

## **27 05 43 Inter-Building Ductbanks/Cabling for Communication Systems** (Revision date: 5/2/11)

### **1.0 Purpose**

- A. These guidelines provide requirements for designers to incorporate into bid documents. They are part of the University Wiring Standard (UWS), version 3.0.

### **2.0 General Requirements**

- A. Underground system. A system of underground ductbanks is employed across campus to house inter-building telephone and fiber optic communications cables. The system is comprised of larger backbone ductbanks and smaller entrance ductbanks run to each building. This system utilizes a two-level hierarchical star topology to interconnect all campus buildings. The campus is divided into Main Distribution Frame (MDF) zones, each served by an MDF facility. Ductbanks emanate from each MDF to all campus buildings in the zone and to connect adjacent zones together. Telephone and fiber optic cables are installed outward from the MDF (or intermediate passive cross-connect) to each building. Additional cables interconnect the MDFs and connect the entire system to the "outside world".

### **3.0 Materials and Standards**

- A. Materials. The materials used for this system are generally NOT manufacturer and part number specific. Equivalent, high quality materials may be utilized without submittals to NCSU ComTech. However, the university reserves the right to reject materials that are considered of substandard quality. See Section 27 06 00 Schedules for Communications Systems for a list of materials acceptable for use in NC State University projects.
- B. Construction details. Detail drawings describing various raceway components are available for download and modification by designers at the NCSU ComTech website.
- C. Standards. All work shall be in accordance with the latest edition of all applicable campus, State, and Federal regulations and codes. All work shall also be in accordance with the latest versions of the BICSI Outside Plant Design Reference Manual, with the BICSI TDMM manual, with the TIA-569 standard, and with the manufacturer's recommendations.
- D. New buildings. The design and construction of the building entrance ductbank for a new building to the nearest manhole should be included in the building project scope. The design and installation of the building entrance cabling is the responsibility of ComTech, and will not be included in the building construction scope. However, new building construction budgets will cover entrance cabling costs.
- E. Ductbank composition. The underground pathway system at NC State consists of a series of manholes and handholes connected by concrete encased ductbanks. These ductbanks include 4" and 1 ½" diameter PVC conduits. The entrance ductbank for a typical campus building is four 1 ½" conduits from the nearest telecommunications manhole to the building BDF.
- F. Single function. The inter-building communications ductbanks and manholes are to be used solely for the telecommunications cables described herein. They are not to be shared with electrical cabling, any low voltage system cabling, or any other utility. They shall not be used by other communications service providers to access campus buildings. The ductbank trench may be constructed as a joint telecommunications/electrical trench as long as there is

a minimum of 4" of concrete separating each telecommunications duct cell from any electrical duct cell.

- G. Construction methodology. Typically, all ductbanks constructed on campus will consist of PVC conduits encased in concrete. On occasion, when site considerations dictate, other underground installation methods may be employed. These include boring of metal casings under rail lines or roadways, directional boring, and other similar non-trenching methods. These should only be used when trenching is not feasible, and with approval from ComTech.
- H. Ductbank bends. A manhole or handhole should be installed in ductbank runs for every 180 degrees of conduit bends. The minimum bend radius which is acceptable at any point in the ductbank run (horizontally or vertically) is 12" (for 1 1/2" conduits). Ductbanks should be designed to allow for installation of very long sweep bends accomplished by heating and bending straight conduit sections. When factory elbow fittings are required, the bend radii for such fittings should not be less than those specified above.
- I. Tree protection. Ductbanks should be designed so as to remain outside of the drip line of existing trees.
- J. Manhole placement. Manholes or handholes should be installed at least every 300' in straight ductbank sections and every 150' in ductbank sections with at least 90 degrees of total conduit bends.
- K. Manhole type. Manholes and handholes shall be of pre-cast or cast-in-place concrete construction. Manhole size should be determined by the number of conduits connected to it. The designer should consult with Facilities and with ComTech on sizing of manholes to take into consideration master plans for that part of campus and the potential need for additional future ductbanks. Standard backbone manholes are typically 10' X 10' X 7'H. 8' X 8' X 7'H manholes may be used in less dense areas. For ductbanks serving a single building (with no potential for future additional runs) a 4' X 4' X 4' handhole can be used. For very small installation or for remote sites, polymer concrete "quazite" boxes with open (gravel) bottoms may be used. These should not exceed 18" X 30" in size, and only be used in areas with pedestrian (no vehicular) traffic.
- L. Interior hardware. Two cable racks are to be installed securely on the inside of each wall of the manhole or handhole. They are to be evenly spaced horizontally unless prevented by the location of the conduit penetrations. Two cable hooks are to be installed on each cable rack. A manhole ladder is to be installed inside each manhole. It is to be securely fastened with bolts and anchors to the neck (or top) and the bottom of the manhole. Each manhole and handhole is to be equipped with a minimum of four floor mounted pulling irons. No internal hardware is required for quazite boxes.
- M. Grounding. A grounding rod is required for each manhole, handhole, and quazite box. The rod should be installed in the bottom, typically into designated ground rod hole or into the sump opening. Each cable rack is to be properly bonded and grounded to the grounding rod in series using a #6 copper ground wire or bonding ribbon using bolted connectors.
- N. Covers. Round manhole covers are to be installed for all manholes and handholes, based on the type of pedestrian or vehicular traffic expected in the area. Covers are to be installed flush with the surface of streets and walkways. For non-paved surfaces, the covers are to be installed to ensure that positive water drainage away from the cover occurs. The contractor is to provide all items necessary, whether precast or masonry, to extend the rim and cover above the manhole or handhole to accomplish the above. All entrance extensions should be

sealed to prevent water infiltration. Covers for polymer concrete boxes should match the box selected. All covers should read "Communication".

- O. Building penetration. For new buildings, the entrance ductbank should be installed under the building slab and stubbed up vertically (4") through the floor of the BDF. Horizontal penetration into a below grade building area is also acceptable.
- P. Water infiltration. Entrance ductbanks should be designed so that water that may collect in the conduits will drain away from where the conduits enter the building. Whenever possible, the top of the manhole nearest to the building should be lower than the finished floor of the BDF. In addition, the manhole wall should be sealed around the conduit penetrations to prevent excess water infiltration.
- Q. Routing to the BDF. Entrance ductbanks which require less than 50' of entrance cable (measured from the point where the ductbank enters the building to the point of cable termination) may be constructed with EMT conduits run inside the building. For runs longer than 50', rigid or intermediate metal conduit and fittings shall be used. The portion of conduits installed in the building slab is not to be considered in the length calculations.

Conduit turns inside the building should be accomplished by conduit bends, not by installation of pull points at the bend. Pull points should be installed in the entrance conduit runs for every 180 degrees of conduit bends (including bends both inside and outside the building). These pull points should be installed only in straight conduit sections. For EMT conduit runs, these pull points should be constructed by installing junction boxes or straight sections of wireway along the run. For rigid metal conduit runs, they should be constructed by installing "Type C" condulets along the run. LB type (or similar) condulets should not be used.

- R. Ductbank construction. The following guidelines govern typical ductbank construction.
  - 1. Pre-trenching. Prior to any excavation activity, the contractor shall arrange for an approved utility locator service to locate and mark all public utilities on the project site. The contractor shall also coordinate with the Facilities to locate and mark university-owned utilities on the project site. Asphalt and concrete surfaces are to be sawcut along the ductbank route and at manhole and handhole locations. Removed materials are to be disposed of off campus and at no expense to the university by the contractor.
  - 2. Trenching. The contractor shall follow all OSHA trenching and excavation safety standards. Unsuitable materials are to be disposed of off campus and at no expense to the university by the contractor. These shall be promptly removed from the project site, without significant on-site stockpiling. In all areas where new ductbank crosses existing utilities of all types, hand excavation will be employed by the contractor as required.
  - 3. Utility damage. The contractor shall notify Facilities immediately if any existing utilities are damaged. Any existing utilities damaged shall be repaired by the contractor (or the owning public utility paid by the contractor) at no additional expense to the university. Repairs shall be made expeditiously to minimize inconvenience to the university and with methods and materials of the same or better quality than the existing.
  - 4. Conduit installation. All conduit installed shall be Schedule 40 PVC unless otherwise noted. Plastic spacers are to be installed every 5' to maintain minimum separations, vertically and horizontally, between adjacent conduits, and between the conduits and the sides, top, and bottom of the ductbank. The minimum required spacing between conduits is 2". The minimum required spacing between any conduit and any edge (side, top, or bottom) of the ductbank is 4".

5. Underpinning. Sections of #4 rebar shall be installed between the bottom of the conduits and the bottom edge of the ductbank. A minimum of 1 ½" of concrete should be maintained between the rebar and the bottom edge of the ductbank. Rebar should be installed longitudinally at 12" O.C. with cross members of #4 rebar installed every 60" O.C.
  6. Concrete pouring. The contractor shall have the installed conduits inspected and approved by Facilities or the Designer prior to pouring of concrete. 3,000 PSI concrete will be used to encase all university ductbanks. The concrete should be allowed to set for 24 hours minimum, prior to backfill.
  7. Warning tape. A continuous run of magnetically detectable underground marking tape shall be run directly above the ductbank at 12" below finished grade.
  8. Backfill. A minimum of 24" of cover is required above the top of the concrete in each ductbank run. This is measured to the top of final grade, and includes asphalt, concrete sidewalk, brick paver, seeded topsoil, and corresponding subgrade base layers. In roadway and walkway areas, at contractor discretion, controlled low strength material (CLSM), "flowable fill," may be used to backfill the trench. The contractor shall have the installed concrete encasement inspected and approved by Facilities or the Designer prior to installation of backfill material. Compaction of earth backfill shall be at least 98 – 100% maximum density, using the Modified Proctor Method at all locations. Compaction testing is to be performed by a geo-technical testing firm approved by NC State.
  9. Final construction items. Following ductbank installation, all construction debris should be removed from manholes. Also, a mandrel shall be pulled through each duct cell, and each duct cell cleaned of debris. Finally, a mule tape (high strength, conduit measuring tape of non-deteriorating material with footage markings) should be installed in each duct cell and secured to cable racks in each manhole or handhole.
- S. Site restoration – asphalt pavement. All asphalt pavement surfaces cut or damaged by the construction of the ductbank should be restored to pre-project conditions as much as possible. Methods used shall comply with the latest version of the NCDOT – Standard Specifications for Roads and Structures.
1. Subgrade preparation. The finished subgrade should provide a uniform bearing surface. The subgrade should remain in satisfactory condition and properly drained until surface courses are placed. Methods used shall be in accordance with the NCDOT Specifications Section 500.
  2. Aggregate base course. The aggregate base course (stone) shall comply with the applicable paragraphs of the NCDOT Specifications Section 520. The compacted base shall be a minimum of 6" thick.
  3. Bituminous concrete surface course. The spreading, compaction, and finishing of the surface course shall comply with the NCDOT Specifications Sections 610 and 645. The asphalt installed shall be type I-2 at a minimum compacted depth of 2".
  4. Tack coat. Application rates, methods of application, and curing shall be in accordance with NCDOT Specifications Section 605. Vertical surfaces shall be coated with AC-20 tack coat prior to paving operations to ensure proper bonding.
  5. Pavement markings. All pavement markings disturbed by the ductbank construction shall be replaced to match existing. All work will conform with the NCDOT Specifications Section 920.
- T. Site Restoration – Concrete sidewalks, and curb and gutters. Curb and gutters. Curb and gutter disturbed by the ductbank construction shall be constructed or repaired to match original conditions. Present alignment and grade should be maintained to promote drainage to existing curb inlets. The curb and gutters shall be constructed in accordance with the NCDOT Specifications Section 846.

Concrete sidewalks. Concrete sidewalks disturbed by the ductbank construction shall be constructed or repaired to match original conditions. The sidewalks shall be constructed in accordance with the NCDOT Specifications Section 848. In addition, sidewalks should have contraction joints spaced equal to width of the walk. A ½” expansion joint should be placed at all intersections and at locations where the walk abuts structures and other walks. Finally, walks should receive a light broom finish.

- U. Site restoration – brick areas. All brick areas damaged by the construction of the ductbank should be restored to pre-project conditions as much as possible.
  1. Brick pavers. Brick pavers disturbed by the ductbank construction shall be constructed or repaired to match original conditions.
  2. Reuse of existing. For small repair jobs, salvage, and re-use existing brick pavers. If additional pavers are required to complete the repair, they must match in color and size, and be added to the old brick in a random distribution. If brick cannot be salvaged, new brick must match existing in size and color. Any reuse of brick pavers is to be approved by Facilities. Where existing brick pavers are to be reused, the bricks are to be carefully removed, stored on pallets, and reinstalled as needed. Bricks that are chipped, cracked, broken, or otherwise marred are not to be reused.
  3. Pre-construction requirements. The contractor installing the brick paver should submit samples of each paver unit type to the designer for approval to illustrate color, surface finish, and texture. The gradients and elevations of the substrate should be verified so as to mate with the surrounding paver system.
  4. Brick materials. For pedestrian walkways, the paver material shall be solid, hard-burned, red-flash, ASTM C 902, SX (durability standard, SX is used where the brick may be frozen while saturated with water), Pedestrian and Light Traffic Paving Brick. The campus standard for running bond walks is Pine Hall, 3-5/8” x 7-5/8” x 2-1/4”, modular, full range, red flash pathway pavers. For heavy vehicular traffic areas, the paver material shall be solid, hard-burned, red-flash, ASTM C 1272, Type F, Heavy Vehicular Paving Brick. Do not use pavers with chips, cracks, voids, discolorations, or other defects, which might be visible in finished work. The campus standard for vehicular paving is Pine Hall, 4” x 8”, x 2-3/4” (For flexible base course applications), English Edge, heavy duty, full range, red flash pavers.
  5. Aggregate materials. The aggregate base course used shall comply with Section 520 of the NCDOT Specifications. Aggregate shall be a maximum diameter of 1-1/2” and conform to the gradation requirements of ASTM D-2940. See Aggregate Base Course Gradation Acceptance Ranges below.

Sieve Size	% Passing
1 1/2"	100
1"	75-97
1/2"	55-80
#4	35-55
#10	25-45

#40	14-30
#200a	4-12
#200b	4-10

Contractor must submit to Facilities that aggregate for base is from an NC DOT certified quarry. Contractor must submit to Facilities a test certificate from the quarry indicating 100% maximum dry density. Contractor must submit to Facilities a batch ticket from the quarry certifying that aggregate is ABC.

6. Other materials. The setting bed sand used shall be ASTM C33. Sand shall be free of salts and other deleterious materials to avoid efflorescence or staining. Dry sand-cement mixes and crushed screenings from quarry operations are not acceptable. The jointing sand used shall be ASTM C33. Sand shall be dry when used. Use white sand. Sand shall be screened, with a maximum particle size of 1/16". The filter fabric used shall be non-woven drainage geotextile, minimum 4-mil thickness.
7. Sub-grade installation. Sub-grade is to be installed so as to attain 95% compaction (of modified Proctor Density). Compaction must be achieved by use of a self-propelled steel-wheeled vibratory compactor. A plate tamper can be used if the area is less than 100 square feet. Contractor will notify Facilities when sub-grade preparation is complete. Facilities must approve the sub-grade preparation before the aggregate base course is applied. Facilities will verify that the sub-grade elevation is adequate to receive the specified full depth of aggregate base course required.
8. Aggregate base course installation. Aggregate base course is to be installed to a minimum standard depth of 8" (Sub-base testing to determine bearing strength is required to alter the minimum standard depth). 98% compaction is required. Course is to be installed in two maximum 4" lifts. Contractor is to wet and roll each 4" lift. Contractor will notify Facilities when stone base course is applied and compacted and is ready for inspection. Filter fabric is not to be applied until directed by Facilities. Facilities will coordinate compaction testing.
10. Sand setting bed installation. Sand setting bed shall be no more than 1" deep. Sand is to be swept over surface to fill joint irregularities, and then worked into place with a plate vibrator, continuing until joints are full. Brick surface is to be tamped smooth. Joints are to be refilled with sand after tamping and then tamped again. Repeat process until joints are filled. More than one day's worth of sand setting bed is not to be prepared. If any screeded bed is not paved by the end of the day, it should be removed and re-screeded the following day. The sand shall be screeded approximately 1/8 inch to 1/4 inch above the desired bed elevation to allow for compaction and settlement after the bricks are installed. Contractor will notify Facilities when sand setting bed is compacted, leveled, and ready for inspection, and will not apply brick pavers until directed by Facilities.
11. Filter fabric installation. Filter fabric should be installed between the aggregate base and sub-grade. Filter fabric can also be placed between the aggregate base and the setting bed if needed. Filter fabric shall overlap 12 inches at its ends. The fabric shall be laid out smooth, and cut to match the paving area. It shall cover the base and extend up the sides of the excavation to the top of the setting bed material.
12. Brick pavers installation. Widths of walks are nominal and do not require the cutting of brick to comply. Actual brick width of walk must be within one brick width, plus or minus. Brick pavers shall be set 1/8" to 1/4" above finished grade. Do not use less than 1/2 brick in any pavement area. Pavers shall be laid with a maximum 1/8" joint between pavers. All pavers to be cut with a diamond-bladed brick saw or brick snapping tool specifically designed to produce an accurate clean straight cut. Broken edges caused by masonry hammers will not be acceptable. The edges of adjacent pavers shall be flush.

Pavers adjacent to drainage inlets and channels shall not be lower than the top of the drain, and not more than ¼ inch above it. Standing water in any brick area is unacceptable. 2 % minimum slope is required on all brick paving. Slopes less than this may require additional subsurface drainage. 2% maximum cross-slope is allowed. Edge restraints should consist of a brick sailor course, either level with adjacent sidewalk where lawn abuts sidewalk, or 2" above adjacent sidewalk where a mulched area abuts the sidewalk, set in a bed of mortar. Where sidewalk abuts curb and gutter, no additional edge restraint is required. Edge restraints shall be installed before pavers are installed.

13. Cleaning. Soiled areas of the paver surface should be cleaned with an appropriate cleaning solution. The cleaning process should not harm the pavers, joint materials, or adjacent surfaces. Non-metallic tools should be used in the cleaning operation. Surfaces should be rinsed with clean water and broom swept clean. Pedestrian traffic should not be permitted on the paver for at least 48 hours after final completion.

V. Site restoration – grass areas. All grass areas damaged by the construction of the ductbank should be restored to pre-project conditions as much as possible.

1. Acceptance. The final authority for the acceptance of the restoration work and the practices used for grass areas is Facilities. The contractor shall ensure a uniform stand of specified turf no less than 30 days after germination. Upon final acceptance, Landscape Services will assume responsibility for maintenance of the work. Intermediate inspection and acceptance of the work by Landscape Services is required at the following milestones: 1) after installation of the subsoil and topsoil, and 2) at the removal of the Certified Seed Tag from the seed being placed – witnessed by Facilities. At the discretion of Facilities, the contractor may be required to submit a list of proposed materials, together with such samples as may be requested.
2. Subsoil. All areas should be subsoiled to a depth of 6". Subsoils should be used which are closely related to existing soils in the area, and should be compacted to 85% density. Subsoils should not be worked under frozen, muddy, or saturated conditions. Immediately prior to the dumping and spreading of the topsoil, at least the top 2" of the subsoil should be loosened or scarified to permit bonding of the topsoil to the subsoil.
3. Topsoil materials. The contractor should furnish soil which is fertile, friable, natural loam surface soil. Existing topsoil removed during excavation may be used upon approval from Facilities. New topsoil shall not have more than 20% subsoil, and shall not contain slag, cinders, stones, lumps of soil, sticks, roots, trash, or other extraneous materials larger than 1" in diameter or length. It shall also be free of plants or plant parts of: kudzu, quackgrass, Johnson grass, nut sedge, poison ivy, or other noxious weeds.
4. Topsoil installation. Topsoil should be uniformly distributed to a depth of 4" after firming. The topsoil should be graded to match the surrounding drainage scheme. Upon completion of grading, the area should be cleared of all grade stakes, surface trash, or other objects which would hinder the maintenance of the seeded areas.
5. Seeding materials. Since the exact composition of seed materials is site and season dependent, the type used will be determined by Facilities on a case by case basis. The two typical seed compositions used on campus are: Unhulled Bermuda, seeded at a rate of 2 lbs./1,000 sq. ft. with overseed of Annual Rye at a rate of 5 lbs./1,000 sq. ft. and Tall Fescue, seeded at a rate of 6 lbs./1,000 sq. ft. All seed shall be 95% pure with 85% germination. Seed shall be fresh, clean, new crop seed complying with the tolerance for purity and germination established by the Official Seed Analysis of North America. Wet or moldy seed shall not be used. Seed mulch shall be clean wheat straw.
6. Seeding. Seed should be lightly disced or raked into top 1" of topsoil. Clean wheat straw should be applied as mulch at a rate of 45 lbs./1,000 sq. ft. Emulsified asphalt tack should be installed in sufficient quantities to hold straw in place.

7. Warranty. Any seeding requiring correction shall be reseeded by the contractor up to one year following the completion of the project at no expense to the university.
- W. Site restoration – site equipment. All fencing damaged or removed as part of ductbank construction shall be restored to original conditions. Other on-site equipment damaged or relocated during the ductbank construction shall be restored to original conditions, including supports. These include: signs, outdoor furniture, planters, and other similar items.
- X. Site management. Management of ductbank construction sites should be managed as follows:
1. Cleanliness. Contractors will be required to maintain a clean work site at all times during, and upon completion of, construction. Sites shall remain clear of excess debris, surplus materials, and tools and equipment not in active use. Contractors will be responsible for cleaning campus streets and walks of any debris, dirt, or mud resulting from construction and contractor's vehicle traffic. Catch basins should be protected or covered to eliminate dirt, mud, asphalt, and tack from entering them. Any materials that do enter catch basins shall be cleaned out by the contractor at no expense to the university.
  2. Vehicle traffic. Contractors shall be responsible to coordinate all closings of parking lots and streets with the NCSU Transportation. Contractors will be required to make arrangements for closings at least two full working days prior to closure. Street closures shall also require notification to Transportation in order that emergency vehicles may be properly rerouted. Contractors shall maintain continuous, safe vehicular traffic flow through and adjacent to the project site. This includes, but is not limited to, use of flagmen, signage, barricades, cones, and lighting. Contractors will be responsible to provide all such equipment and will not be allowed to use university equipment for such purposes. Areas where sawcut asphalt has been removed may not be left open for vehicle traffic unless backfilled with stone or flowable fill. Warning signs will be required to alert traffic of uneven surface.
  3. Pedestrian traffic and safety. Contractors shall be responsible for ensuring that all sites are properly equipped with warning and barricade equipment at all times. Detours for pedestrian walkways are to be properly planned with considerations given to handicapped access. They are to be approved by the university, and clearly marked and barricaded. No handmade signs will be allowed.
  4. Tree protection. Contractors will not stockpile debris or surplus materials, or park vehicles or equipment under trees. Care should be taken to ensure tree limbs are not damaged by vehicles or equipment. No trees or shrubs may be removed without prior university approval.
- Y. Inter-building cabling installation. For new campus buildings, design and installation of entrance cables will be managed or performed by ComTech. ComTech will coordinate directly with AT&T on the design and installation of the telephone entrance cable. The architect or contractor will not coordinate work with a AT&T BICS engineer as is customary in new commercial building projects. ComTech will also install the fiber optic entrance cable to the building from the nearest MDF.

All cables should be neatly routed and fastened to cable hooks in all manholes and handholes. New pull strings should be installed with all cable pulls. In each manhole or handhole, cables should be installed with one revolution of slack loop unless prevented by space limitations.

Fiber optic cables should be installed in 1" plastic innerduct when run in 4" conduits in campus backbone ductbanks. They should be run without innerduct in 1 ½" conduits. New pull strings should be installed both inside and outside of all innerducts. Multiple cables

should be pulled in each innerduct until full. Fiber optic cables should be labeled in each manhole or handhole with a permanent, waterproof, wrap-around tag, denoting size, type, and both end destinations of the cable.

The innerduct containing the fiber optic entrance cable should be routed from the entry point into the BDF to the nearest ladder rack. It should be fastened to overhead ladder racks to reach the equipment rack where the cable is to be terminated. An additional 10ft. (minimum) cable slack loop should be installed and fastened to overhead ladder racks, and secured with Velcro cable ties.