

# Roofing Criteria



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**ROOFING DESIGN  
GUIDELINES AND POLICIES  
FOR LOW SLOPE ROOFS**

**STATE OF NORTH CAROLINA  
DEPARTMENT OF ADMINISTRATION  
STATE CONSTRUCTION OFFICE**

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## PREFACE

This criteria for roofing design is a compilation of data, policies, legal aspects, preferences, experiences, prejudices, etc. that a Designer may find useful and necessary in designing roofs and roofing systems and preparing contract documents relative to roofing of State owned buildings.

This criteria is not a compendium of all roofing knowledge. It is not a State roofing specification, not to be copied and printed or referenced in the Designer's specifications. It is a tool of communication between the State Construction Office, the Designer and the User Agency to make the process easier and the end result more successful. The Designer is to research the latest references, test data, product manuals, etc. and review the project with local roofing contractors and manufacturer's representatives in evaluating the appropriate system to use.

Contrary to a popular and belief, the State Construction Office does not have an "approved" list of roofing systems or manufacturers nor a "not approved" list. Any of the roofing systems and materials that are included in this criteria will provide a good sound roof when appropriately selected, designed and detailed by the Designer; when properly installed by the Contractor, and properly maintained by the Owner. The Designer is hired to evaluate all aspects of the building construction, function, site and budget, and to select and prepare contract documents for a roofing system that will satisfy the design requirements and reflect the latest in good roofing practice. State General Statutes require that the Designer name at least three acceptable manufacturers that can provide the specified system.

The State of North Carolina owns a wide variety of buildings that range from turkey breeding barns to art and history museums, marine aquariums at the shore to magnetic resonance imaging facilities at medical institutions; and lowland gorilla enclosures at the zoo to maximum security prisons. There are also different levels of maintenance provided at each facility. Many State owned building are unique buildings requiring well thought out selections for roofing systems and detailing.

The State owns about 12,000 buildings. In a typical year the State Construction Office may review between 200 to 300 projects that could roughly be divided into 1/3 new buildings, or additions, 1/3 repair and renovation and 1/3 roofing replacement.

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## CHAPTER 1

### DEFINITIONS AND REFERENCES

#### 1. General:

This document made numerous references to The North Carolina State Building Code.” This code, for the purpose of this document, shall be known as the “*Code.*”

The North Carolina State Building Code comprises seven (7) technical codes but only five (5) are pertinent to this document, North Carolina State Building Code; Building Code; Plumbing Code; Fire Prevention Code and Energy Conservation Code; North Carolina Existing Building Code.

#### 2. Definitions:

The two (2) dictionaries used to define the terms are the “Webster Dictionary” latest edition and the “Dictionary of Architecture and Construction” 4<sup>th</sup> Edition by McGraw Hill. Other definitions not in the dictionaries are from NCSBC, NRCA and SMACNA.

- A. **Control Joint:** A joint placed within a roof system to relieve stresses between adjacent systems which does not directly correlate to an expansion joint in primary building framing.
- B. **Expansion Joint:** A joint placed within a roof system to relieve structural stresses between adjacent structural framing which aligns with or otherwise correlates to and continues a break in the structural framing system and other components of the structural.
- C. **Overburden:** All items placed on the roof after a waterproofing membrane is completed on a green roof such as engineered soil, insulation, pavers etc.
- D. **Overflow:** Design method by which water is discharged from the roof when the primary roof drainage systems is not functioning or blocked.
- E. **Roof:** According to “Webster Dictionary” is the outside top covering of a building or structure that protects, shelters or guards.” For the purpose of this criteria, according to “Dictionary of Architecture and Construction” 4<sup>th</sup> Edition by McGraw Hill,” the top covering of a building, including all materials and constructions necessary to support it on the walls of the building or uprights; provides protection against rain, snow, sunlight, extremes of temperature and wind.
- F. **Roof Deck:** Can be of any construction material including wood, metal decking and concrete. It is the flat or sloped surface not including its supporting members

or vertical supports. The deck supports the non-load bearing components such as insulation, membrane, flashing etc.

- G. **Roof Drain:** A drain designed to receive water collecting on the surface of a roof and to discharge it into a leader or a downspout.
- H. **Roof Drainage System:** On the roof of a building, a system composed of storm-water collection devices, and piping connected to these collection devices; transports the rainwater off the roof, out and away from the building.
- I. **Roofing:** Any material (or combination of materials) used as a roof covering, such as membrane, corrugated metal, sheet metal, shingles, slate, thatch, tiles and membrane; usually provides waterproofing and wind protection.
- J. **Roof Recover:** The process of installing an additional roof covering over a prepared existing roof covering without removing the existing roof covering – as defined in NCSBC.
- K. **Roof Repair:** Reconstruction or renewal of any part of an existing roof for the purposes of its maintenance.
- L. **Roof Replacement:** The process of removing the existing roof covering, repairing any damaged substrate and installing a new roof covering.
- M. **Scupper:** A means of drainage consisting of an opening through a wall/parapet lined with sheet metal to allow the passage of water.
- N. **Vapor Retarder:** An impervious membrane placed in the roof system to retard or prevent the passage of water vapor.
- O. **Vegetated Roof Assembly:** A waterproofed substrate with plantings/landscaping installed above.

### 3. References:

The references listed publications/entity are basic essentials to proper design and detailing of a roof.

- A. **State Construction Office (SCO)**  
North Carolina State Construction Manual  
301 N. Wilmington Street, Suite 450  
Raleigh, NC 27601-1058  
Phone Number: (919) 807-4100  
Fax: (919) 807-4110  
Web Site. <http://www.nc-sco.com>

- B. State Construction Office (SCO)**  
North Carolina State Building Code: Building Code (NCSBC)  
North Carolina State Building Code: Existing Building Code (NCEBC)  
North Carolina State Building Code: Mechanical Code (NMC)  
North Carolina State Building Code: Plumbing Code (NCPC)  
North Carolina State Building Code: Fuel Gas Code (NCFG)  
North Carolina State Building Code: Fire Prevention Code (NCFPC)  
North Carolina State Building Code: Energy Conservation Code (NCECC)  
301 N. Wilmington Street, Suite 450  
Raleigh, NC 27601-1058  
Phone Number: (919) 807-4100  
Fax: (919) 807-4110  
Web Site. <http://www.nc-sco.com>
- C. North Carolina General Assembly (NCGA)**  
North Carolina General Statute Website:  
<http://www.ncleg.net/gascritps/statutes/Statutes.asp>
- D. National roofing Contractors Association (NRCA)**  
National Roofing Contractors Association Roofing Manual; Membrane Roof System  
Green Roof Systems Manual  
10255 W. Higgins Road, Suite 600  
Rosemount, IL 60018-5607  
Phone Number: (847) 299-9070  
Fax: (847) 299-1186  
Website. <http://www.nrca.net>
- E. Sheet Metal and Air-Conditioning Contractor's National Association, Inc. (SMACNA)**  
4201 Lafayette Center Drive  
Chantilly, VA 20151-1209  
Phone Number: (703) 803-2980  
Fax: (703) 803-3732  
Website. <https://www.smacna.org/>
- F. Underwriter's Laboratory (UL)**  
2600 N.W. Lake Road  
Camas, WA 98607-8542  
Phone Number: (877) 854-2577  
Fax: (360) 817-6278  
Website: <http://www.ul.com/global/eng/pages/>
- G. Factory Mutual Global (FM)**  
Presto Ridge III  
3460 Preston Ridge Road, Suite 400

Alpharetta, GA 30005  
Phone Number: (770) 777-3600  
Fax: (770) 777-0414  
Website <http://www.fmglobal.com>

- H. **American Society of Heating, Refrigerating and Air-Conditioning Engineers**  
(ASHRAE 90.1)  
36588 Treasure Center  
Chicago, IL 60694-6500  
Phone Number: (800) 527-4723  
Website <http://www.ashrae.org/resources--publications/>

- I. **Single Ply Roofing Institute** (SPRI)  
465 Waverly Oaks Road, Suite 421  
Waltham, MA 04252  
Phone Number: (781) 647-7026  
Fax: (781) 647-7222  
Website <http://www.spri.org>

- J. **Roof Consultants Institute** (RCI)  
1500 Sunday Drive, Suite 204,  
Raleigh, NC. 27607  
Phone Number: (800) 828-1903  
Fax: (919) 859-0742  
Website <http://www.rci-online.org>

- K. **NSF International**  
P.O. Box 130140  
789 N. Dixboro Road  
Ann Arbor, MI. 48105  
<http://www.nsf.org/>



## CHAPTER 2

### GENERAL DESIGN

#### 1. Purpose

The purpose of this manual is to establish a minimum design standard for facilities owned by the State of North Carolina. This document is not intended to be a State roofing specification or a summary of the North Carolina State Building Code or the authority on low slope membrane roofing. Designer is solely responsible for ensuring compliance with all applicable codes and standards.

#### 2. Designer Responsibility

- A. State projects involving roofing shall use and follow the Department of Administration document “Roofing Design Guidelines and Policies” only for the purpose of preparing the designer’s plans and specifications for their specific project. This document is not written in contractual language for bidding purposes and/or contractual enforcement and is NOT to be inserted into the specification.
- B. It is the Designer’s responsibility to be well versed with all relevant criteria in the State Construction Office “Roofing Design Guidelines and Policies.” This and other guidelines are available on the State Construction Office website.
- C. If the roofing project is a ‘stand-alone’ project, review the State Construction Office Manual for documentation and bidding requirements.
- D. Modified version of the Building Code Summary, Appendix B, For All Commercial Roof Projects – this document is intended to summarize the minimum requirement by State Construction Office for roofing projects on State Owned facilities. It does not modify the requirements of the Building Code. The designer of record is responsible to ensure all roofing projects conform to the minimum requirement of the Code.
- E. Design Calculations – The Designer is record is responsible for performing all necessary design calculations to ensure compliance with the Code. Calculations should be sealed by a licensed Engineer in the State of North Carolina and maintain in the Designer’s project files. Design calculations should include:
  - a. Dead Load
  - b. Wind Uplift Pressures
  - c. Primary Drainage
  - d. Secondary (Emergency Overflow) Drainage
  - e. R-value
  - f. Dew Point Analysis

### 3. Protection and Safety

- A. The majority of roofing projects occur on occupied existing building, the Designer shall explore components and systems not only from a performance standpoint but also for life safety.
- B. Consideration should be given to the inventory of the building, and incorporate components and system as necessary to protect those contents. This is especially true with laboratories, storage/warehouse etc.

### 4. System Selection

roofing system should be selected based on the intended use of the facility. Designers should consult with State building Owner/Users to determine the specifics of the facility that affect roof system selection (anticipated future use, service, life rooftop equipment, etc.)

### 5. Energy

- A. The minimum roof insulation shall meet the requirements of the North Carolina State Energy Conservation Code (*NCECC*) or the mandatory provisions of *ASHRAE 90.1-2010* or GS143-138 for existing building.
  - 1. New buildings and major additions – Roof insulation shall meet the requirements of the current NC Energy Conservation Code.
  - 2. Existing Building – SL 2014-90 9GS 143-138) allows the application of the 2009 North Carolina Energy Conservation Code to existing buildings that were construction prior to January 1, 2012 and subsequent additions of up to 50% of the original floor area, instead of the 2012 North Carolina Energy Conservation Code. The 2009 North Carolina Energy Conservation Code has significantly lower insulation requirements than the 2012 code.
  - 3. North Carolina Existing Buildings Code, Section 908 – alterations to existing buildings are permitted without requiring the entire building to comply with the energy requirements of the North Carolina Energy Conservation Code. The alterations shall conform to the energy requirements.
- B. The minimum thermal resistance of the insulating material installed either between the roof framing or continuously on the roof assembly shall be as in the *Code*.
- C. Insulation installed on a suspended ceiling with removable ceiling tiles shall NOT be considered part of the minimum thermal resistance of the roof insulation according to *NCECC*.

## CHAPTER 3

### BASIC CRITERIA

#### 1. Purpose and Use

- A. Any roofing system that is properly selected based on intended use of the facility, properly designed, properly installed and properly maintain should function for a long time.
- B. Low slope roof systems for state owned facilities should be designed for life expectancies of 20 years or more unless other criteria have been established for a specific facility.
- C. Pedestrian plazas and vegetative roof gardens are uncommon on State owned facilities. When such system is justified and approved by the owner they shall be designed by professionals specifically experienced in such systems. The system shall be designed to comply with all other roof system requirements in this criteria. Designer should give consideration for additional cost, difficulty associated with replacement of such systems in the future and a system that has a life expectancies of 30 years or more.
- D. Gravel ballasted roof assemblies are discouraged unless the ballast are concrete pavers.
- E. Annual maintenance costs should be taken into account for selection and design of all roof systems. Access drains, flashings, equipment and other items requiring routine inspection and maintenance should be assured in all design.

#### 2. System Selection

Roofing shall be selected based on the intended use of the facility. Consult with the building Owner/Occupants to determine the specifics of the facility that affect roofing selection such as use for today, anticipated future use, service life, sustainability, and rooftop equipment.

#### 3. Slope

- A. A minimum requirement of  $\frac{1}{4}$  inch per foot slope is required by *NCSBC*. There should be no ponding on the roof. Any water that does not drain must evaporate within 48 hours.
- B. Reroofing is not required to meet the minimum design slope requirement of one-quarter unit vertical in 12 unit horizontal (2-percent slope) in the *Code* for roofs that provide positive roof drainage. However, it is encourage to maintain a

minimum of ¼” per foot slope.

- C. Positive drainage should be designed in all valleys with crickets. Valleys shall have the same minimum slope as the adjacent roofing.



Picture 1 – Standing water must evaporate within 48 hours

- D. Roof garden, plaza and pedestrian walks are NOT exempt from the roof slope requirement. The code does not have an exception in permitting the use of a dead flat roof. This type of use, plaza/garden/pedestrian walk/water feature, is over an occupiable space and is the roof for that space below.



Picture 2 – Garden, plaza, walkway, water feature etc. are roofs of the building

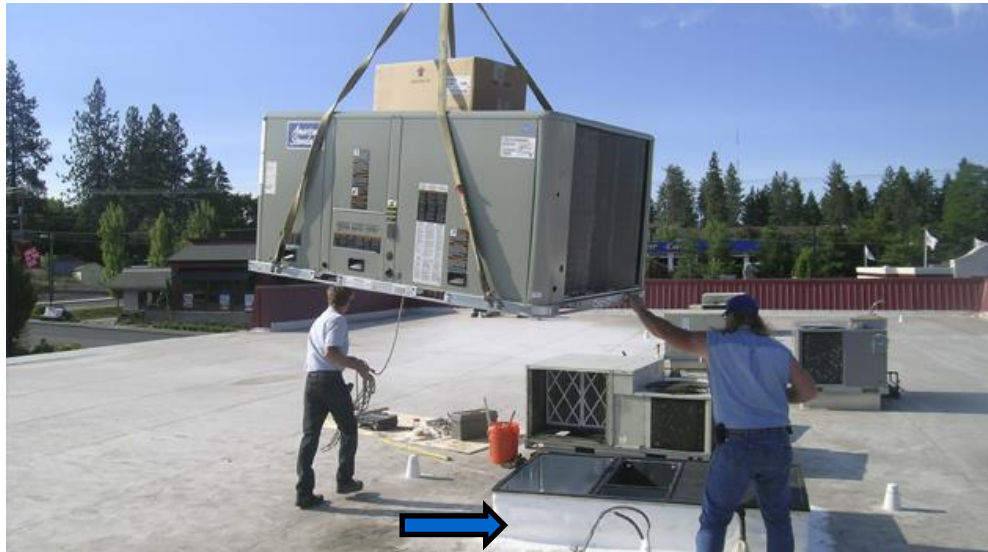
- E. Roof framing should be sloped to achieve the desired slope per *Code*. This creates a uniform thickness of roof insulation and reduce the amount required to built-up the slope.



Picture 3 – Low slope roof with built-in or framed-in slope

#### 4. Roof Mounted Equipment

- A. Avoid roof mounted equipment whenever possible or utilize the roof penthouse or design the top floor as a mechanical floor. If that is not economical the following minimum requirement shall be met.
1. Equipment shall be supported on a properly constructed curb or an elevated metal frame.



Picture 4 – Rooftop equipment curb

2. Curbs shall extend a minimum 8 inches on the high side above the finish roof surface.
3. Curbs shall be properly flashed with a two (2) piece type flashing that will facilitate re-roofing in the future or the equipment to be set atop it includes a cover with turn down edge forming a flashing.
4. Metal frames or platform should be used to support large or heavy equipment on the roof surface. Steel columns shall be connected directly to the building super structure. Steel penetrations shall be flashed. The flashing system may be pre-manufactured “boots” or draw bands with sealant on top or welded metal bonnet.



Picture 5 – Mechanical platform or frame

5. Metal steps that are part of the frame platform should be suspended from the platform and not set on the roof surface. This reduces the number of roof penetrations.
6. Where metal frames are utilized to elevate equipment above the roof surface, frames shall be constructed with sufficient clearance to allow roofing installation to occur beneath the frames in a safe and efficient manner.
7. Walk-pads shall be included leading from the roof access to platform steps, equipment requiring service and inspection.



Picture 6 – Rooftop walk-pads and at equipment service panel.

## 5. Access

- A. Access to a roof is required by *Code* for life safety and insurance reasons but is also necessary for routine rooftop mounted equipment inspection, service and maintenance. A multi-level roof shall have ladders mounted on wall between levels or roof access doors that are available on each floor adjacent to the roof.



Picture 7 – Roof ladder. Not anchored to the roof.

- B. Permanent fixed ladders shall be utilized. The use of portable ladders on roof is discouraged since ladders have sharp edges that will damage the roofing membrane and deform the roof edge or parapet flashing. It can become a flying object in strong gust or hurricane.
- C. Roof access doors/hatches shall have locks with key operations. A warning sign measuring 14”x18” shall be mounted adjacent to the roof access in Red letters and White background to read “NO ACCESS – Authorized Personnel Only.”
- D. If access is required by *Code*, such as the extension of the stairway to the roof in buildings four or more stories, then the lockset must be connected to the fire alarm system for un-latching.
- E. Fall protection at open Roof Access Hatch is not required by *Code* but is required by OSHA. It is strongly advised that fall protection system be specified in your specifications and detailed in the drawing set to avoid potential change order.



Picture 8 – Roof hatch. Note the fall protection system required by OSHA around the hatch opening with a self-closing gate frame

- F. Provide guardrails where Roof Access Hatch opening located within 10 feet of a roof edge in accordance with NC Building Code.



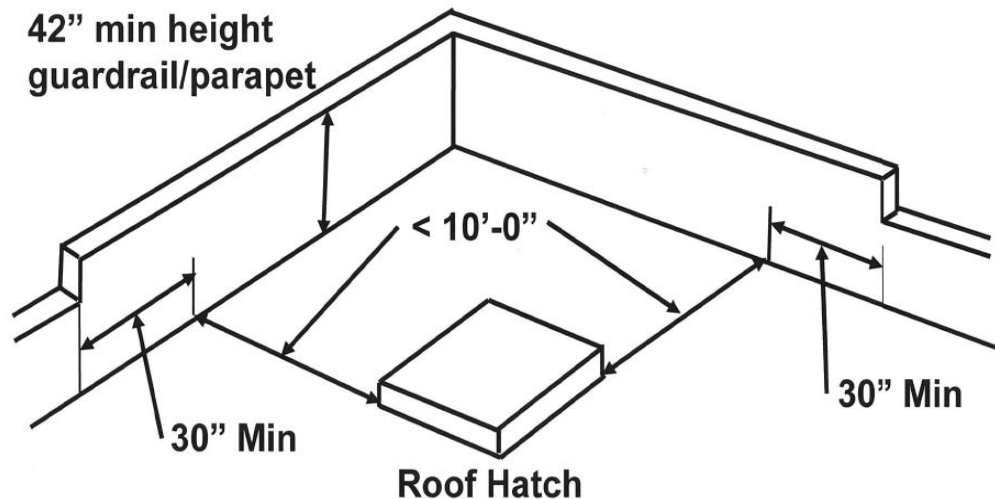


Figure 1 – Guardrail required where roof hatch opening is less than 10 feet from roof edge

## 6. Vapor Retarders

The NRCA and major roofing material manufacturers recommend serious consideration of vapor retarder on any roof where the outside average January temperature is 40 degrees F or less and the interior relative humidity will be 45% or greater. The responsibility lies with the Designer to determine if the conditions will apply to his project. Built-up roofs are sensitive to trapped moisture, and the contact adhesives used in numerous single-ply membrane are sensitive to moisture. Many State facilities can meet the 45% limit on humidity and the western half of the state can reach the low temperatures. Examples of facilities with high humidity would be laundries, cafeteria/kitchens, natatoriums, athletic facilities, “process” plants, dormitories etc.

- A. Unusually high interior humidity (examples; kitchen, laundries, natatoriums, etcetera), combined with exterior low winter temperatures can result in strong vapor drive towards the exterior resulting in condensation and dripping. The condition can be reverse where the interior needs to be kept at extremely low temperatures (example; built-in cold storage room), the roof membrane itself must function as a vapor retarder since it is now on the warm humid side of the roofing system
- B. In order to be effective, vapor retarder must be warmer than the dew point temperature. It is installed on the insulation warm side to minimize vapor migration into the roof system.
- C. Care should be taken to ensure all gaps or openings are sealed during installation of the vapor retarder to ensure no moisture migrate through those small gaps/openings.

- D. Designer shall analyze and rationalized the inclusion or exclusion of the vapor retarder carefully prior to making a roof selection and design. Presently there are various design aids available for Designer's use from proprietary software to manufacturer programs.
- E. If vapor retarder is needed on State facility with a metal deck, the deck must be covered with a mechanically fastened layer of minimum 5/8" fire-rated water-resistant gypsum board to provide a smooth attachment surface for the vapor retarder.
- F. If vapor retarder is used the vapor retarder must be compatible with the roofing system selected.
- G. Detail information on this subject is available in the NRCA Roofing Manual.

#### **7. Wood Blocking and Nailer:**

- A. Wood blocking, nailer and non-structural wood materials used in roofing shall be preservative-treated with water-borne preservatives in accordance with AWWA U1 and M4 for the species, product, preservative and end use.
- B. Wood for blocking or nailer shall be kiln dry after treatment to a moisture content of 19% or less.
- C. The treated wood shall bear the quality mark of an inspection agency.
- D. Details to minimize the thickness and number of layers of treated wood blocking.
  - 1. Premanufactured curbs are suggested over stacked wood blocking for rooftop units.
  - 2. For excessive edge construction heights, consider a knee wall in place of stacked wood blocking.

#### **8. Expansion Joint**

- A. The inclusion of membrane expansion joint in the roofing system is to reduce stress and accommodate the movement of the building components to limit the effect of possible tear and buckling of the roofing membrane. Each building component has its own coefficient of expansion and contraction subject to varying temperature changes resulting in thermal movement. It is the Designer's responsibility in their design to take into consideration the following:
  - 1. Building's thermal movement characteristics.
  - 2. Structural support and roof deck.
  - 3. Roof system selected or in place.

4. Climatic conditions.
5. Rooftop units.
6. Roof drainage.



Picture 9 – This roof expansion joint will not function as intended

- B. The membrane expansion joint in the roofing shall occur at the same location as the building expansion joint. The building expansion joint through the building must be filled with fire safing material in fire rated construction to comply with the *Code* and substantiate by selected test standard.
- C. Expansion joint shall be designed to accommodate expansion and contraction. The joint shall be detailed with wood blocking to a height of 8 inches above the finish roof surface. Ensure the “built-up joint” does not impede roof drainage.
- D. Low profile expansion joint designed to be installed in the plane of the roofing membrane is not recommended due to its exposure to foot traffic during and after construction.

## 9. Area Divider

Area dividers perform important functions as parts of the roof system. For example, in regions where there are periods of freeze-thaw cycles, area dividers may be used to relieve thermal stresses on the roof systems where expansion joints are not required. Also, when roofing is done in sections or stages, area dividers can be used to separate roof system sections that differ in age or type. It can also isolate specific area on the roof such as ripped roofing around penetrations.

Area divider is very similar to Expansion Joint. Care must be exercised in locating

primary and secondary roof drainage systems for each of those areas.

## 10. Building Code

The NC Department of Insurance is the insurer of State owned buildings. The *NCSBC* is the minimum requirement that satisfy 2 parameters, internal and exterior fire exposures. NC Department of Insurance may require or request a higher standard. The roof surfaces on State owned building shall be Class A or Class I.

### A. External Fire Resistance

Roof assembly is susceptible to ignition due to exposure to heat or flying burning brands from adjacent fire. The roof membrane provides the protection from external fire and therefore must be investigated and evaluated. The burning characteristics of roof surface, UL Class A, B or C and FM Class I. Roof surfaces on State Buildings need to be Class A or Class I.

Class A, B or C with UL label are tested with ANSI/UL 790 while FM Class I is tested with ASTM E108. Single ply membrane has difficulty passing these tests without either external protection such as ballast, pavers, coating, or overboard. The following link provides additional information of the tests and “Conclusions and Recommendations.”

[http://staticcontent.nrca.net/masterpages/technical/techbull/0106\\_firetesting.pdf](http://staticcontent.nrca.net/masterpages/technical/techbull/0106_firetesting.pdf)

### B. Internal Fire Resistance

1. A roof assembly is susceptible to propagating an internal fire by contributing fuel through liquids or gases. For roof assemblies, the ceiling assembly and the structural deck provide the protection from an internal fire.
2. Designer shall determine the level of fire protection require for various construction types by using “Fire Resistance Rating Requirements for Building Elements” Table in *Chapter 6 NCSBC*.
3. Hourly rating requirements for specific building elements in new construction are satisfied by selecting tested assemblies that provide the minimum protection as determine by approved testing agencies.
4. Tested fire rated assemblies are available for downloading from internet website such as UL Underwriters Laboratory. Other testing agencies website are also available. The UL website has some requirements that must be followed if the designer elects to download the test report. UL permits the reprinting of their report provided a statement is added to the reproduction. Note: The only way that UL Details can be accurately presented in the drawings as tested is to reprint the information from the UL Fire Resistance Directory. The details must not be manipulated in any way or form. The

reprint of their Designs and Details on drawings are subject to their requirements including the following conditions to protect their copyright: 1) The System/Design must be presented in entirety and in a non-misleading manner, without any manipulation of the data, 2) a statement must appear adjacent to the extracted material indicating that it is “Reprinted from 20XX Fire Resistance Directory (or whichever title is applicable) with permission from Underwriters Laboratories, Inc.” and 3) the reprinted material must include a copyright notice stating “Copyright 20XX Underwriters Laboratories, Inc.”

5. A layer (thermal barrier) of exterior Type “X” gypsum board is required on metal decks under 1½” thick foam plastic insulation or the foam plastic insulation is part of Class A, B or C roofing cover with the foam plastic insulation satisfactorily passes FM4450 or UL1256 tests.
6. Stand alone roof replacement project shall include a modified Building Code Summary for Roofing Projects available on the State Construction Office website.

### C. Wind Uplift Resistance

1. The tests and ratings for roof have been around a long time and are commonly misunderstood by designers and contractors alike. The two tests are FM Standard 4470 and UL580. Neither of these tests correlated with wind speed as thought to be.
2. FM4470: In this test, the specimen is attached to the test apparatus according to the manufacturer’s particular attachment specification. Positive air pressure is exerted on the sample from the underside of the apparatus (to simulate uplift).  
The test pressure starts at 30 psf and maintained for one minute. If the sample can withstand the full minute, the pressure is increased by 15 psf. The test continues with increase of pressure by 15 psf for each additional minute until the membrane split or snap.  
If the membrane can withstand a 60 psf load/pressure for 1 minute, the system will receive a rating of FM-60. Thus FM-90 means the membrane can withstand a 90 psf load/pressure for 1 minute.  
However, FM throws in a safety factor of 2. That means FM-60 is approved for use in uplift design of up to 30 psf. Likewise, FM-90 is approved for use in uplift design of up to 45 psf.  
The “I” in FM I-60 is not an “I” but a Roman Numeral “1.” This “1” or “I” means the membrane also passed other tests including fire resistance.
3. UL 580: The test by UL is for wind resistance only and issues ratings as Class 30, 60 and 90.  
To receive a Class 30 rating, the membrane must remain intact for 80 minutes period at specific positive, negative and oscillating pressures.

For Class 60 rating, an additional 80 minutes (total 160 minutes) of test as in Class 30 is carried out.

For Class 90 rating, an additional 80 minutes (total 240 minutes) of test as in Class 60 is carried out.

4. Ballasted type roofing is not encouraged due to the fact that loose laid ballast becomes missiles in high wind condition which translate to more liability for the State. It is also difficult to inspect and maintain and may be costly to repair. Displaced ballast may not be evenly distributed after repair thus exposing sections of the roofing membrane to UV light. Should the owner have a strong desire to utilize this system, a concrete paver system is preferred.



Picture 10 – Ballasted roof with washed or blown ballast exposing roofing membrane

#### D. Design Loads

1. Wind Loads for structural design are in *Chapter 16 NCSBC*.  
Note: Add 10 mph to the appropriate velocity for State facilities. The State Building Code is based on a 50 year occurrence and the State underwriters prefer a 100 year occurrence.
2. Live Loads for structural design are in in *Chapter 16 NCSBC*.
3. Dead Loads for structural design shall be increased by 10 psf to cover future increases in actual dead loads. See “Roof Add-On” items below.

### 11. Lightning Protection

- A. Lightning protection systems are not required by the Building Code.

- B. The installation of lightning protection system is an Owner's option that is worth consideration. New system shall comply with the NEC and NFPA. Existing lightning system should be replaced and/or upgraded in conjunction with roof replacement. Installation of components require the supervision of a qualified lightning protection contractor. Components that penetrate any portion of the roof structure should be adequately flashed. Recertification programs are available from Underwriters Laboratories (UL) and Lightning Protection Institute (LPI).

## 12. Construction Details

There are numerous typical conditions on a roof and numerous conditions unique to the roof. It is not the intent of these criteria to cover all conditions but to point out some of the common errors that are repeated on State roofing projects.

Designer should be aware, reproducing details from standards and manufacturers standards or referencing all details to standards are not acceptable. It may be in violation of "GS.133-2 Drawings of Plans by Material Furnisher Prohibited". Roofing details must be drawn to scale and be project specific.

### A. Metal Coping

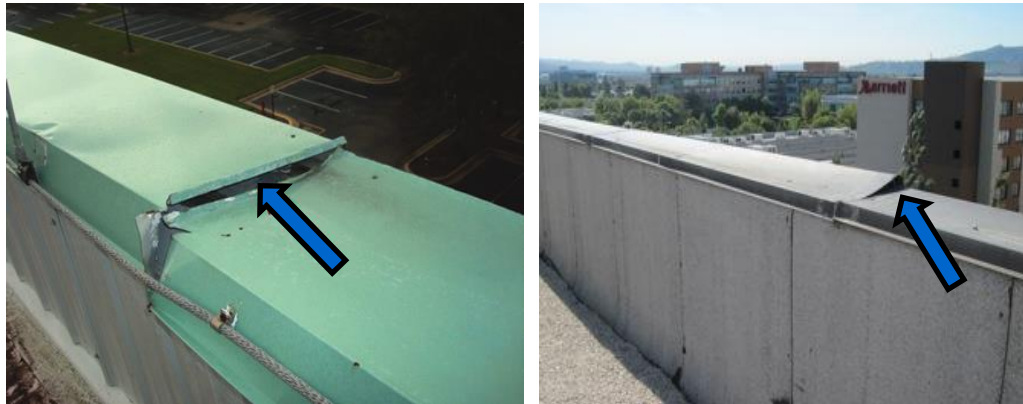
1. The horizontal top surface of the roof parapet is vulnerable to water penetration if not properly built. A piece of roofing underlayment or roofing membrane shall be placed on top of the wood block prior to installing the metal coping.

The addition of this piece of underlayment or roofing membrane is vital in preventing water intrusion into the cavity of the cavity wall.



Picture 11 – The wall cavity must be protected from water intrusion.

2. The top of the metal coping shall slope  $\frac{1}{4}$ " per foot to the roof side.
3. Lapped seams or butt joints of metal copings should not be used.
4. Parapet flashing (coping) failure is due to its weakness in resisting the outward and upward pressures of the wind. The cleat or hook at the detail is attached too far up the wood nailer thus providing good leverage for the wind to apply outward and upward pressures at the lower edge. If the cleat/hook and metal edge is of insufficient gage, the coping will be ripped open exposing the top of parapet. Securing the lower portion of the cleat/hook closer to the lower edge of the flashing and increasing the metal gage may prevent this from happening.
5. The metal coping shall be secured on both sides of the parapet by continuous cleats on the outside and other attachments on the roof side. The lower edge of the coping on both exterior and interior side shall extend a minimum 1 inch below the parapet wood blocking.



Pictures 12 and 13 - Wind damaged metal coping at lapped joint.

### B. Roof Edge Flashing

Metal edge flashing failure is due to its weakness in resisting the outward and upward pressures of the wind. The cleat or hook secured at the fascia is attached too far up from the bottom of the vertical portion of the flashing thus providing good leverage for the wind to apply outward and upward pressures at the bottom edge. If the cleat/hook and metal edge is of insufficient gage, the flashing will be ripped open exposing the edge of the roofing system. Care shall be exercised in locating the continuous cleat and the appropriate metal gage specified. *NCSBC* requires the edge securement for low-slope roofs to be tested in accordance with *ANSI/SPRI ES-1*.

### C. Wall/Roof Flashing

Roofing shall terminate under a two piece type wall flashing and counter flashing. This is to facilitate re-roofing in the future without having to tear out the whole flashing system.



A bath tub does not leak unless the drain is not properly installed. The roof shall be designed as if designing a “bath tub.” This minimizes the number of “roof penetrations” hence eliminating potential leakage.

1. There is a current trend to use roofing membrane as exterior wall finish. Roof membrane is manufactured for “horizontal” application and is also tested horizontally. It is NOT an exterior “wall” finish material and is NOT an industry standard. Re-roofing will require the vertical portion of the roofing be replaced at the same time due to exposure to UV light as well as other air borne contaminants. If the intent is to reduce construction cost, the replacement cost will eventually cost more than a finish wall material. That being the case, any wall two (2) feet above the roof shall be built as a wall with exterior wall finish.



Picture 14 – Roof membrane used as wall finish is not acceptable by this guideline.

2. NRCA details require that a two piece type wall flashing and counter flashing shall be set not less than 8 inches above the finish roof surface nor more than 24 inches maximum above the finish roof surface. Where wall conditions require additional protection, metal panels or other cladding shall be utilized.
3. The portion of the through wall flashing within the wall cavity shall be lapped by the vapor/air barrier to ensure no water is directed behind the metal flashing.
4. Exposed Termination Bar must not be used to terminate roofing membrane onto a brick masonry or CMU wall. They are usually used on smooth watertight surfaces. Sealant is your only protection and it does not adhere well to masonry, CMU and mortar joints. Installation is usually poorly done.

NRCA, SMACNA and BIA recommend cutting a raggle 1-1/2 inch deep in (existing condition) masonry joint and inserting flashing with wedges and sealant fill. [The depth of the raggle is dependent upon the thickness of the masonry/cmu wall]

There are two conditions when Termination Bar can be used. When it is protected from the weather and where Termination Bar is used to terminate the roofing membrane on a smooth concrete wall with appropriate sealant on top.

#### D. Roof Penetrations

NRCA recommends a minimum of 12 inches of clearance between pipes; a minimum of 12 inches clearance between pipe and curb or wall; and a minimum 24 inches between curb and wall to facilitate proper installation of the roof and flashing. Multiple pipe penetrations should be ganged through a penetration pocket. See NRCA recommendation.

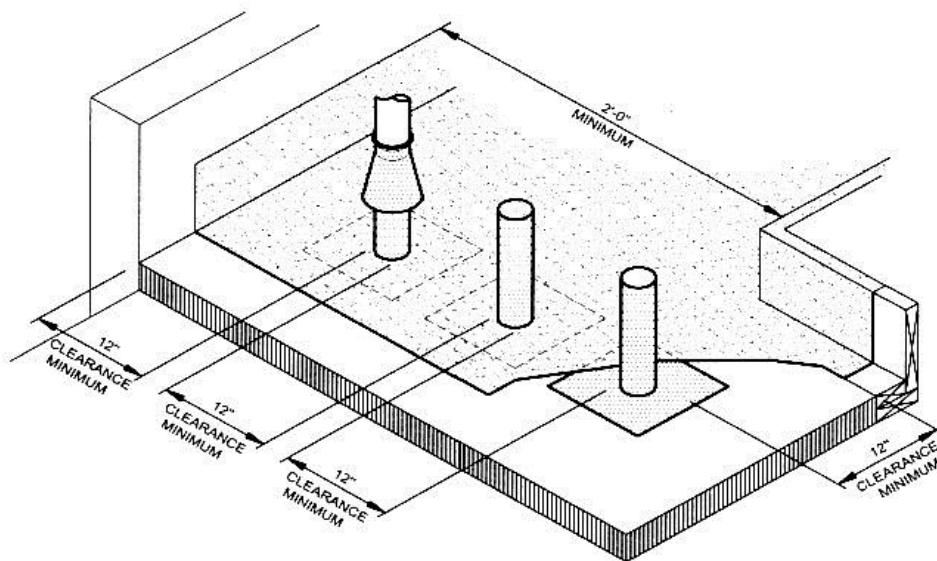


Figure 2 – NRCS recommend the clearances for pipe/wall parapet/curb

1. Penetration flashings should include prefabricated boots or sheet metal flashing systems to conform to the profile of the penetrations.
2. Pitch pockets are discourage, however, when necessary due to conditions, sheet metal hoods should be fabricated to fully cover the base.
3. Multiple pipe penetrations should be ganged through a fabricated metal box with penetrations entering the box on the vertical sides.

### 13. Drainage System

#### A. General

1. Roof drainage is accomplished through the use of primary roof drains, gutters and secondary drainage system in the event the primary systems becomes blocked. The size and roof area requirement for both internal and external drainage of building roof is covered in the North Carolina Plumbing Code (*NCPC-Chapter 11*).
2. Roof drainage should be carefully designed whether the proposed roof system is in conjunction with retrofit applications or new construction. Where existing tapered roof slopes are revised, drainage capacities should be verified to ensure existing pipe systems can adequately carry required discharge. Water that is not efficiently removed from the roof is more likely to find its way through membrane defect such as open base flashing lap, etc. should any exist. Moisture that enter the roof assembly can lead to reduced insulation thermal properties, damaged and deteriorated substrate components, and potential indoor air quality concern.



Picture 15 – Main roof drain and overflow drain combination.

3. Building owners should be contacted regarding their specific preferences as to type of drainage system to be installed on their structure.
4. Drainage onto sidewalks or pedestrian paths should be controlled or eliminated, particularly in locations where frozen precipitation is anticipated.
5. Internal drainage systems with PVC leaders are not permitted in fire rated construction, non-combustible buildings or ceiling spaces used for return air HVAC. Designer shall review the *NCPC* and *NCMC*.

6. Combination type primary/secondary drains that share a common strainer are not acceptable on State roof. If the roof strainer gets clogged, both primary and secondary drainage will be out of commission.

## B. Primary Roof Drainage

### 1. Low Slope Roof Drain

- a. Roof drains shall conform to ASME A112.21.2M or ASME A112.3.1. Roof drains are required to have strainers extending no less than 3" above adjacent roofing. Metal strainers should be considered for longevity. Drain inlet area is to be no less than 1½ times the area of vertical leader to which the drain is attached per *NCPC*.
- b. Vertical drain leaders for primary drains shall be sized based on 100-year hourly rainfall rates map or other local weather data. Size drains for maximum projected roof area in accordance with drain leader size tables in *Chapter 11 NCPC*. Where vertical walls divert rain water on the roof, ½ of the vertical wall area shall be added to the projected roof area.
- c. Horizontal drain leaders (based on pipe slope) using drains and leader sizing see table in *Chapter 11 NCPC*. Most roof drainage systems are limited by the capacity of the horizontal conductors. For re-roofing projects, designer should exercise reasonable care in an attempt to determine the adequacy of existing horizontal leaders or other drainage system components to remain.
- d. Roof drain capacities should be verified for both new construction and roof replacement.
- e. Roof structure shall be designed to support the load of rainwater accumulated to the elevation of the secondary drainage system plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow determined by the *Code*. The roof shall also be checked for ponding instability in accordance with the *Code*.
- f. Retrofit roof drains are allowed when necessary due to existing conditions.
- g. Drainage calculations should be included on the drawing for both new construction and for re-roofing.

### 2. Gutters

- a. Rectangular (hanging) gutters and downspouts are generally sized using Chapter 1 of SMACNA. Gutters should be formed of corrosion resistant materials of adequate gauge based on total girth.

- b. Hanging gutters are “hung” or installed along the roof edge are visible. Support hangers are installed under the gutter and against the wall with spacers.
- c. Gutter lengths are generally limited to 50 feet with a minimum of one downspout per gutter section. Expansion joints are centered between downspouts.
- d. Based on the size of the roof area to be drained and the rainfall intensity for location, the size of gutters and downspouts should be calculated as required by *Code*.
- e. Gutters with semicircular cross section should be avoided unless to match existing conditions can be sized per *Chapter 11 NCPC*.
- f. The front edge of hanging gutter should be at least 1” lower than the back edge. This is recommended so that water will flow over the front edge in the event of the gutter becomes clogged.
- g. Concealed gutters are not visible and are designed to be embedded into the roof structure. This type of gutters is difficult to build, maintain and repair. More often than not, damage due to leaks is not apparent until severe damage has occurred and is costly to repair. The use of, in new structure, concealed gutters is NOT encouraged. However, project specifics may dictate this use. Special care must be exercised while designing and constructing concealed gutters because unlike hanging gutters, any leaks that occur will likely enter the structure and damage substrate components. Mockups shall be built. Completed construction shall be flood tested for a minimum of 24 hours.

### 3. **Eaves/Roof Edge**

Roof drainage is allowed over roof eaves where the roof area is small such as canopies etc. Allowing water to drain over eaves can cause roof water to cascade down the exterior walls which can lead to staining and/or deterioration. The resulting “splash” at grade can negatively (erosion) affect soil/turf adjacent to the structure. It is preferable to use water management systems unless specific site conditions restrict the use of such components. Gutters or drains help to divert water to predetermined locations. Additionally, allowing water to flow over eaves also creates the potential for excess water to create icy conditions that could be hazardous to pedestrians.

### 4. **Scuppers**

- a. Scuppers are acceptable for use as primary drainage system but shall include conductor heads and downspouts to control and direct water off

the roof. Conductor head shall be installed with the head at a minimum 1 inch below the scupper outlet. If the installed higher than the scupper opening shall include an opening at the face of the conductor head to act as an emergency outlet as recommended by SMANCA.

- b. Scupper shall be sized according to *NCPC*. The minimum horizontal opening dimension shall be 4 inches but 6 inches is preferred for ease of construction.

### C. Secondary Roof Drainage

- a. Secondary drainage is required when roof edge construction will not allow water on the roof to exit the roof if the primary drainage is blocked or is otherwise disabled. Overflow drains or scuppers shall be sized to prevent ponding water from exceeding that for which the roof was designed.
- b. The overflow drainage system is required by *Code* to be totally separate system from primary systems so that they can remain functional should the primary drainage become obstructed. Discharge of secondary drainage shall be located where easily observed by the maintenance crews or occupants. *Chapter 11 NCPC*. However, do not locate overflow discharge above exit doorways or at pedestrian walkway where freezing/icing condition can occur.



Picture 16 – Main roof drain and overflow drain have independent drainage system and discharge below roof

- c. The drainage system shall be designed in accordance with rainfall rates in *Chapter 11 NCPC* for 100 years 15 minutes rainfall duration.
- d. Scuppers shall be set 2 inches above the primary drain intake with a minimum horizontal opening dimension of 4 inches (6 inches is preferred). The use of round scupper opening shall be limited to historical or existing structures

where matching is important.

- e. The overflow drain shall be set 2 inches above the primary drain intake. If the roof slope is at  $\frac{1}{4}$ " per foot, this will produce an area of ponding at 8 feet radius around the drain.
- f. Do not sump insulation around overflow drains/scuppers.
- g. Overflow shall discharge in a conspicuous location so as to alert building occupants of a potential primary drainage problem.
- h. Existing facility with no existing overflow (secondary) drainage provisions, the designer is responsible for designing the necessary overflow system to form to the code.

#### 14. Insulation

- A. The minimum roof insulation shall comply with the requirement of *NCECC* or *ASHRAE 90.1 2007*. GS 143-138 allows use of the 2009 *NCECC* to existing buildings constructed prior to January 1, 2012.
- B. Layered insulation shall be installed with staggered joints and taped at each layer to prevent heat loss.
- C. Tapered insulation shall slope minimum  $\frac{1}{4}$ " per foot. Insulation at the drain sump may be 2" thick due to the need to clamp the roof drain.
- D. Ballasted roof shall be spot adhered between the top layer and bottom layer to prevent movement and warpage during and after membrane application.

#### 15. Customized Systems

Equipment support flashing should be made from materials that are durable and able to weather the elements. Base flashings are used to transition roof membranes up vertical surfaces at curbs and walls and are generally made from materials similar to the membrane being used, i.e. modified bitumen base flashings and modified bitumen roofing. Counter-flashings are generally fabricated from corrosion resistant materials and protect the top edge of the base flashing.

Industry standards require base flashings terminate a minimum 8 inches (12 preferred) above roof membranes. Curbed penetrations should be installed to accommodate this base flashing height. During roof replacement projects, curb heights should be modified to obtained a minimum 8 inches (12 preferred) base flashing height.

## 16. Customized Systems

Roofing components are no longer simple generic products that can be mixed and matched at will by the designer or contractor. Most roofing products in use today are man-made synthetics using glass, plastics and rubber as well as bitumen and petroleum products. These materials, their solvents and adhesives are more often than not, incompatible and even destructive to each other.

Roofing manufacturers have created specific systems and warranties based on these characteristics and their own products such that, changing components without the manufacturers written approval may void their warranty.

UL and FM testing is based on specific products and assemblies and changing components could easily alter or void their approval or rating for fire, wind uplift and wind resistance.

Consider requiring manufacturers provide letters that their materials are suitable and appropriate for application and design proposed, preferably when preparing specifications. Advertisements and brochures are not always a good source for design and specification.

## 17. Roof Add-On Items After Acceptance

There are roof top items that have a tendency to “pop-up” after the contract is complete. The following list is by no means a complete one.

- Television and Dish Antenna.
- Solar Collectors
- Photovoltaic Panels
- Weather Stations
- Security Cameras
- Lightning Protection System
- Flagpoles
- Siren warning Systems
- Wind turbine
- Cell phone tower

Designer must ask the Owner/User of the facility if there is any intent after construction or later to add any “equipment” to the roof of the building. Support frames and posts with weatherheads for wiring can be properly designed and included for installation by the roof contractor.

All support, penetrations and securement shall comply with Code, recommendations in NRCA and SMACNA. **DO NOT USE PITCH POCKETS** unless it is absolutely necessary and if used must include a sheet metal bonnet/umbrella. Also do not



attached any support that penetrates the top of parapet wall and metal coping.

## **18. Sustainability**

### **A. General**

- a. The Stat of North Carolina supports sustainability efforts in proper design, installation and maintenance of roof systems. Much of the sustainability effort with regard to roofing systems can be capitalized on in designing and installing new and replacement roof systems and maintaining existing roof system to realize the maximum life potential, thereby reducing the impact and demands on natural resources, the production of those resources into required materials, the transportation of those materials from production plants to project sites and associated energy costs.
- b. The Stat of North Carolina encourages designers to consider sustainability with regard to roof system design. Designers should consider the possibilities of system selection, material selection, recycling and maintenance.

### **B. System Selection**

- a. Designs should consider the highest quality roof system that the budget

## **19. Sequence of Construction**

The timing, methods and sequence of construction are consider to be within the Contractor's domain in the majority of construction contracts. The Designer should require an inspection of the roof deck (new or existing) prior to application of the roofing system. If all penetrations, curbs, parapets and major mechanical equipment are not installed and ready for roofing operations, the Designer should notify the Contractor that all roof work should be complete prior to application of the roofing system. If the Contractor proceeds with the roof operations prior to acceptance by the Designer, the Designer shall notify him there may be cause for rejection of the work if the Designer feels the roof system has been damaged or compromised by subsequent operations on the roof.

The State or Owner may not accept roofing systems that have been damaged due to "premature installation" and extensively "patched" or "gobbed" with sealants.

## CHAPTER 4

### ROOFING SELECTIONS

#### 1. General

Low slope roof typically occurs on large buildings where the use of a sloped roof is not practical. This type of roof is composed of three components, the roof deck, roof insulation and a waterproof or roof membrane.

There are numerous types of roofing membrane available on the market. The most popular ones are Built-Up-Roof, Modified Bitumen, and Single Ply. The finished surface of these roofs can be a cap sheet, gravel, ballasted or simply untreated as the material is formulated to withstand the onslaught of UV light. Additional information is available in numerous publications such as NRCA and online.

There is a belief by agencies, building owners, designer and contractors there is a roofing type preferred by State Construction Office. This is not true. State Construction Office does not have a preferred roofing type, only ones that perform according to the specification.

When selecting a roofing type and insulation board, Designer shall thoroughly review this guideline, NRCA suggestions and discuss the appropriateness and selection with roofing manufacturer to resolve all potential issues.

#### 2. Built-Up-Roof

This Built-Up-Roof (BUR) system has been the traditional roofing system for flat roofs in the United States for about 100 years. It comprises multiple felt layers, 2 to 5 plies, with bitumen between layers, hence the term Built-Up Roof. Bitumen is heated to a high temperature and mopped onto the roof or ply in ‘shingle style’. This continues until the desired number of plies is reached. The last ply is hot mopped and gravel or a cap sheet applied. This top coat or cap sheet serves as a reflective coating to reduce the temperature on the surface and protect it from UV light.

In the mid-20<sup>th</sup> century, fiber glass felts were introduced and in the 1970’s modified asphalt products were developed that lead to a “cold-process” built-up-roof thus eliminating the hot kettle, odor and heat during installation.

#### 3. Polymer-Modified Bitumen or Modified Bitumen (MB)

The Europeans developed this system in the mid-1960s and the US started to use it in the mid-1970s

The system is similar to the BUR with polymer-modified-bitumen membrane interlaid with hot polymer-modified bitumen and then top with gravel, cap sheet,

metal foil-laminated surface and smooth liquid-applied surfacing.

#### 4. **Single Ply**

There are two (2) major types of single-ply roofing; Thermoplastic and Thermoset

A. **Thermoplastic:** Within this group are four roofing types of membrane of these TPO and PVC are more popular than others.

1. **Polyvinyl Chloride (PVC).**

In 1966 a German company formulated and produced the first PVC roofing to combat a wide range of roof problems. Its performance was quickly recognized and within a very short time was used throughout Europe.

Less than 10 years later, US companies started to manufacture the membrane without having to import it. A critical error was made in the reduction of the number of plasticizers used to minimize cost which lead to failures. The membrane simply reverted to its original inflexible state and shattered in cold weather. A massive recall of the product followed. Since then, US companies have reverted to the old formula that included plasticizers.

2. **Thermoplastic Olefin [Polyolefin] (TPO).**

TPO is a blend of polypropylene (PP) and ethylene-propylene rubber (EPR) polymers. Other ingredients added may include flame retardants, color pigments, UV absorbers and proprietary ingredients. They are available from 40 to 100 mils thick. NRCA recommends specifying sheets complying with or exceed ASTM D6878.

TPO exhibits positive physical properties; heat ageing, cold temperature flexibility, puncture resistance and tear resistance. They are resistant to degradation from exposure to animal fats (cooking oil), hydrocarbon and vegetable oils. It is resistant to microbial attack and does not support growth of microorganisms.

It is used with ballasted roofing, can be fully adhered or mechanically fastened. Designer should consult with the manufacturer's representative regarding securement.

3. **Ketone Ethylene Ester (KEE).**

This is a sole propriety product by DuPont. It mixes KEE with PVC to produce a type of roofing that is easy to heat weld, resistance to chemicals, weather resistant, long-term flexible, durable, resistant to microbial growth and energy efficient. Should the Designer elects to use this, NRCA recommends specifying sheets complying with or exceeding ASTM D6754-10.

4. PVC Alloys – Copolymer Alloy (CPA), Ethylene Interpolymer (EIP), Nitrile Alloy (NBP). Additional information is available in the NRCA Roofing Manual or online. Should Designer wish to use any of these roofing membranes, consult with manufacturer on detailing and securement.
- B. Thermoset Single-Ply Roof Membrane: There are three roofing types of membrane; of these EPDM is commonly used.
1. Ethylene Propylene Diene Monomer (EPDM).  
EPDM is a synthetic rubber material that is formulated for use as a membrane sheet roofing. The common thickness range from 45 to 60 mils. It exhibits good resistance to ozone, UV rays, weathering and abrasion, low temperature flexibility, resistance to some acids, alkalis and oxygenated solvents, i.e. ketones, esters and alcohols. Contact with aromatic, halogenated and aliphatic solvents, animal and vegetable fats (cooking oil) and petroleum products should be avoided.
  2. Chlorosulfonated Polyethylene (CSPE).  
This is a synthetic rubber material known in the roofing trade as “Hypalon”, also a proprietary name of a compound developed by DuPont. When used as a roofing membrane, it was quickly realized the material is durable and has excellent adhesion capability. Damages to “Hypalon” roof are easy to repair. It is lightweight, has a strong chemical resistance, and UV (Ultra Violet) stable. However, it is more expensive than other single-ply. In 2009, DuPont announced they will stop manufacturing CSPE and the factory stopped producing the product in 2010.  
  
“Hypalon” or CSPE is still available but manufactured by other roofing manufacturers. Should the Designer chose to specify this type of roofing, NRCA suggests the specification should be written to meet or exceed the criteria in ASTM D5019.
  3. Polyisobutylene (PIB).  
Polyisobutylene is a butyl-based compound extruded into sheet form. The material is sensitive to coal-tar pitch, specific solvents and some organic oils and fats. It has good resistance to UV light and weather. If this type of roofing is selected, NRCA suggests using reinforced sheet, the specification should be written to meet or exceed the criteria in ASTM D5019 and ASTM D7067.
- C. Ballasted Roof:
1. Ballasted roof membrane may be a thermoplastic or thermoset single ply sheet membrane. Minimum roof slope is 2:12 which makes the roof steeper.

2. Stones: ½” smooth round rock. ASTM D448 #3. Most systems require a minimum of 10 psf. FM Bulletin 1-29 ballasted recommendations must be followed for pattern and distribution. The Department of Insurance does not accept loose stone ballast for roofs over 30 feet above adjacent grade and also request a 12 psf minimum. Stone should be clean and washed of fines and chips less than ½” at application. On site screening and washing of fines and mud is desirable and should be required if the Designer feels stone is not acceptable.
3. Pavers: Concrete and concrete masonry pavers may be used as ballast in lieu of stone. Pavers usually have interlocking, tongue and groove, or overlapping joint systems that cause them to work together rather than individually to resist uplift. The pavers must have raised supports, fluted or channeled bottoms to permit free flow of water to drains. The system must meet UL/FM testing requirements.

#### D. Insulation Systems

Insulation serves two important functions in the roofing system. It must provide efficient thermal resistance between the inside and outside environments of the building. It must provide a compatible base and adequate support for the roofing membrane. In addition, Designer should consider the effect its characteristics will have on the performance of the project, overall product cost and the value for the dollar.

##### 1. Rigid Board

###### a. Fiberglass

Fine glass fibers are compressed into a rigid board usually with a facer material on one or both sides. Facers vary but the most common is an asphaltic kraft paper to control bitumen absorption. It is a non-combustible, inorganic, dimensionally and thermally stable material with a long record of usage with BUR systems. Tapered boards are available.

FM requires mechanical attachment to metal decks. This board should not be used where “high roof traffic” occurs due low compressive strength and “softness.”

###### b. Perlite

It is a volcanic material, essentially glass, that is crushed and heated to high temperature which causes expansion of internal moisture to form glass spheres. It is then mixed with asphaltic binders and cellulose fibers. The resulting material is non-combustible, dimensionally and thermally stable.

- c. **Cellular Glass**

Cellular glass or foamed glass is just that. Crushed glass is mixed and heated with a foaming agent producing glass spheres of an inert gas. This unique cell structure is inherently water resistance and provides a highly effective vapor barrier. It is unaffected by common chemicals and by most corrosive environments. It is non-combustible and is thermally and dimensionally stable. It is also an expensive and proprietary product in the market.
- d. **Wood Fiberboard**

Used mostly as a utility and recovery board rather than insulation to separate or protect roofing components. The boards can be reused at the end of life and are biodegradable or can be used as a fuel source.
- e. **Plastic Foam**
  - i. Polystyrenes are thermoplastic and therefore sensitive to high temperature and organic solvents (petroleum and coal tar derivatives). They must be protected from UV and are combustible. The Code and FM approval requires a fire-resistant barrier between polystyrene and metal deck. Most plastic foam products involve the use of Chlorofluorocarbon gases, CHFC, which is implicated in the loss of ozone in the high atmosphere. Most foam insulations will require protection from the hot bitumen of BUR and modified bitumen systems.
    - 1) Molded Expanded Polystyrene (EPS), sometimes referred to as “bead board” is formed by heating polystyrene “beads” with steam causing them to expand. They are then conditioned and as they cool, steam in the voids within the mass condenses causing air to diffuse into them. After conditioning, the granules can be cast into molds and further expanded using blown steam forming rigid blocks. The blocks are cut to shape depending on the customer’s requirement.
    - 2) Extruded Polystyrene (XPS) is formed by a continuous extrusion process based on steam injection process. This result in a continuous product with a smooth surface skin and enhances the mechanical properties.
  - ii. Polyurethane and Polyisocyanurate foam are thermosetting materials and can withstand higher temperatures. Certain insulations containing polyisocyanurate and phenolic foam have UL/FM Class I/A ratings but polyurethane is combustible and must be protected. Various facing are used on these foams

and are necessary for protection, roofing compatibility and dimensional stability. These insulations have the highest R-value per inch due to the CHFC gas in the cells but the gas can diffuse through the cell walls over time and is replaced with air. The replacement reduces the R-value by nearly 20% over a relatively short time depending on material thickness and facers. The loss is referred to as “thermal drift.” Energy loss considerations and calculations should be based on the proper “aged value.” The industry is trying to establish an appropriate aged R-value for design purposes that is presently around 5.6/inch.

- 1) Polyurethane is formed basically by a liquid chemical reaction between isocyanurate and polyol. The cell gas is CHFC. It is rarely available in roofing boards as manufacturers prefer polyisocyanurate for better fire rating. It is used extensively by the spray foam system.
- 2) Polyisocyanurate is a mix of polyisocyanurate and polyurethane polymers that form a closed-cell structure. For commercial polyiso foam, the polyurethane is modified with some polyisocyanurate, creating superior fire resistance and maintaining toughness. The foam-forming mix is deposited on a continuously moving lower facing, where it expands. As it moves on, an upper facing is brought into contact with the rising foam. This combination moves into a heated conveyor press where the expansion and attachment of the facers are completed.

E. Green Roof: Review Chapter 7 of this Guidelines and Policies.

## CHAPTER 5

### NEW ROOF CONSTRUCTION

#### 1. Slope in Structure

In new construction, NRCA recommends the roof deck slope for positive drainage. This will lessen the quantity of insulation required on the roof and result in a uniform insulation thickness. The roof deck shall slope  $\frac{1}{4}$ " per foot as required by *Code*. Designer shall also recognize "camber" in the roof structural system that may impact the roof drainage system. Deflection in a sloped structure system, caused by dead load, equipment, rainwater accumulated and "add-ons", may impair a drainage system if drains are improperly located and structural slope does not account for deflection. The drainage system must work positively under both maximum and minimum loading of the structural system.

One way or two way sloping of the structure is preferred to four way slopes in multi-bay systems. Valleys must be tapered ( $\frac{1}{4}$ " per foot) to provide positive drainage.

#### 2. Structural Deck

The roof deck is part of the roof structure and plays a significant role in the selection of roofing type that is compatible with the deck. Sloping of new roof deck is encouraged resulting in a uniform roof insulation thickness and reducing use of insulation for building up slope.

- A. Metal decks are light, flexible and, depending on the construction type, may require fire rating. Sloped roof deck is relatively easy to achieve. However, care must be exercised when in locating roof drains due to deflection.
- B. Concrete decks are rigid and fire resistant. Sloped roof deck is also achievable. The attachment of the roofing membrane to the concrete deck is limited.
- C. Wood decks are also light, flexible and, depending on the construction type, may require fire rating. Slope roof deck is achievable. This type of deck is versatile, can accept different methods of roofing attachment but is subject to rot should the roof leak. Care should be exercised when locating roof drains due to deflection.
- D. Gypsum deck, poured and planked, and cementitious wood fiber and cellulose products are strongly discouraged as decks for low-slope roof due to their tendency to deteriorate with prolonged wetting from roof leaks. This type of roof deck is no longer being used in new construction in the US.



### 3. **Insulation**

Follow the requirements in Chapter 4, Basic Criteria of this document.

### 4. **Codes**

The *NCSBC* and Department of Insurance will have a significant impact on the selection and design of the building roof and roofing system. The Department of Insurance (State Property Fire Fund Division) requests that all State owned buildings have, as a minimum, an FM I-90 and Class A rated roofing system. However, this requirement may be exceeded due to location and wind speed as indicated in the *Code*.

### 5. **Drainage System**

The selection of internal or external drainage in new roof construction shall base on the basic roof slope configuration. Steep roofing normally uses an external system of gutters and downspouts attached to the eaves of the roof. Low-slope roofs use an internal system of roof drains and leaders.

- A. Internal drainage systems with PVC leaders are not permitted in fire rated construction, non-combustible buildings or ceiling spaces used for return air HVAC.
- B. Built-in gutter systems on steep roofs are discouraged due to cost and the potential of damage if and when they fail. SCO has seen numerous designs and detailing that are inadequate, and poorly executed. We do not endorse or encourage this type of gutters.

### 6. **Water Testing**

- A. The completed roof/waterproofing system must be tested to ensure integrity of the completed roof system for leaks. There are two methods of testing, testing the integrity of the roof membrane and detecting moisture for leaks.

#### 1. Integrity Testing.

- a. Electric Field Vector Mapping (EFVM) or low voltage testing.  
This technique uses water as an electrically conductive medium. The surface of the roof membrane is wetted or moistened. An uninsulated conductive wire loop is set up around the area to be tested and connected to a pulse generator at one end and grounded at the other creating an electrical plate. The roof deck below the membrane is connected to ground, creating another electrical plate separated only by the roofing membrane. If there is any breach in the membrane when the pulse generator is turned on, the circuit is complete. A technician uses two

probes to locate that breach.

b. High Voltage Testing.

This test is similar to the EFVM above except the test is a dry test. It utilizes a “broom” like brush that sweeps the roof. If there is a breach it will send out an audio signal. The technician will then sweep the area to pin point the breach.

c. Flood Test.

A simple method of testing for leaks. When performing this test, contractor and designer should be aware of the designed load capacity of the structure. All drains are seal and the roof flooded for a period of 12-48 hours. The roof is then safely drained to prevent blowing out elbows in the drain line. Any leaks visible from below must be found top side by visual inspection and repaired immediately.

d. Spray Testing.

This test is to simulate normal to severe weather conditions by spraying water on the roof. A good standard to use is ASTM E1105. Any leaks visible from below must be found top side by visual inspection and repair immediately.

2. Moisture Detection.

a. Capacitance Testing.

The test utilizes an electric field to determine the relative moisture content of the membrane. The roof will have to be dry, the assembly be uniform in its materials and thickness and there is water in the system to provide differential readings at relative dry and wet areas. The test does not locate the breach but identifies moisture content which indicates a breach in the membrane.

b. Infrared Thermography.

As in the Capacitance Testing, the roof has to be dry, the assembly be uniform in its materials and thickness and there is water in the system to provide differential readings at relative dry and wet areas. The test is done at night utilizing an IR Camera. Areas of higher temperature is due to presence of moisture. The area is marked for visual inspection the next morning. Again, this test identifies moisture content which indicates a breach in the membrane.

c. Nuclear Meter

An interpretive test that identifies an area with differing moisture contents similar to the two above.

## CHAPTER 6

### ROOFING REPLACEMENT

#### 1. General

In general all sections of this criterion apply to replacement roofing as well as new roofing. Obviously, the Designer with an existing roof project has less freedom, more investigative work and more compromises to make than the Designer with new building. But there is an opportunity to learn from the building's past errors and significantly improve the roofing and thermal performance of an existing building. Suggested investigation listed in this chapter is not comprehensive, Designer may have other investigation technique that are not listed and may yield effective results.

#### 2. Investigation

##### A. Field Observation:

The Designer's first and foremost action in any re-roofing project is to do an on-site visual and physical investigation. Determine the problem and talk to building users and maintenance personnel before any design action is taken.

1. Check with Owner on the roof's age, performance and maintenance history.
2. Observe the symptoms, usually a leak (observe from below), and determine the source. In some cases it may not be the roofing system causing the leak. (Condensate from pipes above the ceiling finish)
3. What are weather conditions when leak occur.
4. Determine the cause of the problem. This is essential in designing the proper "cure." Is it due to design, installation, materials, age or lack of maintenance?
5. What is the extent of the damage or deterioration? Test cuts or non-destructive roof surveys may be useful or necessary to verify roofing components.
6. Is the membrane intact or exposing the structure? Is asbestos present in the membrane, flashing, roofing cement, underlayment, and mastic etcetera?
7. Deck and Structure shall be checked from below if possible to confirm conditions and consistency with observation above.
8. Check edge condition, blocking and curb construction for attachment.
9. Flashing shall be checked for material, condition, function and attachment.
10. Is there standing water or ponding on the roof?
11. Check proper roof slopes and crickets.
12. Check drainage system for proper operation and location.
13. Check critical height above finish roof such as clearstory windowsill is too low to flash. Clearstory window and roof access door sill heights.
14. Check if there is a vapor retarder. Should this have been installed or not. Is it part of the problem?
15. Is the roofing in compliance with the code based on construction type and fire rating?

16. Is cover board present?
17. Height of various parapet above roof finish surface.

B. As Built Record Drawings:

1. “As-Built” drawings provided by the Owner or previous designer shall be used with caution and must not be used in lieu of preparing new drawings. The drawings should be utilized as a reference and not in lieu of performing a thorough field assessment.
2. As a minimum the following shall be confirmed with field observation;
  - a. Roof fire rating – This is directly related to the building construction type in the North Carolina State Building Code.
  - b. Where there is a fire-wall within the building, check the framing orientation. Verify the roofing on each side of the fire-wall carries the required fire rating in accordance with the *Code*.
  - c. Verify direction of roof framing, type of roof framing and decking.
  - d. Flashing details, expansion joints, equipment curbs, etcetera.
  - e. Drainage system.
  - f. Drawings may not show whether the roofing contain asbestos. This should be confirmed in the field with test samples.
  - g. Is roof slope built-up or built into framing?
  - h. Cover board/vapor barrier present?
3. Hazardous Material:

Asbestos-containing material (ACM) is considered non-intact if it’s structure, has been damaged, exposed to UV light too long or has otherwise deteriorated so that the asbestos fibers are no longer bound within a matrix of the fabric.

  - a. Samples, suspected of containing ACM, shall be taken and tested in a certified laboratory in accordance with North Carolina State requirements.
  - b. Samples, suspected of containing lead paint, shall be taken and tested in a certified laboratory in accordance with North Carolina State requirements.
  - c. Additional information on removal is available by contacting the Health Hazard Control Unit (HHCU) of the Department of Health and Human Services by calling (919) 707-5950 or visit their website <http://epi.publichealth.nc.gov/asbestos.html>
4. Alternatives (Choices).

After the initial investigation the result and rational based on other factors such as budget, exposure to the elements while the building is being occupied etc., the Designer has three (3) basic alternatives, repair, recover or tear-off and replace with new.

- a. Repair: The following minimum factor should be taken into consideration.
  - 1) The roofing system is still within the first  $\frac{1}{2}$  to  $\frac{2}{3}$  of its estimated useful life and repairs will extend service life at least five (5) more years.
  - 2) If non-destructive roof survey indicates the extent of damage or deterioration is limited and repairable. No Moisture may remain in the system after repair.
  - 3) No moisture was detected and damage/deterioration is limited.
  - 4) Can the roofing stand up to roof traffic (due to roof inspection).
  - 5) Can repair extend the life of the roof for another five (5) more years due to limited fund?
  - 6) Re-saturation of BUR felts nor spray coating of existing BUR will not be permitted except as a temporary emergency repair or if the building has a limited useful life remaining.
  
- b. Roof Recover: This is the application of a new roofing over the entire existing surface providing the following conditions exist:
  - 1) A non-destructive roof survey indicates no moisture under the existing membrane and/or a minimum of definable areas of repair or replacement. No Moisture may remain in the system after recovery.
  - 2) The roof insulation is not soaked with water.
  - 3) Drainage is adequate.
  - 4) The existing roofing has not deteriorated and can act as a base for additional roof.
  - 5) The roof does not have asbestos.
  - 6) Does the existing roof system have a vapor retarder.
  - 7) The existing roofing does not have two or more layers of roofing.
  - 8) Building use or budget will not permit the costs of tear-off or exposing building to sudden weather changes.
  - 9) The new roof system must be compatible with the existing and carry a full warranty.
  
- c. Tear-Off: This is a complete removal of the existing roofing and may include insulation if soaked with water. This permits the Designer to perform a thorough visual inspection and to correct all deficiencies in original construction/installation.
  - 1) Verify if a vapor retarder is missing or needed.
  - 2) An opportunity to re-design slope and drainage/overflow system if necessary.
  - 3) Reinforce roof structure if necessary.
  - 4) Add insulation to increase R-value of the roof.
  - 5) Evaluate the economics of tear-off verses other alternatives.

### 3. Roof Deck

The materials and conditions of the roof deck and possibly the roof structure itself are critical to the success of replacement roof system. The Designer's on site investigation must be thorough and as conclusive as possible for the contract documents. If the contractor's tear-off reveals an existing system or conditions unlike anything in the contract documents, the Designer may find he has to start from the beginning again while the contractor waits on the side with a handful of change orders and an irate Owner.

- A. Check physical condition for deterioration, damage, movement or cracking. Confirm "as-built" if available.
- B. Evaluate load capacity if recovering or replacing with a heavier system or additional insulation to create positive drainage.
- C. Evaluate fastening requirement if mechanical fastening is required in system. Concrete deck thickness and condition and metal deck gage greatly affect manner and cost of fastening. Pull-out tests are required on concrete and cementitious fill decks.
- D. Check existing slope, deflections or camber that may influence new system performance.

### 4. Insulation

Comply with the minimum requirement of the current adopted *NCECC* for roof on new building or 2009 *NCECC* to existing buildings constructed prior to January 1, and additions up to 50% of the original floor area with the following exceptions for roof replacement and repair.

- A. Re-cover over existing roofing membrane.
- B. Remove existing roofing membrane, install new over existing insulation in good condition and dry.
- C. If the exposed insulation is damaged and/or water logged requiring replacement, the new insulation shall comply with *NCECC*.
- D. If no insulation is on the roof deck and the roof deck requires replacement due to damage and there is no insulation between roof framing, new insulation shall be added to comply with *NCECC*.

Designer shall review the *NCECC* and the document "Commercial Energy Code Compliance Options" in Appendix B for new buildings and additions to determine the best option for the Owner/Designer.

### 5. Slope

New drainage requirements will be the same as for new roofs with minimum  $\frac{1}{4}$ " per foot slope to drain. However, the minimum slope requirement need not meet the current building code provided the roof has positive drainage with no ponding. Designer is cautioned if this option is selected as a minimum criterion, he/she is solely responsible for standing water or ponding on the roof and shall remedy the condition at his/her expense.

## 6. **Drainage System**

The existing internal drains and drainage piping for both primary and secondary system shall be inspected and tested to ensure they are performing properly and are in good conditions. Rusted drain cover shall be cleaned and painted. Damaged drains must be repaired or replaced. Verify that the roof has the appropriated number of drains and they are located for efficient drainage.

Secondary discharge is in a location above grade that would normally be observed by the building occupants or maintenance personnel. Discharge shall not be located above exits or walkways. Drainage onto sidewalks or pedestrian paths shall be avoided especially in location where frozen precipitation is anticipated. NEVER assume existing design and construction was done correctly.

Water that is not efficiently removed from the roof or "ponding" is very likely to find its way through membrane defect, open base flashing lap or simply poor installation and workmanship.

## 7. **Rooftop Equipment**

When rooftop equipment is removed to facilitate re-roofing. Re-installed rooftop equipment must be tested to ensure it operates properly. If the equipment does not operate notify the owner immediately.

## 8. **Unit Prices**

Unit pricing is a very effective and useful method of adjusting roofing contracts for variable conditions that are common to roof replacements. The essential part of this method is the accuracy of the Designer's estimated base bid amount, hopefully established in the investigation of existing condition and of design. Common unit cost items include repair or removal and replacement of; wood blocking, curbs, decking, wet insulation, and flashing, the extent of which is not always readily visible and quantifiable until tear-off of exiting system. Quantities submitted by the contractor shall be verified by the Designer if they vary significantly from the estimate.

## CHAPTER 7

### GREEN ROOF

#### 1. General

Green roof or living roof is the roof of a building that is partially or completely covered with vegetation and a growing medium planted over a waterproofing membrane. It also includes additional layers such as a root barrier, drainage and irrigation systems. Container gardens on roofs, where plants are maintained in pots, are not generally considered to be true green roofs, although this is debated.

Green roofs serve several purposes for a building, absorbing rainwater, providing insulation, creating a habitat for wildlife, and helping to lower urban air temperatures and mitigate the heat island effect.

There are two (2) Types of Green Roofs. The first is the conventional way to grow plants on engineered soil deposited directly on the roof. The second is the employment of a Modular plant system. Within each of these are three major categories:

- A. Extensive roof with engineered soil-base growth medium from 2 to 6 inches. (Shallow).
- B. Semi-intensive roof with engineered soil-base growth medium from 6 to 10 inches. (Moderate Depth)
- C. Intensive roof with engineered soil-base growth medium greater than 10 inches deep. (Deep)

Additional information on green roofs is available in NRCA Green Roofs System Manual 2007.

#### 2. Basic Design

This type of roofing is relatively new to the US even though it has been utilized in Europe since 1960. Designer who elects to include green roof in their project must take into consideration some of the criteria listed. Additional concerns are re-iterated in Chapter 3 Basic Criteria of this Guidelines and Policies.

- A. Climate and geographical location.  
The availability of plant materials for the climate may determine whether the roof will be extensive, semi-intensive or intensive roof.
- B. Intended use and design life expectancy.  
If the roof is to be used as roof garden concrete pavers shall be included [include weight of pavers, site furniture and any other outdoor fixtures in designing the



super structure].

- C. Interior and exterior temperature, humidity and use conditions.
- D. Code requirement such as accessibility if the roof is used as a roof garden.
- E. Type of substrate.  
Substrate shall be concrete or concrete composite slab. Wood is not desirable as it will absorb moisture. Any leak that develops will not be apparent and when it is apparent the damage is usually beyond remedial action. Repair of the roof is costly, time consuming and disruptive to the building owner and users.
- F. Structural system.  
Designer shall include all dead and live load as required in the *Code* plus additional load such as engineered soil, insulation, pavers, water retained by soil and retention system, and absorption by filter fabric. Designer shall take into consideration the structure will deflect due to the added load and must be accounted for, i.e. by designing camber into the roof structure. See *Chapter 16, NCSBC*, section on Landscape Roof under “Live Load” for compliance.
- G. Slope and drainage.  
The substrate or roof structure should be sloped for positive drainage as required by *Code* and shall include primary and secondary drainage systems.
- H. Insulation.  
Insulation on green roof should be high-density, high compressive strength, moisture resistant and laid on top of the roofing membrane. The roofing membrane selected must be able to withstand prolonged moisture exposure.
- I. Availability of water source on the roof.  
The first two (2) years are critical for the seeds to germinate and establish itself. A source of water supply must therefore be available especially when the conventional method is used and no rainfall or a drought occurs.
- J. Roof/Waterproofing Membrane  
The selected system shall be fully adhered to the substrate. Loose laid system is not recommended by NRCA. If water penetrates the membrane barrier it will migrate horizontally from point of entry and do irreversible damage to the substrate before it is apparent. A fully adhered system will not allow water to migrate horizontally.

### 3. Roof System

Starting from the bottom of the system with waterproofing membrane and moving up to the top of the system with plants.

- A. The Green Roof Waterproofing Membrane is the water defensive system for the building. It must be designed with minimum penetrations and built like a tub. The membrane material is generally sensitive to UV light and must be protected. If a material is unaffected by UV light protecting it is not critical. There is also the possibility that both sensitive and non-sensitive materials are combined in the membrane. It is up to the designer to ensure the materials are compatible or design it to be separated but the system still maintain its water tightness.
- B. The membrane should be water tested prior to placing overburden. See Chapter 4 for types of water testing current available.
- C. Protection Layer. This layer protects the membrane from damage during and after construction. This layer and Roof Barrier can be interchanged depending on design.
- D. Root Barrier is an important component of the green roof. It stops the roots from growing below it that may result in damaging the waterproofing membrane. The barrier must be included in both conventional and modular plant systems. The barrier and Protection Layer can be interchanged depending on design.
- E. A drainage layer below the rigid insulation directs water into roof drains.
- F. A layer of high density and high compressive strength moisture resistant layer on top of the drainage layer.
- G. An aeration layer helps to keep the insulation layer dry thus maintaining the insulation R-Value.
- H. Moisture-retention layer is dependent upon the type of plant materials and reservoir layer used.
- I. Reservoir layer is also dependent upon the plant material, whether the moisture retention layer is present and where there is no plant material such as under pavers.
- J. Filter fabric layer is simply a geotextile that is tightly woven. It permits water to go through and keeps the soil above.
- K. Engineered soil is a mixture of organic and inorganic material, and light weight for plants to grow. The brand is usually a proprietary material.

#### **4. Accessories**

- A. Inspection Boxes:  
There are two types. The first is for drain inspection and cleaning if necessary. The second is for access to valves, electrical connections, and fittings. Leveling

the top of inspection boxes with paving or overburden is preferred.

**B. Drainage System:**

The code requirement for drainage system is no different than that of a standard low slope roof. A 1/4" slope per foot minimum is required. Primary and secondary/emergency drainage system with separate collection and discharge is required.

**C. Metal Components:**

Metal should be selected based on service life of the item. Preferably a metal that can outlast the service life of the green roof. Copper should not be used as contaminated water (with copper) will do damage to the plant materials.

## **5. Re-Roofing or Convert to Green Roof**

- A.** Designer and Owner shall discuss the selection of a green roof thoroughly prior to making the decision. One important topic is re-roofing. Is the Owner to replace with another green roof? What is the cost at replacement 30 plus years in the future? Replacing a green roof takes more time and effort. Is the Owner willing to do that?

If the green roof is to be replaced, it is an opportunity to thoroughly check the roof deck and repair if necessary. The waterproofing membrane layer should be replaced and the whole roof system starts anew.

- B.** When converting to a green roof, a Structural Engineer must review the capacity and super structure to ensure it can support the added dead load and live load.

## **6. Construction Detail**

- A.** It is not the intent of this section to describe all construction details for a green roof. The intent is to bring awareness to the Designer of issues/problems SCO has encountered.

**B. Building expansion**

Where there is a building expansion joint, the joint shall carry through the green roof.

**C. Penetrations.**

Roof penetration shall occur where pavers are used. Penetration that terminates above the roof shall terminate at a minimum 4" above the paved surface.

**D. Flashing**

Installation of flashing shall be as recommended by NRCA. Care must be exercised in placing overburden to avoid damaging any flashing installed in-place.

## CHAPTER 8

### DOCUMENTATION

#### 1. General

How well the documentation is prepared on a project directly reflects the roofing knowledge of the Designer and his interest in doing a good job. The Contractor sees this as well as the SCO Reviewers. Clear, complete and well conceived documents result in faster reviews and fewer comments. The contractor sees what is required (as well as seeing that the Designer knows what is required) and can feel assured of an accurate bid.

See State Construction Manual for additional design and planning criteria and complete description of review process and procedures.

#### 2. Review and Approvals

Roofing project document, regardless of dollar value, will always require review and approval by the Owner and The State Construction Office. In addition, the Archives and History Division of Cultural Resources must review roofing projects involving properties on National Register of Historic Places or Historic Districts.

Project review and approval by State Construction Office is for: conformance with the design contract and project funding, conformance with generally accepted design and construction standards, conformance with NC General Statutes relative to construction and contracting for State owned facilities, and conformance with this criteria where applicable. State Construction Office reviews are not “office checks” and do not ensure the accuracy or the appropriateness of the drawings, materials or specifications.

#### 3. Submittals

##### A. Schematic Design

Projects involving a new building would begin with the Schematic Design submittal which is part of the basic building layout and general description of the proposed building systems and materials. The roofing system is determined largely by the building basics of area, use, height, construction systems and *Code*.

Roofing replacement projects may begin with the Design Development submittal which is sometimes referred to as combined schematic/design development. The Designer uses the schematic time to investigate the existing system and its requirements and prepare “as built” drawings of the existing system.

## B. Design Development

The Design Development submittal relative to roofing, whether new or re-roofing, should basically describe the complete system that is proposed. Specification should be in outline form describing the complete system and its components. The drawings should be developed sufficiently to indicate proposed sloped drainage system, drain locations and a typical edge condition. The cost estimate may be based on unit costs of area.

Roofing replacement should include a description of the existing roofing and its condition and structural roof system and its condition. The non-destructive roof survey, if done, should be submitted. "As Built" drawings provided by Owner must be field verified for accuracy and changes.

## C. Construction Document

This submittal should be the complete documentation ready for bidding. The minimum criteria for this submittal is described in "E. Contractual Documents." Cost estimate should be based on material quantity takeoffs and must be broken down into the major components of the roofing materials and process. A minimum breakdown (formatted) would be the basic CSI MasterFormat 49 Divisions.

## D. Cost Estimate

The cost estimate must be included with each submittal outlined above as required by Owner/Designer Agreement. The cost estimate must also include a tabulated breakdown of total project funds as shown on the Design Contract. The contingency is set by the design contract and is reserved for testing, changes and unforeseen conditions. It cannot be used until after construction contract is begun at the discretion of the Owner. The construction costs at bid must not exceed the construction funds available' therefore, the Designer should be realistic. Alternates are an acceptable method of controlling costs at bid time and are described below. The final cost estimate submittal and tabulation should also show a breakdown according to prime contract base bids and alternates as they would be recorded on bid tabulation sheet.

## E. Contractual Documents

State Construction projects whose total contract value exceeds \$500,000 are considered "Formal" contracts and must meet GS.143 Article 8 for bidding procedures and include all standards forms and documents.

Projects whose total contract value is less than \$500,000 may bid as an "Informal" contract. This is a method of bidding and contracting and do not imply that the construction documents, plans and specifications be "informal" or

general in nature. The construction documents must adequately describe and detail the work to be performed regardless of contract amount. Informal projects are reviewed the same as others but a single submittal (Construction Documents phase), depending on the nature of the work, may be made with prior approval by SCO.

1. Formal Contracting, follow the requirements of a standard project as described in the State Construction Manual.
2. Informal Contract, utilize the document titled “State of North Carolina Standard Form of Informal Contract and General Conditions” available at the State Construction Office website.
  - a) Notice to Bidders:  
The notice is the first page of the document and double as the Advertisement for Bid. Designer shall edit this page to be project specific.
  - b) Bid/Acceptance form:  
This is the bid form as well as the agreement between Bidder and Owner. Bidder must ensure all required information is complete or the bid is not a bona fide bid.
  - c) General Conditions:  
The General Conditions in the “Informal” contract is a condensed version of the “Formal” General Conditions. All articles in the “Formal” General Conditions still apply in “Informal” construction contract.  
Designer should thoroughly review this General Conditions to ensure the articles are appropriate for the construction project and edit as necessary. Extensive editing is not encouraged.
  - d) Supplementary General Conditions:  
Complete the Time of Completion and Liquidated Damages. Review the SGC and edit to be project specific.
  - e) Specifications:
    - i. CSI Format:  
CSI 16 Division Format is no longer in use or supported by Construction Specification Institute as of December 31, 1995. The current acceptable CSI is the 2004 Edition with 49 Divisions.  
However, SCO still accept CSI 16 Division Format but it is the responsibility of the Designer to ensure all industry references, standards, test standards such as ASTM and UL. are current.  
Designer should be consistent in the use of CSI formats, do not

mix and match different format as this will only add confusion and lose consistency.

- ii. General Statute 133-3  
Designer shall specify in their construction documents at least 3 items of equal design or their equivalent design which would be acceptable upon such work as required by statute. Additional information on this statute is available on the State Construction Office website.
- iii. References:  
Standards referenced shall be to the current addition. Standards such as ASTM, ANSI, UL, etc. are acceptable, Federal or Military Specifications are not appropriate for State construction work.

f) Drawings:

The drawings are a primary tool of communication that describe the scope of work and the intent of the Designer. Construction Documents must be clear and informative for bidders to provide an accurate bid.

- i. Drawing set sizes shall be 24" x 36" or 30" x 42". Drawing shall be securely edge bound. Any other sizes other than required shall be approved prior to submittal.
- ii. Cover sheet:  
Re-roofing projects shall have a cover sheet that includes as a minimum a vicinity map, site map with adjacent buildings, access, staging areas, and heights above grade to roof.
- iii. A Building Code Summary sheet to verify the selected roofing type is in compliance with the *Code*.
- iv. A complete roof plan and all major roof top equipment, penetrations, hatches, skylights, dimension, heights above grade to each level of roof. Knowing the heights above grade gives three dimensional feel even though the drawing is in two dimensions.
- v. Include an existing roof plan and necessary details to verify construction type and appropriateness of the roofing type and attachment method.
- vi. Details shall be a minimum 1½" scale for each typical and unique conditions. Referencing details in industry standards or

manufacturer details are not acceptable. Details must be drawn specifically for the project.

If an alternate system bid is included in the documents, a complete set of details and specifications of that system is required in the bid documents where it differs from the proposed base bid system.



## CHAPTER 9

### WARRANTY

#### 1. General

The State has been receiving warranties on roofing systems and installation based on the two statements in “Basic Scope and Coverage” below. These are minimal statements at best and do not constitute a warranty nor adequately define the warranty to be submitted. The State usually receives the Standard CRSMCA form or similar for the Contractor’s Warranty and the Manufacturer’s standard form for the twenty (20) year warranty. These documents go well beyond the statements below in defining the conditions of the warranty. These conditions, as would be expected, favor and protect the contractor much more so than the Owner.

The State has not yet had any significant problems in getting adequate responses from contractors or membrane manufacturers relative to roof leaks and roof warranty work. But with the number of roofs and the volume of roofing the State has, a more equitable warranty document is needed. The following articles address the issues and conditions that should be a part of the document. The Designer shall continue to include the statements in “Basic Scope and Coverage” below in The Roofing specification section.

#### 2. Basic Scope and Coverage

- A. The Roofing System Manufacturer shall inspect the installation and warrant the materials and workmanship of the roofing system against leakage for a minimum period of twenty (20) years following acceptance of the project by the Owner. The warranty shall be a non-pro-rated, no dollar limit covering all roof system components that fail.
- B. Pre-finished sheet metal components such as parapet coping shall carry a minimum warranty of twenty (20) years.
- C. The Contractor shall warrant the materials and workmanship of the roofing system against leakage and against defects due to faulty materials, workmanship and contractor negligence for a period of five (5) years following acceptance of the project by the Owner.

#### 3. Nature of Remedy

In the event of a leak the Contractor/Manufacturer shall repair the leak and repair any components of the warranted roofing system that is damaged or impacted by the leak. This includes recovery board, insulation, fasteners and gypsum board, down to the roof deck.

#### 4. **Monetary Limits and Consequential Damages**

The minimum monetary limit on expenditures required to repair the roofing system shall be the Owner's original cost of materials and installation and the limit may be prorated over the warranty period.

#### 5. **Exclusions**

- A. Exclusions are those events or conditions that result in roof leaks which may not be covered by the roofing warranty. These should be only events or conditions that are beyond the control of the roofing contractor/manufacturer and that result in failure of the roofing system to be leak free.
- B. The following exclusions are acceptable in warranty of the roofing system installed on State owned facilities.
  - 1. Natural Disasters – lightning, fire, tornadoes, earthquakes, hail, falling objects and high wind speed.
  - 2. Negligence and Abuse – misuse by anyone other than the Contractor, vandalism, riots and war.
  - 3. Structural Failure – abnormal movement, settlement or displacement of the building structural system not provided for by an expansion joint. This does not include localized thermal movement of metal flashings, gravel stops, insulation, fasteners and other components of the roofing system itself.
  - 4. Secondary Moisture – moisture that enters the roof system from locations other than through the roof system, including moisture vapor from within the building.
  - 5. Substance and Chemical Contaminants – that manufacturer considers damaging to the membrane and that were specifically listed in written form and presented to the Designer and Owner prior to installation.
  - 6. Change in Building usage or environment that would significantly and adversely affect roofing system.
  - 7. Alterations, additions or repairs – made upon, through or to the roof and the roofing system without prior written notification and approval of the Installer/Manufacturer.

#### 6. **Null and Void Provision**

Once the warranty is in effect, i.e. work complete with inspections and payment satisfactory, then there shall be no conditions that can make the warranty null and

void in its entirety. An event or condition may be excluded from the warranty as described above for that particular occurrence or condition but cannot be applied to the warranty in its entirety or affect the warranty period.

## **CHAPTER 10**

### **SUSTAINABILITY**

#### **1. General**

- A. The State of North Carolina supports sustainability efforts in proper design, installation and maintenance of roof systems. Much of the sustainability effort with regard to roofing systems can be capitalized on in designing and installing new and replacement roof systems and maintaining existing roof system to realize the maximum life potential, thereby reducing the impact and demands on natural resources, the production of those resources into required materials, the transportation of those materials from production plants to project sites and associated energy costs.
- B. The State of North Carolina encourages designers to consider sustainability with regard to roof system design. Designers should consider the possibilities of system selection, material selection, recycling and maintenance.

#### **2. System Selection**

- A. Designs should consider the highest quality roof system that the budget allows, thereby extending the life of the roof system and reducing future materials consumption. Typical life cycles for low slope roof systems should be between 20 and 30 years.
- B. Vegetated roofing systems can provide benefits such as reducing heat island effects and runoffs. Use of these systems requires careful consideration of detailing structural concerns related to increase structural load.
- C. Consider highly reflective roof membranes with high SRI values that result in energy savings associated with reducing heating and air conditioning costs.
- D. Specify insulation and cover board systems in multiple layers with staggered joints.
- E. Mechanically attached membranes are discouraged.
- F. The use of cover boards or protection boards will lead to increased durability and longer lasting roof systems. Cover boards or insulation boards directly under the membrane should be adhered with adhesives or bitumen. This eliminates thermal

breaks in the system and reduces energy loss.

- G. Provide walk-pads across roof areas to minimize damage to roof systems where accessed by maintenance personnel.

### 3. **Material Selection**

- A. Design systems to utilize the minimum quantity of materials necessary to comply with the performance requirements. Careful consideration should be made with regard to the amount of insulation specified to ensure systems are designed to meet the required R-Value but use the least amount of insulation possible.
- B. Specify metal components fabricated from metal types that do not corrode, such as aluminum, stainless steel and copper. These metals, if properly maintained can be reused on roof replacement or recover systems in future years.
- C. Specify materials that are produced efficiently, are high quality, 'green', that use little energy to manufacture.
- D. Select environmental friendly materials, such as water based or bio-degradable adhesives where possible and reduce the amount of harsh chemicals deposited into the environment.
- E. Preference should be given to specifying materials that are manufactured within reasonable proximity to the project site to minimize transportation and shipping costs.

### 4. **Recycling**

- A. Where feasible, specify the reuse of existing insulation provided it will continue to meet fire rating requirements and building code approved assemblies. Recognize that existing materials reuse in a roof system replacement will likely not be warranted in the new system.
- B. All roofing components removed should be recycled.
- C. Research available tax breaks or credits available for recycling on LEED certified projects.
- D. Recycling material: While not every low slope roofing project can be recycled professional roofing designer or contractors are encouraged to explore the option.
  - 1. Built-Up-Roof - B.U.R.  
The oldest type of low slope roof material. It is made from asphalt and reinforcing. Asphalt is a by-product of converting petroleum into gasoline,

diesel, mineral spirits and heating oil. This by-product is cost effective for large volume use.

In addition to being used for low slope roof, asphalt is widely used in the manufacturing of asphalt shingles as well as in road paving.

Asphalt is ground and blended with additional bitumen for re-use in paving. Asphalt shingles is also ground up, heated and re-used in new shingles. BUR is also ground and heated, the material is used in asphalt curbing, walkways and similar applications.

2. Ethylene Propylene Diene Monomer - EPDM.  
This product is a synthetic rubber. Ballasted or mechanical fastened membrane is removed from the roof, transported to be ground into a fine powder substance. The substance is then used in the production of roof walk-pads for new and existing roofs.
3. Polyvinyl Chloride – PVC.  
Removal of the old membrane is packaged and shipped to facility where it is processed into a form that can be reintroduced into the new product stream. The recycle material is introduced into the raw material for the manufacturing of new roofing membrane and accessories.
4. Thermoplastic Polyolefin Olefin - TPO.  
TPO is 100% recyclable, it is melted, purified and re-extruded. Hence old membrane becomes new. The recycled new membrane is used as a bottom ply of the new membrane thus manufacturer is able to offer 15% recycled material in their new roof.

## APPENDIX A

### 1. Inspection

- A. Every 6 Months – Spring and Fall  
Owner shall routinely inspect the roof and all of its components at least every 6 months, preferably in Spring and Fall. This is before and after the roof undergoes its greatest temperature stress. The more often or routinely inspection of the roof the easier and quicker it is to spot any changes that could become problems.
- B. After Adverse Weather  
Inspect the roofing after any adverse weather such as heavy rains, high winds, hail, lightning strikes, very hot or very cold temperatures. Check drains for debris and metal flashings for broken joints due expansion, contraction and wind.
- C. Record Keeping  
Keep complete records of the roof inspection dates, maintenance schedule, note any repairs and alterations and the party responsible.

### 2. Repairs and Alterations

- A. Notify the Warrantor:  
Call the designated contact person on the warranty if any leaks are noted while the roof is under warranty. If the problem is serious, the Owner's personnel should limit any consequential damages as soon as possible whether warrantor has responded or not.
- B. The Owner shall maintain a "repair kit" on each type of roofing system under his/her care. This could be materials provided by the roofing installer or a list of approved products and methods of minor repair that the Owner's personnel can utilize.

## APPENDIX B

NC Department of Insurance  
Office of the State Fire Marshal - Engineering Division  
1202 Mail Service Center, Raleigh, NC 27699-1202  
919-661-5880

### Commercial Energy Code Compliance Options-ASHRAE 90.1-2010

**Code:** 2012 NC Energy Conservation Code  
**Section:** 501.1

**Date:** March 18, 2013

**Question:**

When using the 2012 NCECC, how can I apply the recently adopted<sup>1</sup> ASHRAE 90.1-2010 to new commercial buildings, commercial building additions, or alterations of existing commercial buildings?

**Answer:**

The recent adoption of ASHRAE 90.1-2010 by the North Carolina Building Code Council (BCC) adds a new alternative compliance path for commercial buildings to the 2012 NCECC that can be elected at the discretion of the permit holder. This standard only replaced 501.1 Item 2 as a compliance path. Other compliance pathways in the 2012 NCECC are still valid; they are not being replaced by the ASHRAE 90.1-2010 standard. The other compliance pathways include: 501.1 Item 1, NC specific COMcheck, and Section 507.

If ASHRAE 90.1-2010 is elected by the permit holder as the compliance path for a new commercial building or for an addition to an existing commercial building, then one must stay completely within the ASHRAE 90.1-2010 standard for all of the technical requirements. Then the new building or building addition will be designed to be compliant with ASHRAE 90.1-2010. The standard allows for either of prescriptive, trade-off, or performance approaches to compliance. The COMcheck software recognized in our code also contains a compliance path for ASHRAE 90.1-2010 for new construction or additions. Use of the COMcheck program is a viable pathway to compliance and is a recommended approach.

If ASHRAE 90.1-2010 is elected by the permit holder as the compliance path for a building alteration, then one must stay completely within the ASHRAE 90.1-2010 standard for all of the technical requirements. All new work performed must comply with the requirements of the standard with the caveat that any new work performed shall not reduce the energy conservation measures below that which was pre-existing in the building. For example, if the building is being reroofed and R-30 continuous insulation was pre-existing, but ASHRAE 90.1-2010 would only require R-25 continuous insulation, then R-30 continuous insulation must be reinstalled to not compromise the existing energy efficiency design basis of the building. The COMcheck software recognized in our code also contains a compliance path for ASHRAE 90.1-2010 for



building alterations. Use of the COMcheck program is a viable pathway to compliance also with the caveat that any new work performed shall not reduce the energy conservation measures below that which was pre-existing in the building.

**Keywords:**

**Footnotes:**

1Please refer to Item D-9, at the following Link.

[http://www.ncdoi.com/OSFM/Engineering\\_and\\_Codes/Documents/BCC\\_Minutes/2012%2012%2010~December%2010,%202012\\_.pdf](http://www.ncdoi.com/OSFM/Engineering_and_Codes/Documents/BCC_Minutes/2012%2012%2010~December%2010,%202012_.pdf)

After passing as a “D” Item, the minutes went to Rules Review. The Rules Review Commission did not change anything to Item D-9 therefore it is acceptable as proposed. The results of the Rules Review Commission meeting was reported at the March 11th BCC Board meeting. The effective date for people to use this proposal will be March 1st, 2013. It can be used as an Alternate to the Code at that time.

Once proposed rule changes complete the approval process through the Rules Review Commission, they are posted to the OSFM website under 2012NC/ICC2009 Amendments in the file “2012-2015 Approved Cumulative Amendments” at this location, in the document title 2012-2015 Approved Cumulative Amendments

[http://www.ncdoi.com/OSFM/Engineering\\_and\\_Codes/Default.aspx?field1=Codes\\_-\\_Current\\_and\\_Past&user=State\\_Building\\_Codes](http://www.ncdoi.com/OSFM/Engineering_and_Codes/Default.aspx?field1=Codes_-_Current_and_Past&user=State_Building_Codes)

The results of the March 11th 2013 BCC Meeting will be published in the Minutes to said meeting, and will be available at the following website. The meeting minutes typically are published 30 days after the meeting.

[http://www.ncdoi.com/OSFM/Engineering\\_and\\_Codes/Default.aspx?field1=BCC\\_-\\_Minutes&user=Building\\_Code\\_Council&sub=BCC\\_Meeting](http://www.ncdoi.com/OSFM/Engineering_and_Codes/Default.aspx?field1=BCC_-_Minutes&user=Building_Code_Council&sub=BCC_Meeting)

Please note the .pdf document with the meeting minutes from the March 11th 2013 Meeting will not be posted for approximately 30 days after the meeting.

**APPENDIX C****GENERAL ASSEMBLY OF NORTH CAROLINA  
SESSION 2013****SESSION LAW 2014-90  
HOUSE BILL 201**

The General Assembly of North Carolina enacts:

**PART I. APPLICABILITY OF THE ENERGY CONSERVATION CODE TO  
CERTAIN EXISTING NONRESIDENTIAL BUILDINGS**

**SECTION 1.** G.S. 143-138 is amended by adding a new subsection to read:

"(b15) Exclusion from Energy Code Requirements for Existing Commercial Buildings. – The alteration of commercial buildings and structures that received a certificate of occupancy prior to January 1, 2012, may be subject to the rules pertaining to energy efficiency and energy conservation that were in effect on December 31, 2011. The addition to commercial buildings and structures that received a certificate of occupancy prior to January 1, 2012, may be subject to the rules pertaining to energy efficiency and energy conservation that were in effect on December 31, 2011, so long as the addition does not increase the building area of the existing commercial building or structure to more than one hundred fifty percent (150%) of the building area of the commercial building or structure as it was in existence on December 31, 2011. For the purpose of this subsection, the term "commercial buildings and structures" shall include all structures and buildings that are not classified as a Group R occupancy by the Building Code Council."

**APPENDIX D**

**Building Code Summary**

**2012 APPENDIX B  
BUILDING CODE SUMMARY  
FOR ALL COMMERCIAL ROOF PROJECTS  
(EXCEPT 1 AND 2-FAMILY DWELLINGS AND TOWNHOUSES)  
(Reproduce the following data on the building plans sheet 1 or 2)**

---

Name of Project: \_\_\_\_\_

Address: \_\_\_\_\_

Zip Code \_\_\_\_\_

Proposed Use: \_\_\_\_\_

Owner/Authorized Agent: \_\_\_\_\_ Phone # ( \_\_\_\_\_ ) \_\_\_\_\_ - \_\_\_\_\_

E-Mail \_\_\_\_\_

Owned By:  City/County  Private  State

Code Enforcement Jurisdiction:  City \_\_\_\_\_  County \_\_\_\_\_  State

**LEAD DESIGN PROFESSIONAL:**

DESIGN FIRM\* \_\_\_\_\_

DESIGN NAME \_\_\_\_\_

LICENSE # \_\_\_\_\_ TELEPHONE # \_\_\_\_\_ E-MAIL \_\_\_\_\_

**2012 EDITION OF NC CODE FOR:**  New Construction  Recover  Repair

**CONSTRUCTED:** (date) \_\_\_\_\_

**REPAIR:** (date) \_\_\_\_\_

**RECOVER:** (date) \_\_\_\_\_

**BASIC BUILDING DATA**

**Construction Type:**  I-A  II-A  III-A  IV  V-A  
 (check all that apply)  I-B  II-B  III-B  V-B

**Sprinklers:**  No  Partial  Yes  NFPA 13  NFPA 13R  NFPA 13D

**Standpipes:**  No  Yes Class  I  II  III  Wet  Dry

**Fire District:**  No  Yes (Primary)

**Building Height:** (feet) \_\_\_\_\_

**ALLOWABLE AREA**

**Occupancy:**  
 Assembly

- Business
- Educational
- Factory  F-1 and F-2
- Hazardous  H-1 Detonate  H-2 Deflagrate  H-3 Combust  H-4 Health  H-5 HPM
- Institutional
- Mercantile
- Residential  R-1  R-2  R-3  R-4
- Storage  S-1, S-2, Parking Garage. Repair Garage
- Utility and Miscellaneous

**FIRE PROTECTION REQUIREMENTS**

BUILDING ELEMENT	FIRE SEPARATION DISTANCE (FEET)	DETAIL # AND SHEET #	DESIGN # FOR RATED ASSEMBLY
Roof Construction Including supporting beams and joists			

**STRUCTURAL DESIGN**

**DESIGN LOADS:**

**Wind Uplift Resistance** (This section to be duplicated for each distinct roof area)

Basic Wind Speed \_\_\_\_\_ mph (ASCE-7)

Exposure Category \_\_\_\_\_

**Design Pressure (psf):**

Field \_\_\_\_\_

Perimeter \_\_\_\_\_

Perimeter Width \_\_\_\_\_ ft

Corner \_\_\_\_\_

Corner Dimension \_\_\_\_\_

**Dead Loads:** Existing Roof Load \_\_\_\_\_ psf  
 Replacement Roof Load \_\_\_\_\_ psf  
 Net Load Change \_\_\_\_\_ psf

**Snow Load:** \_\_\_\_\_ psf

**ENERGY SUMMARY**

**ENERGY REQUIREMENTS:**

The following data shall be considered minimum and any special attribute required to meet the **North Carolina Energy Conservation Code** shall also be provided. Each Designer shall furnish the required portions of the project information for the plan data sheet. If performance method, state the annual energy cost for the standard reference design vs annual energy cost for the proposed design.

**Climate Zone:**  3  4  5

**Method of Compliance:**

Prescriptive (Energy Code)

Performance (Energy Code)

- Prescriptive (ASHRAE 90.1)
- Performance (ASHRAE 90.1)

**THERMAL ENVELOPE**

**Roof/ceiling Assembly** (each assembly)

Description of assembly: \_\_\_\_\_  
U-Value of total assembly: \_\_\_\_\_  
R-Value of insulation: \_\_\_\_\_  
Skylights in each assembly: \_\_\_\_\_  
U-Value of skylight: \_\_\_\_\_  
Total square footage of skylights in each assembly: \_\_\_\_\_sq.ft.

---

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**ROOF DRAINAGE SYSTEM DESIGN CALCULATION/SIZING**

Existing system calculation:

Modification to existing system:

New (where none exists) secondary system:

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