spaces. Illustration 3 displays the ambient richness of in-situ images captured in Quebec City's winter landscape. This configuration offers a series of rich morphologies that suggests aerodynamic shapes and spaces that can be reinterpreted into architectural patterns, such as bubbles, crevasses, mounds or

stalactites. For example, in the image A of illustration 3, where air bubbles are seen frozen in the floating ice, these shapes evoke the "blob" style in architecture (Larroche, 2012). In the same way, images D and E, which consist of melted snow that has refrozen and later being shaped by the wind, evoke the curved shapes of the digital architecture of Zaha Hadid or Coop Himmelblau. Moreover, snow drifts patterns (image C) and icicles (image F) may suggest the "steep" or twisted forms, characteristics of Frank Gehry's production (ibid.). These images therefore reveal the eroded potential of the sun and wind in winter cold climates, which should inspire the design process in early design stages.

Illustration 3: Inspiration of eroded shape ambiances in winter's natural environment



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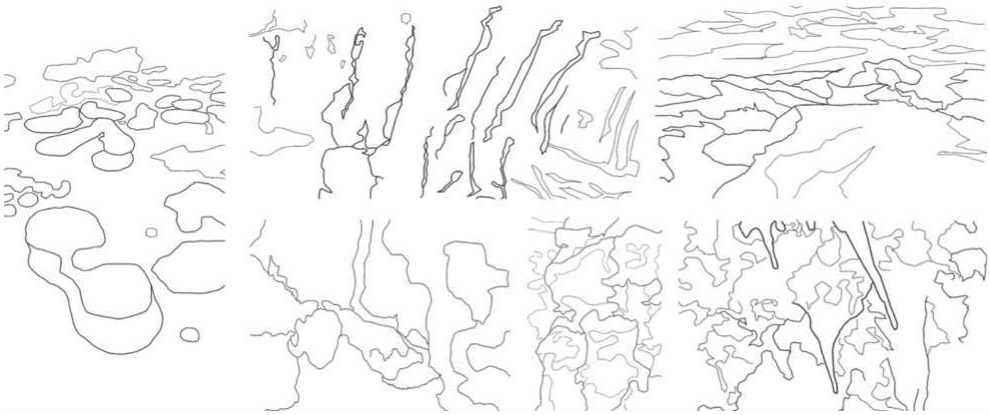
12 Illustration 4 consists in capturing "formal simplifications" (Demers 1997) of previous illustration 3 in-situ images. It is a close reminder of Viollet-le-Duc's (1876) bi-dimensional drawing outlines that simplify complex landscape morphologies. These outlines can even illustrate the potential for architectural inquiries about built forms that would offer a design process coupling photography and tactile manipulation through the erosion of ice. Line drawings become abstract representations of the directionality of landscaping patterns, hence the structural specificities of the object, which refer to the action of the sun and wind. This kind of observation also relates to ubiquitous architectural design tools normally used in early design processes, including drawing and sketching. Those in-situ images capture and "simplify" complex patterns, and therefore become triggers for inspiration in relation to design opportunities relative to cold climatic fluxes.

Illustration 4: Formal simplification of eroded shapes in winter's natural environment



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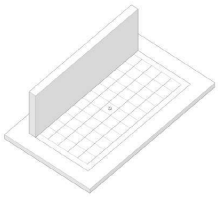
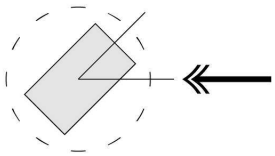
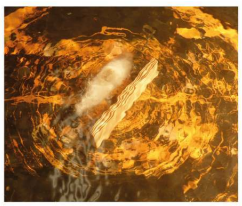
Analogue Erosion: Light Explorations of the Eroded Shape

13 This first design stage analyses the shape and ambiance of the results obtained during the form generation experimentations. The process is based on the method developed by Charest (2015, 2018) and Laplante (2006), where the "shape" of twenty different frozen models is obtained through the interaction between the flow of wind and ice obstacles. The action of the cold north wind is reproduced by a simulation tool called "hydraulic channel" (Potvin, 1993, 1996; Charest, 2015, 2018). Illustration 5 displays the different variables associated with one of the twenty experimentations.

14 The use of ice is directly inspired by the phenomenon of snow accumulation observed in northern climates, which is reminiscent of Figure 3. This situation being due to the association of wind orientation with obstacles present in the environment, the intention is to reproduce the effects of the wind in a controlled environmental context, where the typologies of forms are determined by their climatic context through the erosion process. To generate this type of geometry, about ten models composed of an acrylic base, a screw grid and wooden obstacles (square A and B, illustration 5) were built on the basis of those by Charest (2015, 2018). These elements correspond to parts of an architectural program, an urban context or natural features on a site, such as rows of densely planted trees. Subsequently, the models were drowned in ice blocks so that the water stream from the hydraulic channel that simulates the wind would quickly melt the ice in the most turbulent areas around the obstacle. This phenomenon gradually sculpted a more "hydrodynamic" volume of ice surrounded by a laminar flow. After a period of 90 seconds (square E, illustration 5), the eroded ice corresponded to the "wind envelope" (Laplante, 2006) associated with the specific configuration of the obstacle under study (square F, illustration 5). This method, developed on the basis of Charest (2015, 2018), has therefore made it possible to generate "new morphologies adapted to a climatic context" (*ibid.*, 2018: 7).

Illustration 5: Table of variables of an experienced model in the hydraulic channel

A.Obstacle typology	B.Materials	C.Congelation
_Simple transversal obstacle 	_Base in ACRYLIC _No screws	_Ice bloc very off the base. 
D.Orientation in the flume	**E.Time of the experiment**	**F. Formal result**
_Oblique wind 45 ° 	_90 seconds 	

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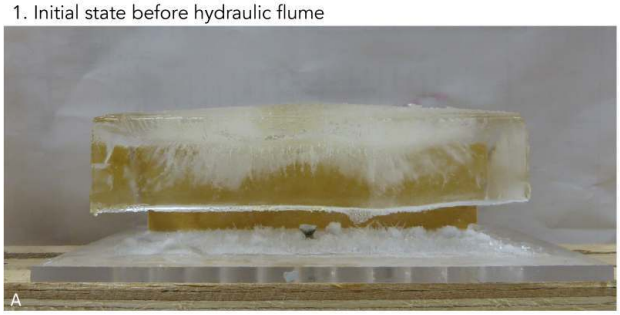
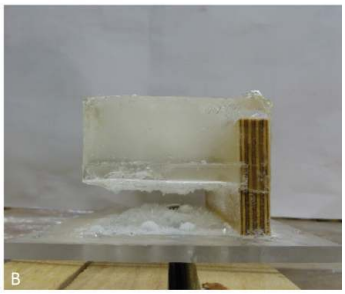
15 Illustration 6 presents the initial state of the volume (6.A and 6.B) and the final state (6.C and 6.D) of the same model, where the eroded ice shape has been defined by its obstacle's typology.

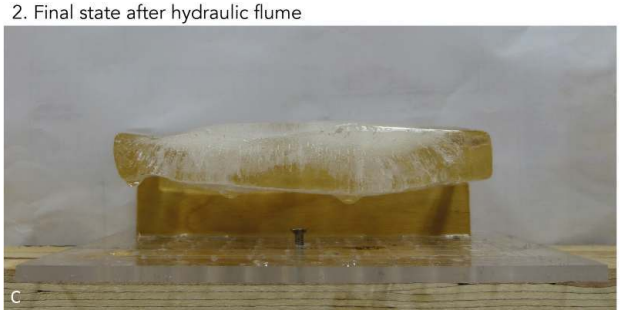
Illustration 6: Initial and final state of an experienced model in the hydraulic channel

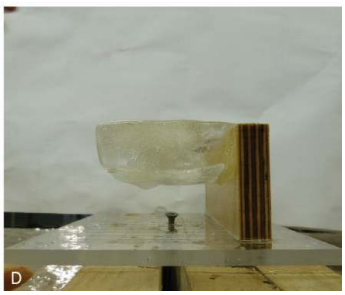
1. Initial state before hydraulic flume





2. Final state after hydraulic flume





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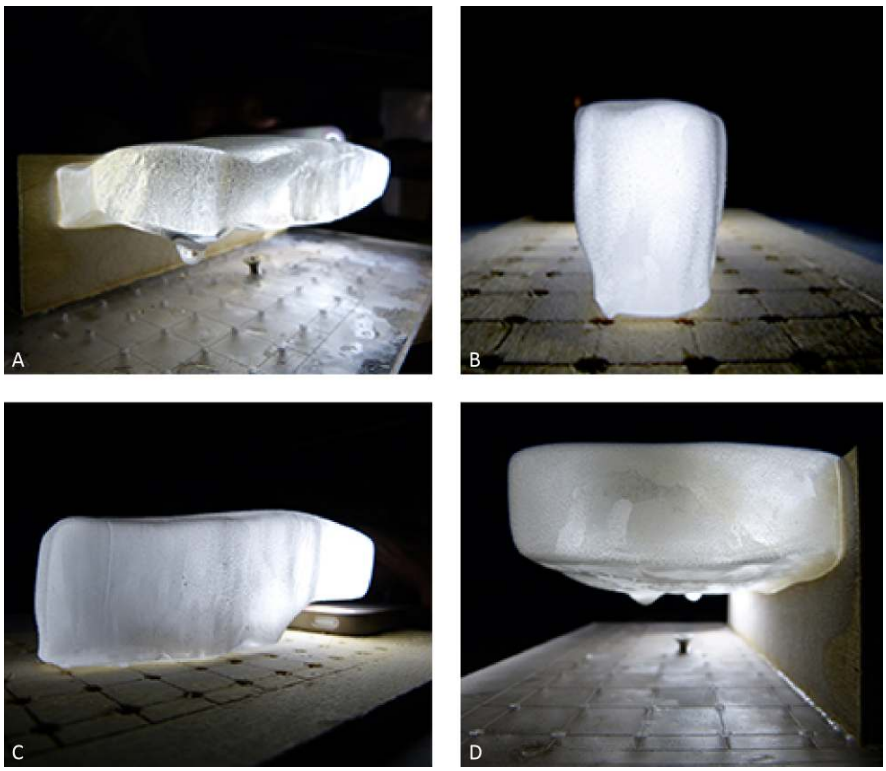
16 Following these experimentations, photographic pictures of the newly generated, more rounded shapes with their obstacle are captured. In order to visualize their spatial and architectural potential, these images are acquired at human eye level, where the focal point is located near the models' base (Biron, 2008) (Demers, 1993, 1997) (Stoilkov-Koneski, 2014). This experimentation is developed under a single light source used as illumination in reference to the fact that "light gives sight, it immobilizes an element [...] where the ratio becomes precise between light and matter" (Ciriani, 1992). The artificial lamp of a phone is used to manually allow controlled light, where explorations may even suggest night-time interpretations, totally independent from sun lighting patterns. This light setting explores initial ambiance generated by ice shapes, and aims to study the light behavior and translucency of the models' components (illustrations 7 and 8). Moreover, the coupling of the manipulation and the changing direction of a light source allows for the consideration of formal and ambient discovery (Pallasmaa, 2013; Twarowski, 1967). Through these new ambiances, the spaces between the ice and the obstacles seem to come to life and evoke different types of architectural configuration such as "in-between spaces" (Bille, Bjerregaard & Sørensen, 2015). This process enables a quicker immersion of the designer's mind within the model in order to emulate architecture (Pallasmaa, 2013; Holl, Pallasma and Perez-Gomez, 1998). These experiential activities with light therefore constitute the beginning stage of imagining architectural ambiances, leading towards the generation of inhabited spaces.

Illustration 7: Night-time ambiances of resulting eroded ice models in the water flume



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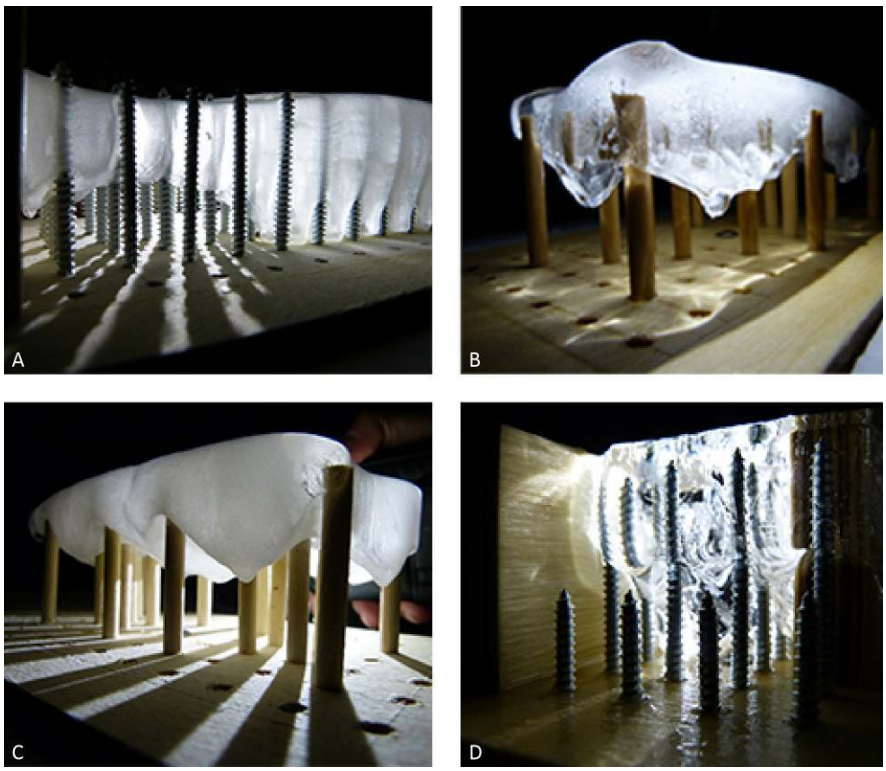
17 Images 7.A and 7.D show the ambient result of the experience previously displayed in illustrations 5 and 6. One can observe the diffused light in the volume of ice in a homogeneous way due to the frosted effect. Likewise, illustration 7 shows that the

volume acts as a light source, illuminating the space in a dialogue with its translucent volume supported by an opaque vertical wall. This spatial configuration evokes the use of "emotional light" in architecture, primarily associated for introspection or religious spaces. It relates to typologies of "light which acts on the opacities without which they would have difficulty to exist" (Ciriani, 1992). Thereby, this strategy makes it possible to better reinterpret the volume of ice with greater abstraction of its interiority. Instead of the models shown in illustration 7, those in illustration 8 were tested in the water flume without any screws or obstacles to observe if the shape could be altered in different ways by the simulated wind, and see if the volume of ice and its obstacle interact with the screws, such as explored by Charest (2015), creating potentially inhabitable "in-between spaces" (Bille, Bjerregaard & Sørensen, 2015) or mini-disturbances.

Illustration 8: Night-time ambiances of ice models using screws or wood studs after erosion



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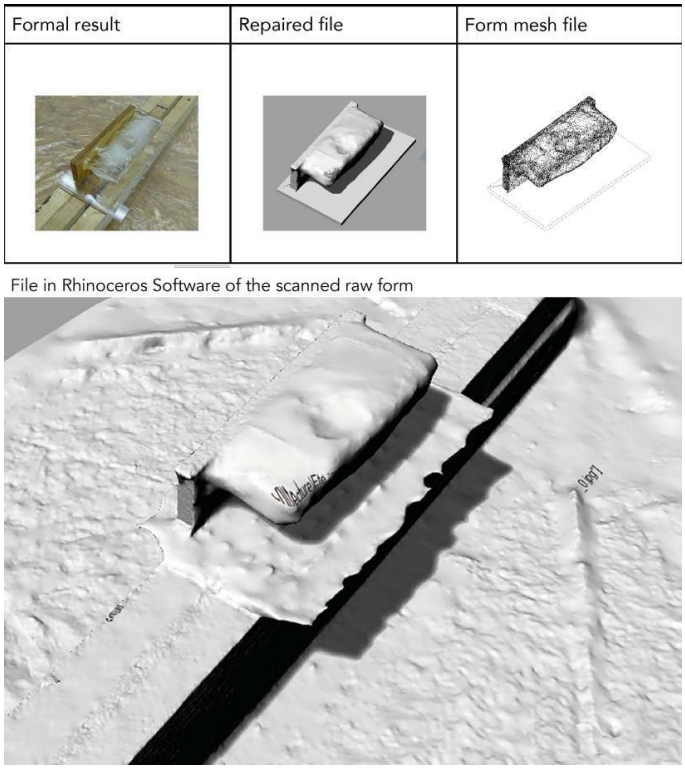
18 The emergence of architectural spaces is clearly visible in illustration 8 through suspended ice volumes. Screws and pegs, initially needed to attach ice to the model frame (Charest 2018), suggest a probable structure literally supporting the translucent volume of glass, such as expressed in images 8.B and 8.C. Moreover, on image 8.A, screws act as columns that come to rhythm the complex space created by the ice erosion to suggest an "in-between space" acting as a semi-external shelter. On image 8.D, the adjacent wooden walls seem to "wedge" the space of the ice volume, which is deeper at the wood ground level and closely appears as a cavity. Therefore, the structure needed to generate the volume accentuates the perception of interiority of the spatial experience, suggesting a continuity of space within the volume. Moreover, the presence of structural objects suggests a rhythm, and even a scale interpretation of the ambient spaces, unlike images of illustration 7, which were more abstract in that regard.

19 To conclude, the form finding process allows the emergence of an imagined architectural space through a selection of images of analogue erosion forces combined with light manipulations, where the light orientation "dialogues" with the observation point of view. Such a process of model interactions could enliven the designer's experience of projected architectural ambiances and, according to Ciriani (1992), spark emotional affect. Evocations of beauty made possible by the "play of clair-obscur produced by the juxtaposition of various materials" (Tanizaki, 1933, 2011) could even be suggested to the designer. The process emphasizes the discovery of ambiances within these conceptual images. It should guide the definition of the next design stages of the research and serve as a direct material source for the final architectural renderings needed to fully express ambiances of design proposals.

Digital Erosion: Exploration and Classification of the Forms

20 Following the previous experimentations as part of the design process of form finding through "analogue erosion", this second stage consists in recording and printing digitally the newly generated shapes with their obstacle. This "fixed", even restored, copy of the ice form could serve to develop new models in various spatial configurations and ambient evocations. Illustration 9 shows an example of the backup process of one model generated during the "analogue erosion" stage, where the shape is digitized for further processing in parametric design software. However, the digital scanning process may become imprecise by the presence of transparent materials, which consist of ice. Such unexpected results are part of the translation of volume into shapes. The present research suggests to refer to this discrepancy as a "digital erosion". In order to make the files printable and comparable, these results were "repaired", or reinterpreted using a parametric design software (illustration 8, square 3), and then configured for the three-dimensional printer (illustration 8, square 4) to produce hollow, more inhabitable physical models.

Illustration 9: Table showing a typology experimented in different states during the digital process



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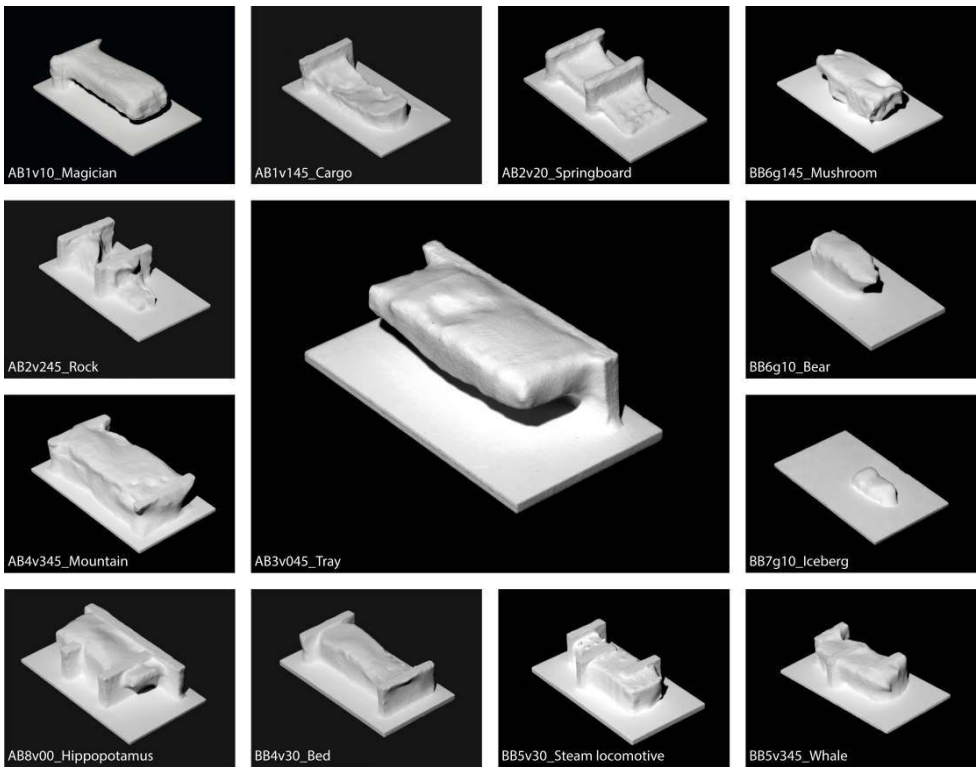
21 Only thirteen forms have been selected, numerically saved and printed in three dimensions from the twenty initial tests of the "analogue erosion" stage and are summarized in illustration 10. As in the previous stage, photography is used to observe the new models to classify and discuss the generated volumes. All models are presented in axonometric views and under a constant source of lighting, since an "axonometry combines in one view the information of the plane, the section, the elevation and the interior volume [...] it is an effective means to give an objectifying image of space" (Meiss, 1986). As a result of the "digital erosion", and in order to differentiate the envelop shapes, printed models are liberally named by the designer according to their "appearance" to highlight their spatial particularities associated with imaginary potential of the future ambiance. For example, the formal model resolution at the centre image of illustration 10 is entitled "the tray", because it focuses on its huge cantilever, which was originally structuring the ice hung on the wooden board. This effect can also be observed in similar resulting morphologies shown in previous images 7.A and 7.D.

Illustration 10: The thirteen printed shapes after digital erosion



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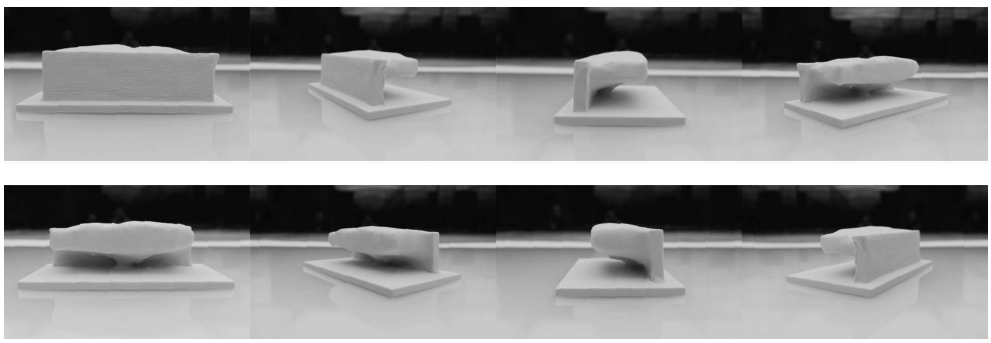
22 Illustration 11 presents the printed models in a "storyboard" that provides an understanding of the shape from different viewpoints. The model is rotated 45° under a diffuse light in an artificial sky (Demers, 1993, 1995). Diffuse light is privileged at this design research stage, because it "attenuates the plasticity of the object" (Meiss, 1986), and liberates shadow interpretations from deterministic site orientations and references to time.

Illustration 11: Formal photographic study in 360° of the model AB3v045 in diffuse light



From left to right: back longitudinal elevation, back oblique view, left side elevation, left oblique view, front longitudinal elevation, front oblique view, right side elevation and right oblique view.

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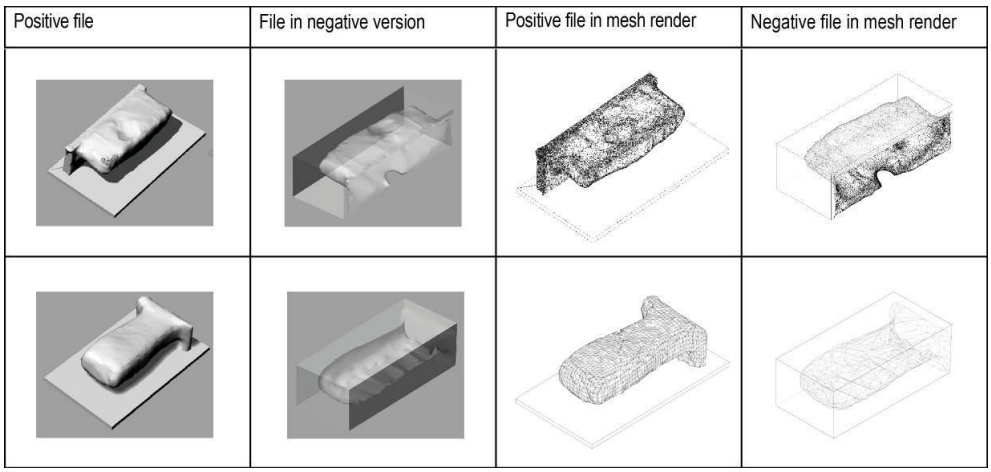
23 Through the photographic study carried out on these numerically printed models (illustration 11), it is possible to imagine glimpses of "in-between" spaces (Bille,

Bjerregaard & Sørensen, 2015), which correspond to spaces neither inside nor completely outside, such as the resulting space located under the cantilever. Moreover, this series of visual analyses allows to understand the spatial qualities of the generated forms in a simplified and abstract manner. However, this opaque finishing of the models and the absence of openings limits inhabitability in the reading and exploration of possible interior spaces. It would therefore be conceivable for a future design stage to use a more translucent material and even to determine openings in order to be able to explore the interior spatiality of those shapes.

Tactile Erosion: Exploration of the Negative Space as the Beginning of Habitability

24 Following the last two design stages of form generation, this third stage consists in analysing and translating shapes into interior spaces by the production of new models in a negative version, because "the solid space prohibits any mental transformation" (Meiss, 1986). Illustration 12 displays negative file modeling works in the same parametric design software as previously used. First, the original "mesh" file needs to be simplified. The obstacle is then removed from the shape before doing the "boolean" command with the original ice volume to obtain the negative version. Withdrawing the obstacle can therefore allow a non-arbitrary opening, thus can allow observations of the negative space.

Illustration 12: Process table for the treatment of two negative files



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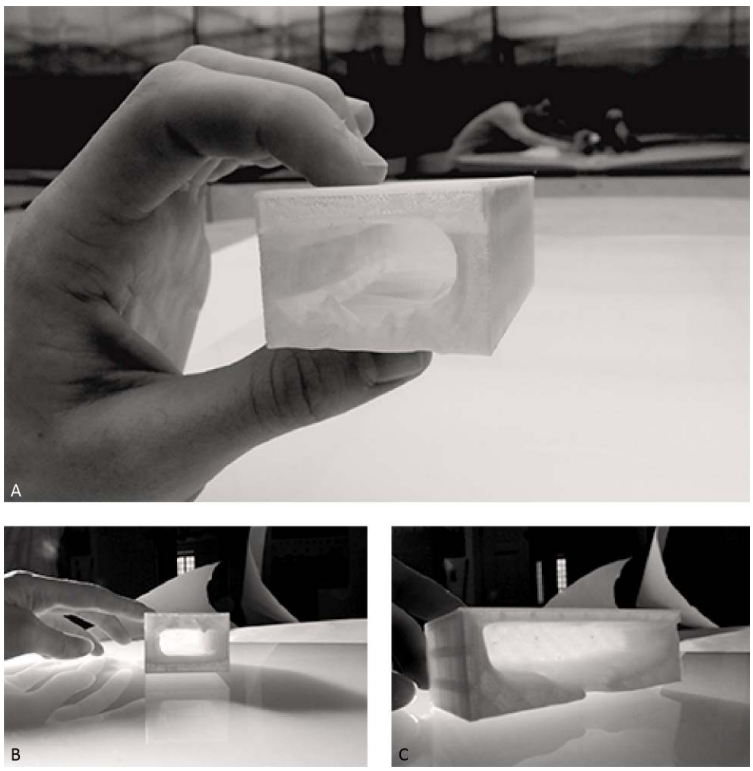
25 After those digital handlings, the negative files were printed into a polymer translucid material, with a specific printer for plastic, to better represent the interiority of the generated spaces with were otherwise enclosed, compact, opaque and appearing inaccessible to potential inhabitants. Another advantage of the translucent material is that is conveys light. The purpose of producing these new models was to allow the visualization of their interiority qualities. Illustration 13 originated from the file displayed back in illustration 12. It shows selected images of the first manipulations where image 13.A is photographed under diffuse light, whereas 13.B and 13.C are in direct light. Under the diffuse light of image 13.A, the composition of the space in its negative model and depth is very subtle, not clearly visible, because there are few contrasts.

Therefore, as can be seen in the images 13.B and 13.C, the interior space of the translucent models now appears as a glowing void, clearly expressed under the direct light, since it emphasizes its tridimensionality and optimizes shadows. As previously mentioned, this tactile handling of models allows for the exploration of space and discoveries by moving, rotating and observing the model in every way to discover qualities and architectural potential of a new space.

Illustration 13: "Tactile Erosion" of Negative Models morphologies explored by the "Thinking Hand"



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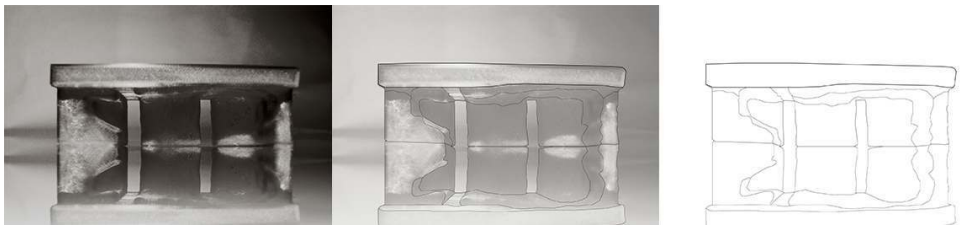
26 To "capture" the space of the negative form and to visually explore its potential of inhabitability, the model is located on a table with a light-reflective surface to be photographed afterwards at a human eye level (Biron, 2008). Such as expressed in illustration 14, a study of the model's image is planned to tame the lighting ambiance and spatial composition, which helps understanding the shapes and model contours through an image editing software. Then, using a vector drawing software, the outlines of the form were drawn in lines reminiscent of the images of illustration 4 from the stage entitled: "Climate as a trigger for inspiration". This outline representation allows for the visualization of new elements in addition to the work in an image editing software (Demers, 1997; Biron, 2008), as the space's depth and the perspective of the image like in a pictorial work (Baxandall, 1999; Gombrich, 1996; Gibson, 1950). Visualizing those elements could help identifying their spatial qualities, as possible entrances, openings, "in-between" spaces, or even horizontal surfaces that could eventually serve as seating areas. By applying such image simplification to determine the spatial composition (illustration 14), the horizon and the vanishing lines can thus allow a correct insertion of characters in harmony with the space and its architectural potential.

Illustration 14: Preliminary study of the AB8v00's negative model image before the addition of inhabitants



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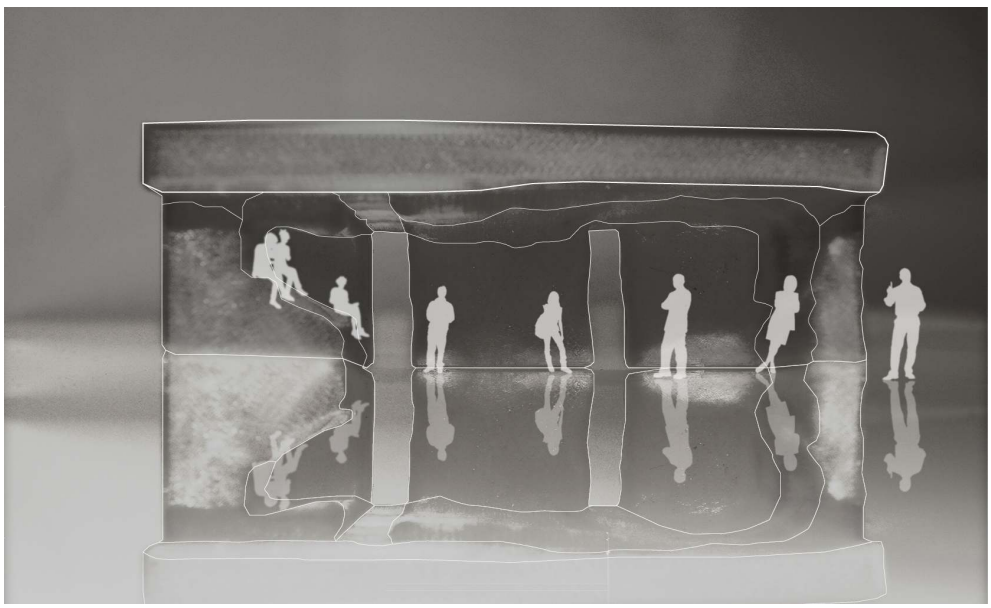
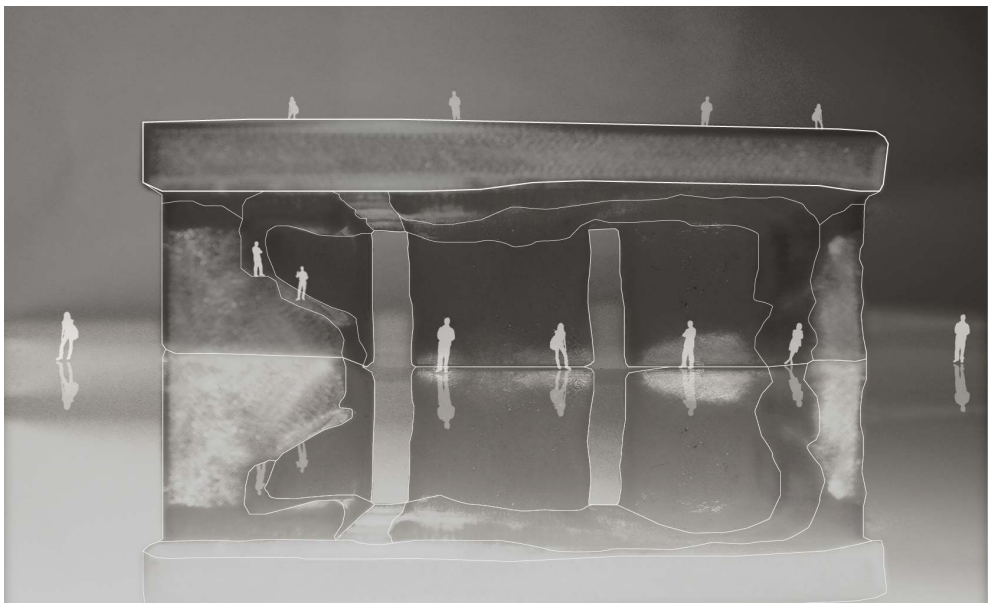
27 Adding characters to the images confers a spatial scale, expressing the first form of inhabitability that could be imagined such as sketches and premises of an architectural project. Illustrations 15 to 18 represent two different images of a negative model, where the characters are inserted at different scales. Illustrations 17 and 18, have quite a different architectural ambiance according to the size of their "inhabitants". For example, illustration 18 recalls the Markthal Rotterdam building, designed by the architectural firm called "MVRDV", which is a very large arch-shaped project, whereas illustrations 15 and 17 convey the scale of small shelters.

Illustration 15: Potential habitability of AB8v00's negative model at a small scale



Source and copyright: Louise Mazauric ©Université Laval.

Illustration 16: Potential habitability of AB8v00's negative model at a large scale



Source and copyright: Louise Mazauric ©Université Laval.

Illustration 17: Potential habitability of BB4v30's negative model at a small scale

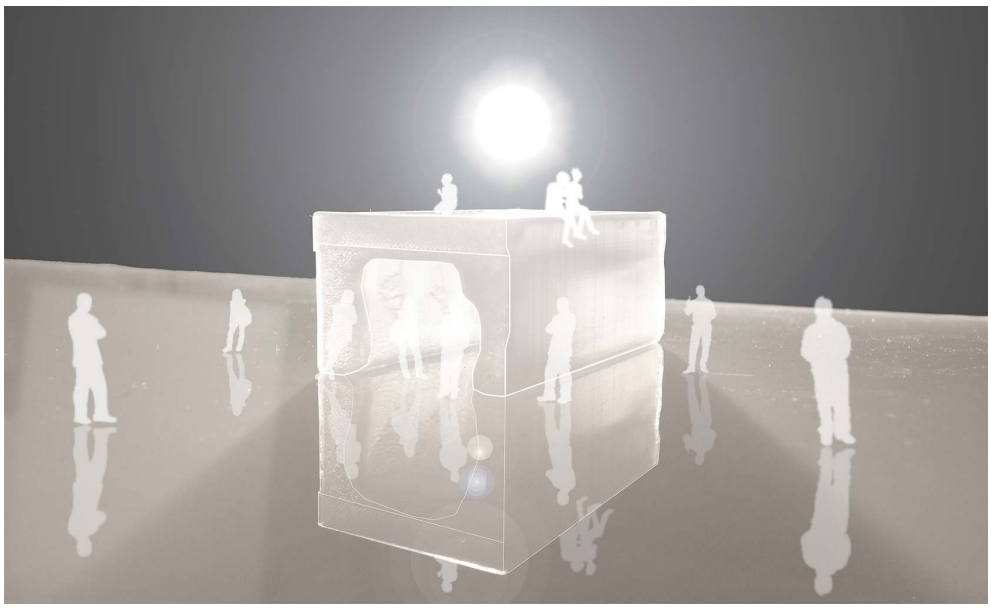


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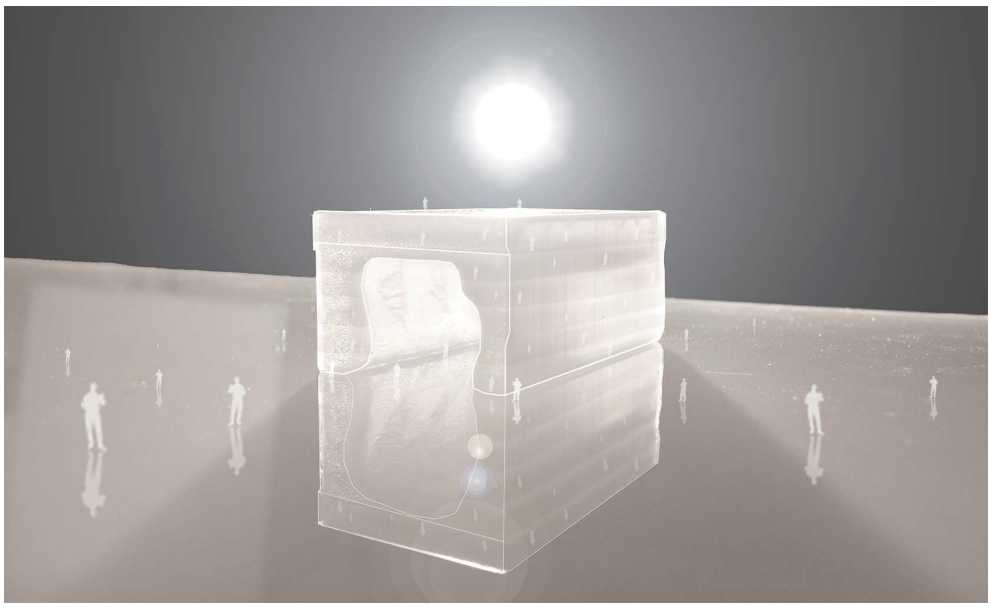
Illustration 18: Potential habitability of BB4v30's negative model at a large scale



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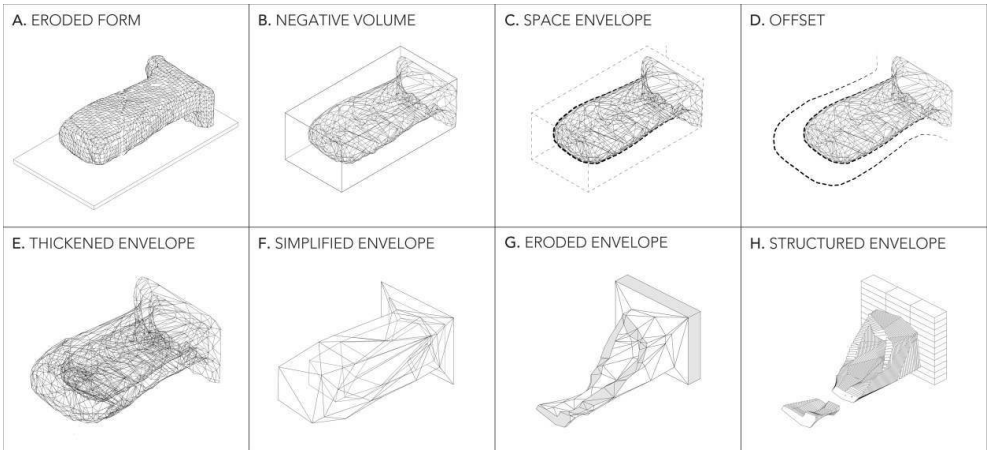
28 The negative version of eroded models reveals new potentials of the initial introverted and enclosed space. Architecturally, the process allows to distance ourselves from previous contextual explorations of initial opaque models. However, and although its use brings new spatial data, negative models challenge the previous contextual approach and run counter to the use of the erosion design process of wind applied in a specific climate. Indeed, as visible on illustrations 15 to 18, the shape of the outer inhabited envelope is no longer determined by the wind flow. This cubic envelope, which represents the initial volume of ice before exposition to the erosion process, is hereby completely abstract. Nevertheless, the thickness of this translucent volume is interesting to explore and manipulate for the following stages, because of its potential for serving as a filter for light and to delimit new "in-between spaces". Therefore, as in illustration 19, the envelope of the initial shape could become thickened, a process accomplished by an "offset" of the volume into the parametric design software, as described from stages 19.A to 19.E. This thickened envelope can be afterwards simplified (19.F), then punctured or eroded (19.G) at the places where "singularities" have been discovered during the negative model explorations. Finally, to be translated into a more architectural scale and to follow the negative version qualities, the thick eroded envelope can be designed in a way to serve as a light filter. The structural design the structure could thus be developed in the form of stratifications as displayed in the last stage 19.H.

Illustration 19: The design stages of AB1v10's transformation from the eroded shape to the thickened envelope



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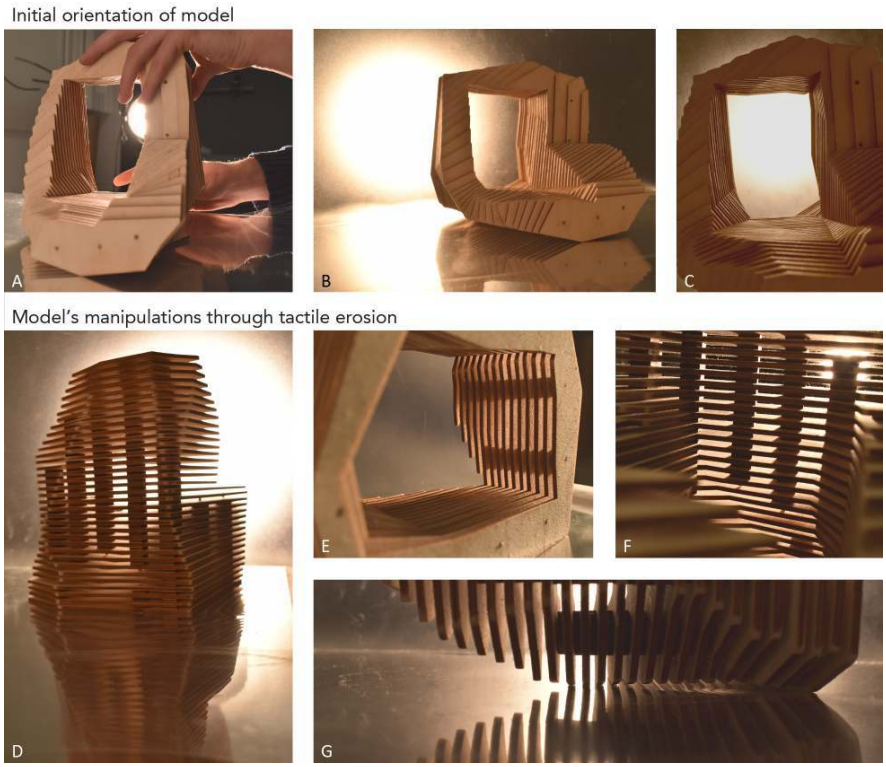
Tactile Erosion: Exploration and Design of the Architectural Ambiance

29 Following a process of form finding and their inhabitability explorations, this fifth and last stage aims to develop an architectural project by integrating it in a climatic context in relation to a more specific site and program. From the conclusions of the previous stage, a 1:20 scale wood prototype was built physically. This model was developed from the final shape illustrated previously in diagram H.19. It has been constructed from wooden slices cut with a laser cutter and assembled with glue. The purpose of building this model is to observe and analyse its different ambiances and luminous behavior through several climatic and ambient contexts: day, night, and winter season. This stage is key to address inhabitability as those manipulations and provides more information on the atmospheric potential of models according to different "lighting environments".

30 Direct lighting under the constant artificial light, as experimented in the previous stage, allowed contrasting night-time effects of models in a night-time ambiance. The analysis was carried out under constant light in a studio. Images 20.B and 20.C represent different views of the prototype illuminated from the rear. These first observations allowed to visualize the materiality of light, which despites its porous structure, had a very compact sun blocking effect. Unlike the "translucent" negative effect exposed in anterior model illustrations 15 to 18, the materiality chosen for the prototype does not fully allow any light through. Therefore, the orientation of the model has been altered to observe if the relationship between materiality and light could change, and observe if for example, depending on the lighting, the structure may appear lighter. Therefore, images D to G (illustration 20) show the prototype in a vertical way, which turned out to be an interesting discovery: the layers of wood filter the light with a porous atmosphere, the structure suggests a series of columns of the structure that come along to rhythm the shape and make the structure slimmer and less massive. This model ambiance is reminiscent of the images shown in illustrations 7 and 8 of the analogue erosion models. In the way of a creating a new "erosion", this manipulation by the "thinking hand"

allowed somehow questions the model's form in relation to sun lighting patterns which changes the designer's perception about the model.

Illustration 20: Ambiance photographic study of a detail model by artificial lighting



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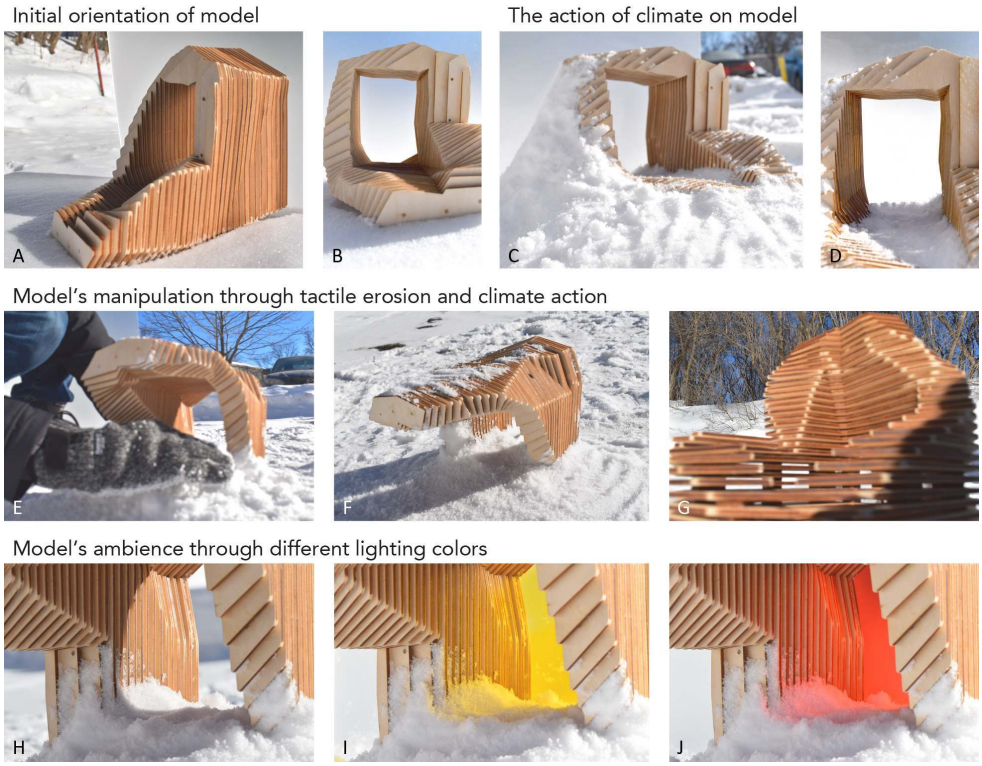
31 After the studio lighting study, the model was experimented in a real winter context. Renewing with the original inspiration of the northern climate, the model was observed outside on a sunny winter day. As for the previous handling, on the images 21.A and 21.B the model is first observed according to its initial orientation. Then, one part of the model was buried in the snow (pictures 21.C and 21.D) to observe the dialogue created between form, light and materiality with the white landscape. Moreover, one can imagine the model at human eye level, exploring ergonomic relationships with space and light. Subsequently, in the same logic as discoveries that occurred during the studio manipulations, the model was diverted from its original orientation to observe its relation to both exterior sun lighting patterns and the winter snowy environment. Images 21.D to 21.G illustrate these various manipulations of prototypes from many angles. The outside snowy ground allows the model to fit in more intermediate positions than in the studio. Therefore, in the inverted position, as in images 21.D and 21.E, the result evokes the cantilever, which reminds the first formal results in illustrations 10 and 11. In addition, similar to images 20.D to 20.G, image 21.F shows the model in a vertical position where the landscape can be perceived through the porous effect of the wood layers structure. During the previous stages, the camera was located on the ground, as for illustrations 11 and 15 to 18, where the human view allows to imagine the model as a real architectural object. The model is reminiscent of a high-rise building (image 20.D), which may speculate about the background landscaping, expressed through gaps between layers that could remind floors.

32 For the latest experiments, color filters have been applied on selected model surfaces to explore ambiances at a further level of complexity. Whereas black and white images relate to intensity contrast, a constant value experienced from one person to another, colour images relate to chromatic contrast, which relates to subjectivity. In that sense, colour experiences bring a rich component to a space, adding complexity, and thus give materiality to the light. In the model's explorations illustrated in images 21.H and 21.J, coloured lights are gradually diffused through the structural layers and reverberated on the snow explorations. This dialogue, created between light and object, is reminiscent of the ambiance observed in illustration 6 with models produced through analogue erosion. Moreover, although the use of wood is known to generate a warmer atmosphere (Watchman, 2017, p. 9), the addition of color appears to generate the emphasis on ambient space. With all these different tactile experimentations on the 1:20 model, new results referring to previous stages are produced, in addition to new material and structural explorations. These design results are contextually experimented with their environmental colors in relation to the winter climate context, adding another level of complexity in the experimentations.

Illustration 21: Ambiance photographic study of a detail model in winter climate exterior conditions



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33 Later design stages produced a more specific interpretation of inhabitation. Such development is illustrated through the project entitled "*Luminescences Érodées*", which consists of the integration of the design research experiments in relation to a specific inhabitancy program and context. More particularly, the architectural project addresses ambiances generated from landscaping installations located on the Plains of Abraham of the Northern City of Quebec (Mazauric, 2017). Illustrations 22.C and 23.F represent the project's architectural renderings, which result from the last experimentations

(illustrations 20 and 21). The project proposes that 1:1 architectural installations should embody some of the forms explored during the design research by careful transformation promoting their inhabitability for this specific context. The architectural project proposes to use winter's severe climate as a trigger for inspiration. The primary functional purpose of the project being to offer climatic shelters to site users, the form takes inspiration in the winter season and its windy context. Each intervention consists of a stratified wooden structure which serves as furniture and shelter, and a wall of ice which serves as night lighting, a strategy previously explored in similar installation projects of the Snow Show (Fung, 2005). At nightfall, this association is reminiscent of the atmospheres of illustrations 7 and 8, which were obtained from analogue erosion models. Therefore, we find the introduction theory described in illustrations 1 and 2 about the "inhabitability process" of form: the architectural forms generated by the climate are also perceived through climatic actions as wind and light, which determine their atmospheric environment.

34 This project's architectural ambiances, rendered as photographic representations, are obtained through a retouching work with an image editing software, by the combination of captured images in real spaces. Laboratory photography of reduced scale model (1:20) is incorporated into the image of the project's landscape and climatic context. During the manipulations expressed in illustration 21, the cold winter conditions made the photographic capture and analysis difficult. Therefore, to realize the final rendering, images 22.C and 23.F, which illustrates a night-time ambiance, could not solely rely on the outside context to perform illumination experiments. For this reason, the model was photographed in a controlled environment, where winter conditions of the site were recreated. Real blocks of ice were used to reproduce the "illuminated" and diffused effect of previous illustrations 7 and 8 during "analogue erosion". Then, a projector located at the rear of the model enabled to reproduce, on a larger scale, the effect of light diffused throughout the translucent material (Fung, 2005). Ultimately, human silhouettes were introduced into the actual model, whereas some new inhabitants were added later as collages to the rendering (Lassance, 1998) to confer even more life to the architectural design. Overall, those contextually rich and realistic experimentations of ambiances confer a poetic rendering of an actual environment, emphasized with tactile manipulations described in the design research, carried out upstream in the design process, during the previous stages of research explorations with matter.

Illustration 22: The design process of making an architectural atmosphere with a single model

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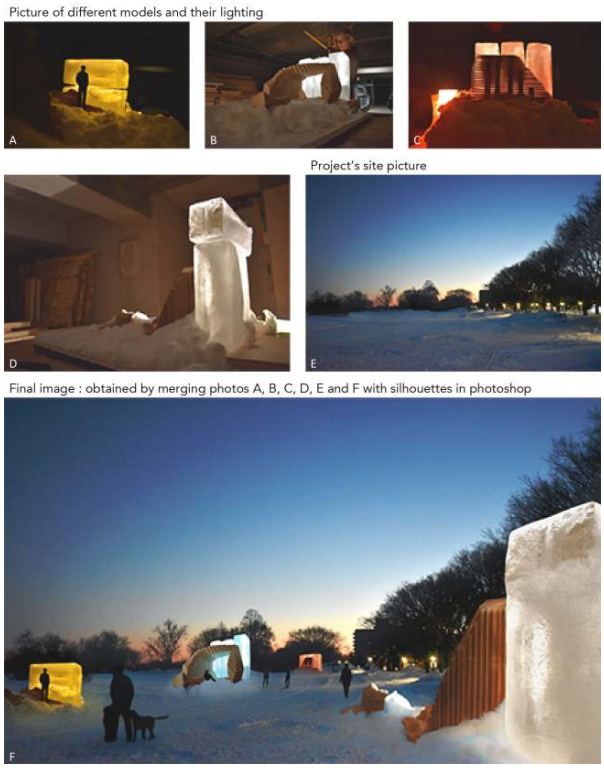
Illustration 23: The design process of making a complex architectural atmosphere with multiple colored models



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Conclusion

35 This paper proposes an experimental inhabitability process where the winter season of a critical cold climate becomes the trigger for inspiration during early design stages. In the proposed creative process, "erosion" not only refers to the literal action of climate on matter, but also as an actor of the design process, because a form, or more precisely the built envelop, may continuously be shaped through experimentation stages by the various exposed analogue and digital processes. The process begins with the development of a form eroded by the climatic wind flow, by means of an "analogue erosion". Subsequently, the "writing" of an envelope by "digital erosion" allows for the production and reading of an interior space represented as a model. The design and lighting explorations through "tactile erosion" that follow allow to imagine the potential inhabitability of the model, as its ambiance is felt by its potential occupants due to exposure to light and the action of climate.

36 The research proposes activities, such as coupling scale models, imaging and digital editing, to explore a series of design stages for connecting winter climate and architecture. Therefore, the image is used as a sensitive, even responsive element that participates in the design of new generated forms, whereas the model's spatial component appears to take a life of its own in the designers' mind. It becomes a key element of the design process that translates abstract theories into more concrete

concepts, from the ephemeral to the durable matter, and from the reduced scale model to the actual architectural project.

37 The paper focuses on a more developed version of an "eroded typology", which allows the complete exploration of scale models transposed into built forms, to explore, analyze and classify their spatial qualities through different lighting ambiances. The eroded shapes are developed through successive design stages, where physical or digital models are produced. Each step of producing and manipulating a model adds an additional degree of complexity, allowing to extend the perspectives of development to bring the formal structure closer to the architecture. For example, following the first two design stages of form generation, the third stage consists in analysing and translating eroded shapes into interior spaces by the production of models in a negative version, which reveals new potentials in the initial introverted and enclosed space. Architecturally, the process allows to distance designers from previous contextual explorations of initial opaque models. Therefore, in the frame of ambiance perspective, the experimentation of physical and digital models at every new stage enables to capture one element at a time of the architectural complexity. Moreover, the last realistic experimentations with colors and materials confer a poetic rendering of an actual environment, emphasized with tactile manipulations described in the design research, carried out upstream in the design process during the previous stages of research explorations with matter. These manipulations operated by the "Thinking Hand" (Pallasmaa, 2013) and the proposed "Digital Thinking Hand" allow to better assess the architectural inhabitability of the form. During each production stage of a physical model, the image encompasses a portion of the designer's memory of an ambiance. This medium becomes a vector of emotion, whether taken after a tactile experiment or as the result of a collage (Lassance, 1998) through digital software. Visualizing the inhabitability of architectural space becomes the creative tool that links all the experimental processes involved in the "inhabitability process" (illustration 1). Architectural renderings realized throughout the research-creation process "enable designers to dream" (Adolphe, 1998). While experimenting with eroded shapes in analogue or digital environments, this form finding process feeds their architectural imagination and assists designers to find more poetic and significant translations of the Nordic landscape into architecture, and therefore to participate in the development of a real sense of place.

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ABSTRACTS

This research aims to develop a design process through experimenting cold climatic fluxes with a combined tactile and digital approach to create new architectural forms. Through successive design stages, this experimentation intends to validate the habitability of these new typologies of forms shaped by climate, which could offer multiple architectural ambiances. This paper addresses the following questions: How can these new forms be transformed and manipulated through design stages to visualize their potential architectural inhabitability? How can the design process inspire architects and designers to engage a more tactile and digital reflection with climatic fluxes, such as wind and light? Physical models are produced through combinations of lights, materials and scales, which are then studied through photographic explorations to visualize their inhabitable potential of these new climatic form. Images are further contextualized through digital collages by inserting inhabitants and an external environment to create architectural renderings. The final result offers new visual images of lively climatic ambiances that suggest a more contextual relation to the environment and ultimately, a new representation of our relationship between winter and architecture.

Cette recherche développe un processus de conception par l'expérimentation des flux issus du climat froid hivernal, au moyen d'une approche à la fois tactile et numérique, afin de créer de nouvelles formes architecturales. Au travers d'étapes successives, ces expériences tendent à valider l'habitabilité de ces nouvelles typologies façonnées par le climat, qui pourraient offrir diverses ambiances une fois transposées à l'échelle de l'architecture. Ainsi, cet article aborde les questions suivantes : comment ces nouvelles formes peuvent-elles être manipulées au travers d'étapes de conception pour pouvoir visualiser leur potentiel habitable et ainsi architectural ? Comment ce processus peut-il inspirer les architectes et les concepteurs à s'engager dans une réflexion à la fois tactile et numérique qui utilise les flux climatiques tels que le vent et la

lumière ? En combinant différents éclairages, matériaux et échelles, des maquettes sont produites afin de visualiser la possible habitabilité des nouvelles formes générées. Celles-ci sont étudiées au travers d'explorations photographiques, où les images sont ensuite davantage contextualisées au moyen de collages numériques par l'insertion de personnages et d'un environnement extérieur. Le résultat final prend ainsi la forme de rendus d'architecture, où ces nouvelles images d'ambiance climatique suggèrent une relation plus contextuelle à l'environnement et ultimement une nouvelle représentation de notre rapport à l'hiver et à l'architecture.

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Keywords: climate, architecture, design process, ambiances, form, light, inhabitability, wind, image, experimentation
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