Draft Toronto Green Roof Construction Standard – October 2008

This is a draft document for discussion purposes as Appendix 1 to the Report "By-law to Require and Govern the Construction of Green Roofs in Toronto" considered by the City of Toronto Planning and Growth Management Committee at its meeting of November 13, 2008.

1 INTRODUCTION

The purpose of the Toronto Green Roof Construction Standard is to provide requirements and recommendations that will allow a designer to design a green roof that will meet the City's minimum requirements for green roof construction while also meeting the Ontario Building Code(OBC) requirements for the remainder of the building. This Standard does not replace or alter any existing Code requirements, or define a singular code compliant green roof design

The designer should appreciate that the successful application of the measures described here requires a clear understanding of the principles governing the building code requirements for each measure.

The mandatory requirements included within this Guide:

- address the City's policy objectives not covered by the building code, and/or;
- define guidelines for achieving a Code compliant design

Green Roof Systems are considered an alternative solution by the Building Code and will have to meet the OBC objectives to demonstrate compliance with the OBC.

2 DEFINITIONS

Green Roof

A Green Roof generally is an extension of an existing roof, built on top of a human-made structure, that allows vegetation (plants, trees and shrubs) to grow in a growing medium.

The City of Toronto Act defines "green roof" as a "roof surface that supports the growth of vegetation over a substantial portion of its area for the purpose of water conservation or energy conservation. 2006, c. 11, Sched. A, s. 108 (3)".

Green Roof Assembly

A Green Roof assembly is formed by a root repellant system, a drainage system, filter cloth, a lightweight growing medium and plants, and it is installed on the waterproof membrane of an applicable roof.

3 GREEN ROOF COMPONENTS

Typical Components

Designing high performance green roofs requires an understanding of the following layers and their interaction:

- Vegetation
  The correct selection of the plant species installed can determine the success or failure of the green roof. The selection criteria should consider climate conditions, and the maintenance requirements of the plants.

  Alpine species are often the best choice, since they can resist extreme conditions of heat, cold, high winds, extreme sun exposure and long drought periods. Among these alpine species, succulents are the most commonly selected species, because of their capacity for storing water in their leaves and roots, and because of their low substrate depth required for their establishment.

- Growth Media (Engineered Soil)
  This layer is the growing media for the plants. To improve the water retention capacity, soil is often engineered to improve its porosity. When applying green roofs to existing buildings, the growth media must be designed with consideration of the load capacity of the roof structure.

- Moisture Retention Mat
  This layer serves the purpose of retaining water to provide moisture for the growing media and the plants. This layer is commonly made of recycled polypropylene fibers stitched to a thermoplastic fabric sheet, such as polyethylene, and it is installed loose-laid. This layer may also serve as a root protection layer.

- Drainage Panel and Filter Fabric
  The function of the drainage layer is to expel surplus water from the roof during rain periods, and, in some cases, serve as a water reservoir for the green roof during dry periods. It can be made from free draining materials, such as gravel, or from rigid thermoplastic materials such as polystyrene or polyethylene impressed with “cups” to temporarily store the water.

  The filter fabric is a geotextile which provides protection against the accumulation of fine soil in the drainage paths, ensuring the long term efficiency of the drainage layer.

- Root Barrier
  Two risks to long term durability of a green roof that are managed through the installation of a root barrier are the risk of root penetration into membrane seams, and the harmful effect of soil microbes acting on the waterproof membrane. Root barriers are intended to protect the waterproofing materials from these risks, and are commonly made of thermoplastic sheets such as PVC, TPO or polyethylene. As an alternate, chemical products or metallic foils such as aluminum, which inhibit growth, can be used in combination with synthetic fiber material or geotextiles. The use of these types of chemicals should be reviewed for compliance with the local environmental law if applicable.

- Waterproofing Membrane

- Protection Board
  As required as fire separation and protection between the selected membrane and insulation products.

- Insulation Board
  The insulation in a green roof system requires sufficient compressive strength to support the weight of the full saturated soil and water reservoir, hardscape materials and live loads. An impermeable, close cell insulation system is recommended to avoid water penetration and reduction of thermal properties.

Sketch of Typical Green roof cross section

OBC Authorized Materials

Given the recent introduction of many green roofing systems components which are not strictly recognized in the OBC. Ontario's objective based code provides the mechanism for dealing with these materials. It is recommended that designers review green roof systems with Toronto Building staff early in the design process to identify any issues related to material selection.

OBC General Requirements

Building Code Act 9.-(1)	"The chief building official may allow the use of materials, systems, and building designs that are not authorized in the building code if"…they "will achieve the level of performance required by the building code."
Division A 1.2.11.(1)	"Compliance with Division B should be achieved by complying with the *applicable solutions* in Division B, or by using *alternate solutions* that will achieve the level of performance required by the applicable *acceptable solutions* in respect of the objectives and functional statements attributed to the applicable *acceptable solutions* in Supplementary Standard SA-1."
Division B 11.3.1.1	Where an existing building system is materially altered or repaired, the performance level…should be at least equal to the performance level…prior to the material alteration or repair.
Division C Part 3	Qualifications are required for designers. Specific requirements are established for persons completing design required by the OBC.

Requirements

Whether selecting a complete system, or specifying components from different sources, designers shall ensure that all of the materials used in a green roof system have been evaluated to ensure:

- chemical compatibility,
- appropriate resistance to changes caused by chemical and biological action of micro-organisms and other chemical components existing in the vegetation and soil substrate or dissolved in the water,
- acceptable release of chemical substances to the atmosphere or storm water.

Best Practices

The Factory Mutual (FM) Data sheet 1-35, Green Roof Systems, 2.2.16, and the FLL Guideline for the Planning, Execution and Upkeep of Green Roof Sites (FLL) establish performance requirements for the selection and installation of the green roof components listed in the typical components section. As per the FLL the components of the green roof system should as a system provide:

- Effective protection to the waterproof layer against static, dynamic and thermal stresses, as well as mechanical and chemical damage during installation and throughout the useful life of the roof, and
- Promote healthy growth of the planted vegetation.

The FLL recommends that green roofs manufacturers shall provide proof of compatibility between the different components in the system.

4 STRUCTURAL

Green roofs can add loads to a roof structure which are significant in comparison to typical roof design loads. The weight, stability and moisture retention characteristics of the system (particularly the growing medium and water retention mats) need to be determined. The following presents OBC sections which address gravity loads requirements and recommendations on how to respond to these requirements in green roof design, and green roof structural issues not addressed by the OBC:

4.1 Gravity Loads

Green roof gravity loads should be calculated in accordance with OBC Division B, Part 4.1 Structural Loads and Procedures. If building structural members are to be sized based on tables within Part 9 of the OBC, care should be taken to ensure that the loads imposed by the green roof are within the limits required for use of the tables. Best practice is to carry out the load analysis and design per Part 4 of the OBC.

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OBC Structural requirements – Loads

Loads	
Division B 4.1.1.3.(1)	"buildings and their structural members…should be designed to have sufficient structural capacity and structural integrity to safely and effectively resist all loads, effects of loads and influences that may reasonably be expected…"
Division B 4.1.4.1.(b) and (e)	Dead loads to be considered in the structural design include "the weight of all materials of construction incorporated into the building to be supported permanently by the member", and "the vertical load due to earth, plants and trees.
Division B 4.1.3.2.(7)	"Load factor" applied to achieve the desired factors of structural safety for "soil, superimposed earth, plants and trees should be increased to 1.5, except that when the soil depth exceeds 1.2m, the factor may be reduced…".
Division B 5.1.4.1.(1)	"Building materials, components and assemblies…should be designed and constructed to…resist or accommodate… (b) all structural loads…"
Division B 9.4.1.1	Structural members should be designed to Part 9 requirements or "CWC Engineering Guide for Wood Frame Construction" or Part 4.
Division B 9.4.3.1	(2) "Dead loads need not be considered in computing deflections…". Maximum roof deflection as per Table 9.4.3.1 is 1/360 where ceiling is plaster or gypsum board.
Division B 9.26.11	"Built-up roofs" identifies minimum requirements for built-up roofing membrane construction. Requires minimum No. 15 felts and minimum 3 mopped down layers of roofing felt.
Division B 9.23.4.5	Provides additional structural requirements for "heavy roofing materials" such as roofing tile. Joist, rafter, beam and lintel spans in tables are to be reduced to account for the additional loads.
Division B 9.23.15.7	Refers to tables that specify the thickness of roof sheathing where and where not used as "a walking deck".
Division B 11.4.3.2	Where the performance level of an existing building is reduced…(a) remedial measures should be taken to support the proposed loads".

Requirements-Loads Definition
Calculate Green Roof load following the protocol provided by the ASTM standard: "ASTM E2397.05 – Standard Practice for Determination of Dead Loads and Live Loads Associated with Green Roof Systems" and "ASTM E2399.05 – Standard Test Method for Maximum Media Density for Dead Load Analysis of Green Roof Systems"
Include Design loads definition as part of the "Green Roof Declaration" form . This form will be required as part of an application for Building Permit,.

4.2 Slope Stability

OBC requirements

Slopes	
Division B 9.26.3	Minimum slopes for roof coverings are specified in Table 9.26.3.1. Minimum 2% for modified bitumen, 2% to 4% for built-up roofing. Maximum slopes for roof coverings specified in Table 9.26.3.1

Requirements
All roofs with slopes in excess of 11º (20%) and supporting green roof assemblies shall incorporate anti-shear measures

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Best Practices

Minimum Slope:
Given that a green roof conceals and restricts drying of the roof membrane, providing adequate roof slope to drains under a green roof is critical. The roof should, as a minimum, meet the requirements stated in the OBC. Better practice would be to require a minimum of 4% slope and to water test the roof, prior to installing the green roof system, for positive drainage.

FM Global Property Loss Prevention Data Sheet 1-35 Section 2.2.10.1 recommends a minimum slope of 2% for roof systems supported by structural concrete decks and 3% for all other structural support systems.

Maximum Slopes:
The growing medium of a green roof can become unstable as roof slopes increase. FM Global Property Loss Prevention Data Sheet 1-35 Section 2.2.10.2 limits roof slopes (supporting green roofs) to 11º (20%) for systems not including anti-shear measures (to prevent green roof materials from sliding on or off the roof). Above this slope, anti-shear layers, or anchorage and erosion control systems, should be installed. These measures are to be designed to protect both the structural integrity of the green roof system, and the vegetation layer. The anti-shear measures should be designed to avoid damage to the membrane, or other layers in the green roof system, caused by the stress induced by the slope in the system. FM recommends that green roofs not be installed on roofs above a slope of 22º (40%).

FLL recommends the following anti-shear measures for steep roof slopes:

- For slopes between 11º and 15 º, the shear loads can be overtaken by reinforced eaves combined with waterproofed shear barriers. Anti-erosion measures such as geotextile fabrics should be also included in the design.

- Between 20 º and 30 º, additional anti-shear measures should be installed such as special woven matts, and geotextiles, or anti-shear plates and profiles. When using geotextiles, special care should be given to their tensile strength and fastening details to ensure they can support the required loads. To prevent vegetation from sliding, the vegetation substrate should be selected in a way that its structural soundness is not

affected by water (i.e limiting the amount of fine materials which can be washed out). Fast plant root growth should be promoted to guarantee bounding of the system, and avoid erosion.

- Above 30 º (56%), the vegetation may present performance problems due to lack of root resistance to shear, and it is recommended to limit the vegetation type to light weight pre-cultivated mats.

The following graph indicates recommendations for providing stable green roof systems at different slope levels:

GRAPH

Special care should be given to the design of the drainage system to avoid water accumulation and the consequent loads at the lower level of the green roof system in high slope systems.

4.3 Parapet Height and/or Overflow Scupper Locations

The OBC provides direction on how to design for water accumulation from rainfall.

OBC Requirements

Division B Part 4 (4)	"Where scuppers are provided and where the position, shape and deflection of the loaded surface make an accumulation of rainwater possible, the loads due to rain should be lesser or either the one-day rainfall determined in conformance with Subsection 1.1.2 or a depth of rainwater equal to 30 mm above the level of the scuppers, applied over the horizontal projection of the surface and tributary areas"
Division B Part 7 (General)	Provides requirements for design and installation of storm water drains.
Division B 7.4.10.4.(1)	The hydraulic load is the maximum 15 minute rainfall (25mm for the City of Toronto) multiplied by the area of the surface drained and one half the largest adjoining vertical surface.
Division B 7.4.10.(2)	Control flow roof drains may be installed provided "(b) the roof structure has been designed to carry the load of the accumulated water, (c) one or more scuppers are installed so that the maximum depth of water on the roof cannot exceed 150mm…"

Given a green roof's enhanced ability to store rainfall, and the ready availability of debris to block roof drains, additional care must be taken to ensure that adequate drainage is provided for the system.

Requirements
Parapets and Scuppers shall be specified in the design, as required, to limit retained rain water loads to within structural limits in the event of obstructed internal drains.
Analysis shall be done in conformance with OBC Division B 4.1.6.4.(4)

The referenced point for the overflow scuppers height must be clearly indicated to avoid the possibility of confusing the overflow scupper height as being measured above the finished green surface or other layer above the waterproofing resulting in higher water load than accounted for by the design).

*****SCHEME/IMAGE******

4.4 Wind Uplift

OBC Requirements

Wind loads	
Division B 4.1.7.1.(4)	Wind loads are to be calculated using a reference velocity pressure for "a probability of being exceeded in any one year of 1-in-50".
Division B Part 5 5.1.4.1	Building materials, components and assemblies that separate dissimilar environments or are exposed to the exterior shall be designed and constructed to provide sufficient capacity and integrity to resist or accommodate wind up-lift imposed…..

Division B - Part 4 of the OBC requires that the design resist blow-off by the wind. There are practices in the industry, such as loose-laid, protected membrane roofing systems, which are accepted despite limited design information regarding their quantified wind resistance. Green roofs, however, pose a distinct risk of wind uplift.

Requirements
Limit the installation of green roofs in geographical areas where the wind speed (3 seconds gust) does not exceed 45 m/s, applicable to all building heights as per FM document Data Sheet 1-35 Section 2.2.2.
Green roofs shall incorporate a vegetation free border zone and a minimum ballast depth as per the sketch below in areas that present a greater risk of wind uplift. ▪ Roof corners and edges, ▪ Areas where the wind pressures are elevated, and ▪ Roof systems in which root barriers or linens are not fastened to the roof structure.

TYPICAL TORONTO ASSEMBLY DESCRIPTION AND DRAWING

Best Practices

The FM Global Property Loss Prevention Data Sheet 1-35 Section 2.2.14 defines parapet heights and border zones to reduce risks (see the sketch below).

FLL provides a list of specific recommendations related to securement with the intention of providing a system that can withstand a load of1.5 times the positive or negative pressure, as prescribed by DIN 1055 standard, Part 4. Similarly, a prescriptive securement process is defined in the FM Global Property Loss Prevention Data Sheet, 1-35, Green Roof Systems, 2.2.3.3 Wind Uplift, Roof Ballast and Safety Factor The

following summarizes the FM recommendations:

- Use a mechanically attached or fully adhered roof membrane system based on appropriate wind uplift design pressures.

- Growth media as ballast against wind uplift for the roofing membrane and other waterproofing elements only where a uniform depth of 200 mm or more is provided; a minimum safety factor of 1.7 (or as defined by the green roof designer) should be used for wind uplift calculations.

- Use a minimum of 76 mm of stone ballast in the ballasted areas in the non- vegetated borders, unless greater depths are recommended either by the manufacturer or installer.

- Growth media may be used as a secondary ballast material to ballast the loose-laid roofing components above the waterproofing membrane (i.e., drainage panel, retention mat, root barrier, and insulation board), but not the membrane itself. Use wind uplift design pressures and a minimum safety factor of 0.85 (or as defined by the designer) for wind uplift calculations where growth media is used to ballast.

- Where vegetated, pre-cultivated mats are installed, anchor them until the mat's root growth has achieved sufficient attachment into the growth media to adequately resist wind action (at least one full growing season). Vegetated mats should be properly anchored or ballasted against wind forces based on a safety factor of 1.0 (or as indicated by the designer).

- FM document also recommends the inclusion of a Non-Vegetated Border Zones in the areas affected by larger wind pressure (edges and corners). These areas should be free of vegetation and covered by stone ballast or concrete pavers, and have a minimum dimension of 2.6 m..

****SKETCH OF GREEN ROOF EDGE SCHEME****

Wind design should be also incorporated as an item on the "Green Roof Declaration" form integrated as part of the building permit process.

5 SAFETY

5.1 Fire Safety

OBC Requirements

OFC 2.4.2.1	"Combustible materials should not be stored on a roof or adjacent to any building so as to create a fire hazard to the building or its occupants."

Division B 3.1.15.1 and	Every roof covering should have a classification determined

3.1.15.2	in accordance with CAN/ULC-S107-M, "Fire Tests of Roof Coverings".
Division B 11.3.3.2	Where existing…roof assemblies are substantially removed in an existing building and new interior walls, ceilings or floor assemblies are installed, structural and fire resistance elements should be constructed in compliance with the requirements of the other Parts.

Green roof coverings (including plant material) may not comply with "Fire Test of Roof Coverings" standard, particularly if vegetation is dormant. At this point in time, there is no widely accepted testing method develop for Green Roofs.

Requirements
Design for fire safety in conformance with FM Global Property Loss Prevention Data Sheet 1-35 Section 2.2.14

Recommendations

There is no current testing methodology for Green Roofs, thus there is not possible to classify green roofs in terms of fire resistance. Factors that must be considered will include:

- Avoiding vegetation that presents excessive fire risk;
- Keeping the vegetation away from walls, parapets, mechanical equipment;
- Providing non-combustible claddings at areas exposed to the green roof;
- Providing fire breaks to limit vegetation areas;
- Appropriate location of natural gas line supply;
- A consideration of the potential impact of burning vegetation on paths of egress, and
- Requirements for fire fighting (portable extinguishers and adequate water supply and/or fire hoses.

TYPICAL TORONTO ASSEMBLY DESCRIPTION AND DRAWING

Best Practices

The "FM Global Property Loss Prevention Data Sheet 1-35: Green Roof Systems" provides specific recommendations for some of these design variable to limit risks related to fire. It considers a green roof as non- combustible with regard to interior fire exposure if it is installed over a concrete deck. The FLL guideline accepts the guidelines dictated by the Association of Urban Construction and Housing in Germany (ARGEBAU) which considers the green roof system to have enough fire resistance if the green roof assembly meets the following criteria:

- The soil substrate has a minimum depth of 30 mm
- The vegetation planted constitutes a "low fire load"
- There is a distance between the green roof area and any penetration in the roof of at least 50 cm.

The FM document, Data sheet 1-35 2.2.14, also establishes a minimum 50 cm non-vegetated border zones as separation from any penetration in the roof.

In general, design should provide solutions which achieve compliance with OBC Division B and its objectives and functional statements. The FM document (section 2.2.14) recommends avoiding vegetation types with high risk of seasonal dormancy such as grasses and mosses, and limiting the vegetation height to a maximum of 0.9 m.

A maintenance program should be provided with the green roof design. This program should include annual removal of dead vegetation that does not promptly compost and presents a fire risk.

Fire safety should be also included as an item on the "Green Roof Declaration" form integrated as part of the building permit process.

****EXAMPLE IMAGE- separation to penetrations and partitions******

5.2 Occupancy/Safety

OBC Requirements

Division B 9.8.8.1	Guards are required where there is a difference in elevation of more than 600mm or where the slope of the adjacent surface is more than 1 in 2. Guards are not required where access is provided for maintenance purposes only.
Division B 3.3.1.17	A guard not less than 1070mm high should be provided around each roof to which access is provided for other than maintenance.

Requirements
▪ Define use of the building in the Green Roof declaration form
▪ For non-occupied roofs create a non-vegetated border zone within 2m or the roof edge

Best Practices

If the roof is to be accessible for uses other than maintenance, all OBC requirements associate with the stated occupancy should be met (i.e. exits, guard rail, live load capacity, accessibility, etc.).

For non- accessible green roofs (other than maintenance), if guards are not provided at the roof perimeter, the vegetation free-zone at the roof perimeter where there is a fall hazard should be a minimum 2m wide, or alternate safety measures should be present to facilitate maintenance such as adequate safety tie-back anchors for workers to safely access the vegetation for maintenance. System should allow for compliance with applicable workplace safety laws.

Guards should be provided for green roofs used to produce and harvest vegetables, flowers or other crops in accordance with OBC Division B 3.3.1.17

The FLL Guidelines, place the responsibility for fall protection during construction and maintenance activities of the Green Roof on the design professional. This includes provisions for fall arrest and safety devices to prevent falls during construction and maintenance activities in the green roof. The FLL recommends these safety measures to be incorporated in the Building Permit application.

The intended use and occupancy of the roof should be stated in the recommended "Green Roof Declaration" form integrated as part of the building permit process.

6 WATERPROOFING

6.1 Waterproofing

OBC Requirements

Division B 9.26.1.1	"Purpose of Roofing" is to shed rain and prevent water from entering. Includes "platforms that effectively serve as roofs with respect to accumulation or drainage of precipitation."
Division B 9.26.2	"Roofing Materials" identifies applicable standards for waterproofing membranes, shingles and tiles.
Division B 5.6.1.1	A building component or assembly should "(a) minimize ingress of precipitation into the component or assembly, and (b) prevent ingress or precipitation into interior space."
Division B 5.1.4.2.(1)	Materials used should be "resistant to any mechanisms of deterioration that may reasonably be expected".
Division B 5.1.4.2.(3)	"Design and construction of assemblies separating dissimilar environments and assemblies exposed to the exterior should be in accordance with good practice such as described in CSA 478, Guideline on Durability in Buildings." This standard requires buildings, components and assemblies to be designed, operated and maintained to meet or exceed their design service life. The appropriate design service life of each component is to consider difficulty/expense of maintenance, and consequence of failure.
Division B 9.26.4	"Flashing at Intersections" required except where omission does not adversely affect adjacent elements. Minimum thicknesses of acceptable sheet metals are specified.

Best Practices

Maintaining the waterproofing function of a membrane within a green is considerably more critical than a conventional roof system because of the added cost of repair. While the OBC does not impose any specific requirements, it does require designers to fulfill the purpose of a roof, consider the need for resisting water ingress apply to green roofs, and maintain acceptable performance.

There is no limitation on what roofing materials within a green roofing system could be relied upon for preventing water entry. However, increased membrane quality would be judged to be prudent by most professionals in a green roof design. In general, due to the additional risk the green roof system pose on the waterproof membrane, the following general recommendations should be followed:

- Built-up roofing membranes should consist of a minimum of 4 plies. Organic based #15 felts should not be permitted; felts should be glass fiber based Type IV as a minimum.
- The substrate on which the green roof is installed should not be shingles or tiles.
- Some metals have been found to suffer problems with corrosion when integrated within a green roof. In particular, aluminum can be vulnerable.
- Sheet applied modified bitumen membranes should be a minimum of 2 plies.
- Liquid applied membranes should be reinforced and be applied with a minimum 2 plies.
- Waterproofing membranes should be adequately protected from damage from other green roof assembly materials, and from assembly installation activities.
- The design should include materials that adequately protect the waterproofing membrane from damage from roots. Chemical root barriers are only permissible if in compliance with environmental law.

FM Global Property Loss Prevention Data Sheet 1-35 FM 2.3.3 also recommends a leakage testing (flood test) ASTM D5957-98(2005) prior the installation of the above- membrane components

6.2 Drainage

OBC Requirements

Division B 9.26.3	Maximum slopes for roof coverings are also specified in Table 9.26.3.1.
Division B Part 7 (General)	Provides requirements for design and installation of storm water drains.
Division B 7.4.10.4.(1)	The hydraulic load is the maximum 15 minute rainfall (25mm for the City of Toronto) multiplied by the area of the surface drained and one half the largest adjoining vertical surface.
Division B 7.4.10.(2)	Control flow roof drains may be installed provided "(b) the roof structure has been designed to carry the load of the accumulated water, (c) one or more scuppers are installed so that the maximum depth of water on the roof cannot exceed 150mm…"

Requirements
▪ The design hydraulic load should be evaluated assuming the green roof system is fully saturated prior to the maximum15 minute rainfall.

▪ Positive slope to drain shall be provided at the level of the waterproofing membrane.
▪ Drainage mats or equivalent free draining materials shall be employed to permit effective drainage beneath the growth media.
▪ Drainage layer shall be appropriate for storm water retention and must be selected following E2398-05 Standard Test Method for Water Capture and Media Retention of Geo-composite Drain Layers for Green Roof Systems.
▪ Vegetation-free zones shall be provided around all drains.

Best Practices:

As a general recommendation, roof drains should be protected from vegetation coverage or loose soil or gravel which can obstruct the drain, and they should be designed to allow regular inspection and maintenance. FM Global Property Loss Prevention Data Sheet 1-35, in Section 2.2.14 requires a 0.5 m vegetation free zone around drains and roof outlets to prevent them from obstruction. FLL section5.5, provides guidelines on requirements and execution of the drainage components of green roofs to allow for maintenance and inspections of the drains.

For the vegetation system drainage, drainage panels, mats or equivalent free draining materials should be employed to permit effective vegetation substrate drainage.

6.3 Water Retention

OBC requirements

There is no provision in the OBC specifically addressing water retention. In general, water retention should be limited as per the structural capacity of the roof defined in section 3 of this document.

Requirements
▪ Water retention mats or equivalent materials shall be employed as required to promote vegetation growth.
▪ Design the green roof to not exceed a run off coefficient of 60% or provide a minimum 150mm deep growth medium

Best Practices

One of the major potential benefits of green roofs is its capacity for storm water retention and reduction of run-off from the roof in storm events.

FLL section 6.3, outlines the performance parameters used for the calculation of the storm-water retention coefficients which can be assigned to different roof assemblies. Table 3 from this FLL section outlines different water retention coefficients for different roof assemblies.

To meet the required storm water retention, a minimum 150 mm soil course should be installed or equivalent water storage strategies such as those outlined below which are recommended by the FLL guidelines:

- Storage in the vegetation support through the use of substances or materials which retain water, such as prefabricated substrate boards, or
- Water retention mats
- Storage in the vegetation support course and in the drainage course through the use of open pore aggregate (such as porous clay) in graded granular sizes, or
- Storage in the vegetation support course and in the drainage course by allowing water to build up in the drainage layer by using pre-formed drainage boards with retention capacity.

IMAGE OF ALTERNATIVE SYSTEMS

The use of this type of water reservoir systems might also decrease the irrigation requirements of the green roof.

7 VEGETATION PERFORMANCE

7.1 Growth Media

Requirements
▪ Growth media shall be selected so as to support the vegetation.
▪ For new buildings, provide appropriate depth of growth media for the application as determined by Green Roof designer.
• Existing buildings shall be provided with growth media as necessary to support the vegetation, and as limited by structural capacity.

7.2 Plant Selection

Requirements
• Vegetation shall not contain any noxious weeds as defined by the Noxious Weed Act (Ontario Regulation 1096).

• Vegetation shall be appropriate for use in the green roof application, which includes, but is not limited to:
a) As defined in ASTM E2400 - 06 Standard Guide for Selection, Installation, and Maintenance of Plants for Green Roof Systems, and
b) Native from the Southern Ontario area;
c) Appropriate for the Toronto climate and building exposure;
d) Drought resistant to minimize the need for irrigation;
e) Having root systems that are accommodated and resisted by the assembly design;
f) Non-monoculture
• Seeds for groundcover plantings shall be sown at a rate not less than 325/m^2, cuttings shall be distributed not less than 12kg/100m^2, and pre-grown plugs shall be installed not less than 11/m^2.
• The planting design, planting, maintenance, and re-planting (as necessary) shall assure that healthy and complete cover is achieved within 3 growing seasons.
• The design of the green roof assembly shall be stamped by a Landscape Architect registered in the Province of Ontario.
• The design of the green roof system shall be stamped by a Structural Engineer registered in the Province of Ontario.

7.3 Irrigation

Requirements
Adequate measures shall be provided to permit irrigation necessary to initiate and sustain the vegetation

A “Green Roof Design Declaration” form shall be created and integrated into the building permit process. This would be similar to “The Control Flow Roof Drainage Declaration” form created by the Joint Committee of the Engineers, Architects and Building Officials (EABO). This form will solicit the information and confirmation including: growing media depth; maximum retained water depth - overflow scupper drain height; drainage design and over-flow scupper drain design.

8 BIBLIOGRAPHY

- FM Global Property Loss Prevention Data Sheets. Data Sheet 1-35 Green Roof Systems, 2007
- FLL Guidelines for the Planning, Execution, and Upkeep of Green Roof Sites.January 2002.
- "ASTM E2397.05 – Standard Practice for Determination of Dead Loads and Live Loads Associated with Green Roof Systems"
- "ASTM E2399.05 – Standard Test Method for Maximum Media Density for Dead Load Analysis of Green Roof Systems".