APPENDIX F

NOISE WALL FEATURES AND MATERIALS

NOISE WALL FEATURES AND MATERIALS

GENERAL LANGUAGE TO BE INCLUDED IN DESIGN NOISE REPORTS

It is essential that the type of noise wall selected at any particular location consider a variety of factors. For each wall determined to be feasible and reasonable and receiving a positive response from benefited property owners and tenants, NCDOT's selection of the wall's material and type; the specifics of its horizontal and vertical geometrics; and its texture and color will be based upon the consideration of:

- Acoustical requirements of the wall, including its acoustical profile and its surface requirements;
- The wall's proposed location on the project;
- Controls related to other project elements, such as constraints imposed by drainage features, locations of utilities, etc.;
- Potential maintenance implications; and
- Any input received from the public or its representatives during the project's development phases.

The design and construction of each selected wall will adhere to specific NCDOT guidance aimed at producing a wall with an aesthetic appearance from both a geometric and visual standpoint, while meeting all NCDOT acoustical, structural, engineering, and maintenance requirements.

In the Design Noise Report, it is suggested that the following language be included:

The acoustical design developed as part of the final design noise analysis process established an acoustical profile for each feasible and reasonable noise wall recommended for construction as part of this project. These acoustical profiles were the basis upon which wall envelope drawings were developed and the wall envelope drawings will be the basis upon which the selected contractor will develop shop drawings for approval by NCDOT. During the development of the project plans, specifications, and estimates (PS&E) submission, NCDOT will determine the material type(s) and aesthetic design of each project noise wall.

If such data is available at the time that the Design Noise Report is being finalized, include the following paragraph and table in the noise report. Examples in the table are for illustrative purposes only.

The following table summarizes the determinations made to date related to wall types, wall materials, and aesthetic treatment for each noise wall determined to be feasible and reasonable:

Wall I.D.	Wall Material		Wall Type	Wall Location	Panel Type	Wall Panel Surface Treatment				Include Photo, if available
						Texture		Color		
	Panels	Posts				Community Side	Highway Side	Community Side	Highway Side	
NW1	Precast Concrete	Concrete	Post and Panel	Ground-mounted	Full Height	Standard Brick Formliner	Standard Brick Formliner	Red (Brick #xxxxx)	Red (Brick #xxxxx)	
NW2	Precast Concrete	Steel	Post and Panel	On Bridge	Full Height	Dry Stack Stone Formliner	Dry Stack Stone Formliner	Brown (Federal Color #xxxx)	Brown (Federal Color #xxxx)	
NW3	Precast Concrete	Steel	Post and Panel	In Front of Retaining Wall	Stacked	Ashlar Stone Absorptive	Ashlar Stone Absorptive	Tan (Federal Color #xxxxx)	Tan (Federal Color #xxxxx)	
NW4	Precast Concrete	Concrete	Cast-in-place	Behind Retaining Wall	Full Height	Used Brick Formliner	Used Brick Formliner	Tan (Federal Color #xxxxx)	Tan (Federal Color #xxxxx)	
NW5	Precast Concrete	Concrete	Cast-in-place	Ground-mounted	Stacked	Dry Stack Stone Formliner	Dry Stack Stone Formliner	Tan (Federal Color #xxxxx)	Tan (Federal Color #xxxxx)	
NW6	Partial Transparent	Concrete	Post and Panel	Ground-mounted	Stacked	Ashlar Stone & Transparent	Ashlar Stone & Transparent	Tan (Federal Color #xxxxx)	Tan (Federal Color #xxxxx)	

NOISE ABATEMENT PRODUCTS AND OPTIONS

GENERAL: It is essential that the type of noise wall selected at any particular location consider a variety of factors. Too often, a wall's material and type; the specifics of its horizontal and vertical geometrics; and its texture and/or color are selected without regard to its production, transportation, and construction requirements; controls on the construction site; the construction requirements of the wall; its proposed location on the project; controls related to other project elements; or potential maintenance implications. NCDOT must consider a variety of factors when selecting a pallet of acceptable wall products and material types to be considered (and possibly presented to an impacted community) for a particular project. Therefore, no single wall type, product, material or pallet of options is appropriate in all cases. Instead, the determination of the product and material is contingent upon the factors discussed below.

NOISE WALL TYPE AND MATERIAL

1. Reflective Walls

If the wall surface is reflective, many wall products are available. NCDOT currently constructs walls that conform to the following:

- Standard NCDOT concrete panel walls per Standard Drawings SBW1 through SBW5
- Non-standard wall designs from NCDOT Approved Products List
- Other proprietary walls requested by an NCDOT Division

For reflective walls, the selection of the desired material is most likely based on:

- *Aesthetic Factors* - The desired aesthetic appearance on both sides – Concrete and composite material walls provide the flexibility of creating different textures and colors on both sides, while metal and wood walls generally limit the side-to-side variations to just color. Due to their integral pigmentation, plastic walls are generally limited to the same color on both sides.
- *Structural Factors* – Ground-mounted walls are usually not constrained by material weight but are usually limited in height to 25 feet due to cost implications associated with increased foundation and post sizes required for walls above this height. Walls mounted on bridges are limited by their weight, which affects the dead load placed on the structure, and more critically by their height, which affects the overturning moment placed on the structure due to wind loading. The use of lightweight aggregate in concrete noise walls is sometimes used to reduce weight. However, such a weight reduction is usually not substantial, and therefore, the use of a non-concrete wall is often required. Noise walls on existing and proposed bridges will be determined by NCDOT on a case-by-case basis. Noise walls mounted above and behind a retaining wall are treated as ground-mounted walls. The weight of noise walls does not significantly affect a retaining wall. The effects of wind loads on a retaining wall depend on the type of retaining wall. Overturning, bearing capacity, sliding and internal stability might all be affected. However, retaining walls can be designed to resist these loads. Noise walls above and behind existing retaining walls are discouraged. Coordination with NCDOT shall occur prior to noise wall modeling above and behind all retaining walls.
- *Maintenance Considerations* – Material and noise wall type selection is influenced by the ability to keep the wall performing throughout its design life and to maintain its aesthetic qualities. Factors usually considered in this selection process include:

    a. <u>The ability to protect the noise wall from potential damage caused by errant vehicles</u>. For ground-mounted walls inside the acceptable clearance zone (usually 30 feet from the roadway) this is often accomplished by placing a concrete safety barrier in front of the wall (preferred) or by incorporating the protective barrier into the design of the noise wall itself. Noise walls and retaining walls are separated horizontally by a minimum of 6 feet and a concrete wall is typically placed on the traffic side of the noise wall (opposite side of the retaining wall). Noise walls constructed on bridges are mounted either on top of the bridge parapet, attached to the outside of the bridge parapet, or supported on an extended deck slab beyond the bridge parapet. The former option presents the most potential for damage to the noise wall, while the latter option provides the most protection for the noise wall. The last two options also provide advantages over the first option in terms of developing the acoustical profile of the wall (to be

discussed later). On rare occasions where an existing structure cannot support the loads associated with a required noise wall, an independent parallel supporting beam could potentially be used to carry the noise wall across a span.

b. The ability to maintain the physical appearance of the wall. Material selection must consider the potential for the wall to be vandalized by graffiti, damaged by fire, or affected by termites (wood walls) and its potential to be damaged by normal NCDOT operations such as lawn mowing, snow removal, use of deicing and anti-skid materials, etc. While the potential for a wall to be "hit" by "graffiti artists" cannot be eliminated, the choice of a rougher surface or a surface with a deeper pattern relief may tend to defer such hits as compared to a smoother surface. Graffiti removal can be aided by application of either a permanent or a sacrificial anti-graffiti coating. During the graffiti removal process, a sacrificial coating gets removed along with the graffiti and must be reapplied. A permanent coating allows for removal of graffiti without the need for reapplying the coating afterwards. Anti-graffiti coatings may be either clear (as typically applied to an exposed aggregate surface) or pigmented (allowing the color to be obtained by the anti-graffiti coating in lieu of a penetrating stain that provides less anti-graffiti protection). ***If graffiti is to be removed via sand blasting, then the use of a permanent anti-graffiti coating may be appropriate. If graffiti is to be painted over, then neither a sacrificial nor a permanent anti-graffiti coating should be used and a penetrating stain should be considered. Dependent upon the color of the stain, some shadowing of the covered-over graffiti may still be apparent after re-staining.***

2. Absorptive Walls

If the wall surface is required to be absorptive, noise wall products are limited to those contained on the NCDOT Approved Products List. Most absorptive panels used in highway applications are proprietary products comprised of composite materials (wood-impregnated concrete, rubberized materials), although several metal and plastic products with absorptive filling material are also available. Although the composite materials allow somewhat less options for surface textures, they still permit a wide variety of formliner finishes and stained colors to be utilized. Metal and plastic absorptive wall surfaces have the same color and texture limitations as those listed above for their reflected wall counterparts. More attention is typically paid to the surface textures of composite material absorptive noise walls since anti-graffiti coatings must not be applied to absorptive surfaces and color is obtained either integrally or via use of a penetrating stain. In addition, more attention is warranted when deciding on the location and protection of an absorptive-faced wall since it is typically constructed of materials that are softer and/or more susceptible to damage from the conditions noted above.

3. Transparent Walls

Transparent noise wall products are even more limited and must be contained on the NCDOT Approved Products List. Most products on the market today that are used in highway applications use materials that will not show discoloration over time and will retain their transparency. These wall types should be capable of being self-cleaned (of normal dirt) to the extent possible, and therefore overhanging caps are not recommended for use with transparent panels since the caps limit normal cleansing by rain of the upper portions of the panels. Often, wire strands are placed within transparent wall panels to minimize the potential for bird strikes. Transparent panels have been used in ground-mounted and structure-mounted applications, and have been erected as fully transparent walls as well

as in combination with other wall materials (top panels transparent, bottom panels solid). The application of transparent noise walls requires the same considerations related to protection and maintenance as previously discussed.

WALL CONFIGURATIONS AND SIZES

In addition to the consideration of the factors discussed above that may affect the type and material selected for a noise wall, wall component selection may be influenced by other factors discussed below.

1. Transportation of Wall Components from the Supplier to the Project Site

The dimensions of wall panels are controlled by restrictions dictated by highway overpass clearances and wide load restrictions. While full height panels may be shipped flat via a tractor trailer, panel widths of more than 8 feet to 10 feet will typically require a wide load permit. Therefore, many noise wall panel suppliers utilize special A-frame equipped trailers that enable shipment of panels up to 12 feet by 24 feet [based upon conversation with precaster]. These clearance requirements usually cease to be a problem if using stacked panels. Transportation of posts and other wall components does not usually result in issues that affect the section of a particular wall type.

2. Type of Panels Used

Smaller height panels (2, 4, and 6 feet as referenced in NCDOT Standard Drawings SBW2 and SBW5) enable use of post spacing of 10 feet and 15 feet for NCDOT standard precast concrete panels and 20 feet for panels supplied by third party venders. Depending upon the noise wall height required, full height panels may or may not be capable of being used with 15 or 20 feet post spacing. Full height panels have the advantages of eliminating joints between panels, enabling more options in terms of wall textures, and reducing the effects of variation in color or texture of adjacent panels. Their possible disadvantages include requiring more posts, requiring heavier equipment to set panels, and requiring more overhead clearance for panel installation. Stacked panels have the advantages of possibly requiring smaller equipment to place, requiring less vertical clearance to set, and often enabling greater post spacing resulting in fewer posts. Their disadvantages include the need to provide light-tight joints between panels, the need to select wall textures that incorporate the location of horizontal joints in the design, more lifts to complete the wall, and more quality control to assure consistency among stacked panels.

It is recommended that, except for locations where large differences in wall elevations between spans are unavoidable due to topographic conditions, sloped top walls be avoided. Stepping of panels in a manner similar to that illustrated in NCDOT Standard Drawings SBW1 and SBW4 is recommended, following the direction provided in Section C.4 of the *Sample NCDOT Design-Build Noise Special Provision.*

When it is desirable to have the top profile of a noise wall mirror the roadway profile, such a design should be accomplished with stepped panels, not sloped top panels, for the following reasons:

- Wall panels are erected in a plumb position
- Sloping the wall panel's top to match the roadway profile can require the casting of multiple trapezoidal-shaped panels, rather than rectangular panels
- Wall posts have horizontal tops and are erected plumb, causing possible visual problems when supporting sloped-top panels on either side

Noise walls erected on structures present special challenges other than the loading and wall protection conditions previously discussed. If possible, it is preferable to mount noise walls on the outside of bridge parapets using one of the methods previously discussed. Doing so eliminates the problem of matching the grade of the parapet top (usually not truly horizontal) with a rectangular panel's horizontal bottom. The resultant gap between the panel and the parapet often requires caulking or some other sealant to eliminate noise leakage through the wall. While such a technique requires additional panel square footage, it usually simplifies the attachment process and hides the normally unfinished community side of the bridge parapet with the more aesthetically pleasing noise wall surface. Any gaps between the bottom of the wall and the extended deck slab will not require sealing.

PROJECT-RELATED EFFECTS ON NOISE WALL SELECTION

Access to a construction site and requirements to maintain traffic during noise wall construction may affect the type of wall selected. These types of controls could limit routes by which wall materials are delivered to their ultimate location on the project. One example could be where a wall is being constructed on top of a high cut slope or behind a row of trees where the use of a large crane is precluded via overhead clearances or other factors. A construction access road to the location may only allow smaller pieces of equipment to be used to transport and/or set the panels, dictating the use of stacked versus full height panels. If larger pieces of equipment required to set a full height panel are restricted from safely operating due to the proximity of traffic, use of smaller equipment may be the only option, dictating the use of smaller stacked panels or other types of walls having smaller sized components.

Overhead utilities may similarly restrict lifting of noise wall panels, either full height or stacked. In such cases, special post designs (usually steel) may be required to enable panels to be slid into position rather than being lifted. Such conditions may also be encountered where walls are required to be placed underneath an overpassing roadway structure. Either of these situations may dictate the use of a cast in place, a masonry block wall, or a wall that can be more easily constructed with lighter weight materials and/or smaller sized components. Underground utilities or drainage facilities may require an adjustment of post spacing, the use of spread footings, or the use of a post-less type of wall.

NOISE WALL SURFACE TEXTURE

This discussion is limited to the surface textures of concrete and composite material noise walls since the surface textures associated with metal, wood, masonry block, brick, and plastic walls are defined by their materials that provide little if any opportunity to modify their surface texture characteristics. Various techniques are employed to create textures on concrete and composite wall surfaces. They include:

1. ***Mechanically created textures***. These type of methods include floating operations to create a smooth surface; raking, dragging, brooming, or brushing a surface to create a rough texture; and stamping a surface to create a particular texture (such as a brick pattern). These techniques are performed on the top side of a horizontally cast panel in a precast bed.

2. ***Exposed aggregate textures***. These textures are created by exposing a specific type of aggregate that is contained in the wall's concrete. Exposed aggregate surfaces can be created on either or both sides of a wall panel. The bottom of a wall's form is treated with a release agent that keeps the concrete surface soft during the initial stage of curing. The stronger the release agent, the more exposure of aggregate is possible, thus a variety of exposures can be accomplished by selecting the appropriate release agent strength. Following the panel's initial cure, the panel is removed from the form and the downside is washed with water applied at high pressure, removing the soft surface concrete and exposing the aggregate. Should an exposed aggregate be desired on the top side of a horizontally formed panel, the aggregate is hand seeded into the top wall surface. A better surface is usually obtained through exposing the aggregate on the bottom side of the panel.

3. ***Textures created by formliners***. Formliners are molds used to reproduce a desired texture and design on the surface of a noise wall. Those used in highway noise wall production are usually made of elastomeric polyurethane material capable of up to 100 re-uses. There are a vast number of standard textures available from formliner suppliers and specialized formliners can be produced to replicate almost any desired surface texture. Specialized formliners are also available to enable the insertion of thin brick veneers. Some standard formliner sizes include 4' x 8', 4' x 10', and 8' x 12', with optional sizes available. While formliners are most often used to produce a pattern on the downside of a horizontally cast panel, they can also be used to produce a pattern on the top side via stamping the impression into the surface. This enables a noise wall to be produced with one formliner surface on one side and another formliner surface on the opposite side. While better definition is usually obtained on the downside of a wall, acceptable definition can be obtained from use of a stamped in formliner on a wall's top side. Walls are occasionally cast in a vertical position using formliners. Multiple formliners may need to be joined together depending upon the size of the wall being produced. Techniques are available related to joining formliners and attaching them to the formwork, and should be specified, to assure that formliner joints are not visible in the finished product.

4. ***Retaining Walls***. The surface texture of retaining walls shall be compatible with the surface texture of adjacent or nearby noise walls.

Further information can be obtained by contacting one of the following formliner suppliers:

- Architectural Polymers http://www.apformliner.com/
- Custom Rock http://www.customrock.com/
- Fitzgerald http://www.formliners.com/
- Scott System http://www.scottsystem.com/
- Spec Formliners http://www.specformliners.com/
- U.S. Formliner http://www.usformliner.com/
- American Formliners http://www.americanformliners.com/

In developing noise wall surface textures, the following suggestions are made:

- Match cast formliners to hide joints
- Use horizontal patterns (brick, shipboard, lap siding, etc.) so as to minimize the appearance of joints between stacked panels and formliner joints
- If surfaces such as exposed aggregate or mechanically produced surfaces are used in stacked panel designs, position panel joints to provide horizontal joints that line up between adjacent spans of the wall system
- Maintain the consistency of horizontal patterns between adjacent wall spans
- Where possible, match cast panels to help hide joints between adjacent stacked panels

NOISE WALL COLORS

The colors of noise wall component surfaces are obtained using a variety of methods including:

1. Through the natural materials of the wall, such as occur in wood posts and panels, exposed aggregate posts and panels, integral colors of metal and plastic wall systems, etc.
2. Use of clear coatings or penetrating stains applied to wood, concrete, and composite wall posts and panels
3. Application of pigmented anti-graffiti coatings on reflective walls only
4. Painting of reflective walls only
5. Use of pigmented concrete

Colors should be specified using Federal Color Numbers or some other recognized color identification system.

The color of noise walls shall be compatible with the color of adjacent retaining walls.

Important note regarding retaining walls: Getting the finish (texture, stain) on noise wall panels to match the retaining wall facing takes significant coordination especially since retaining walls are added to projects at various stages of design.

REFERENCE MATERIAL

- Expanded discussions of all aspects of noise wall materials, designs, and construction contained within the FHWA *Highway Noise Barrier Design Handbook* (http://www.fhwa.dot.gov/environment/noise/noise_barriers/design_construction/design/design00.cfm).