Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-02/2113-3		

4. Title and Subtitle	5. Report Date
GUIDELINES FOR AESTHETIC DESIGN IN HIGHWAY CORRIDORS: TOOLS AND TREATMENTS FOR TEXAS HIGHWAYS	September 2001
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
James R. Schutt, Kimberly L. Phillips and Harlow C. Landphair	Report 2113-3

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135	11. Contract or Grant No. Project No. 0-2113

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Texas Department of Transportation Research and Technology Implementation Office P. O. Box 5080 Austin Texas 78763-5080	Research: September 2000-August 2001
	14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the Texas Department of Transportation and U.S. Department of Transportation, Federal Highway Administration.

Research Project Title: Develop Cost-Effective Plans to Add Aesthetically Pleasing Features to Transportation Projects

16. Abstract

This study evaluated the nature of aesthetic treatments and elements, which have been used or may have application within the highway roadway. It also studied the literature concerning aesthetics and current practice within the Texas Department of Transportation (TxDOT) and other State Departments of Transportation (DOTs). The use of specific aesthetic enhancements is highly dependent on individual-based design decisions that may be based on personal biases, past experience, tradition, and local climate. It was found that most efforts appear to be not widely discussed within the DOTs, and pertinent information regarding the use of specific practices is not systematically shared, even with a district office. A review of the existing literature and DOT manuals did not find any guidance on how to use specific treatments or elements, nor did the research find any published material on assessing or evaluating proposed aesthetic improvements within the roadway. The researchers used conceptual approaches to human visual perception from the fields of Environmental Psychology and Human Factors Research to design a methodological approach to aesthetic decision making. The approach applies the visual perception framework of complexity, coherency, legibility, and mystery to the highway roadway. These concepts will aid in developing appropriate evaluative questions that focus on the effect of aesthetics on driver performance. The report includes aesthetic guidelines on how to apply this approach and specific technical data on 25 aesthetic treatments or elements under the following categories: poured-in-place concrete, modular concrete, veneers, paving traffic barriers, asphalt, pedestrian barriers, lighting, site amenties, and public art. The guidelines and data sheets will be included in TxDOT's on-line *Landscape and Aesthetic Design Manual*.

17. Key Words	18. Distribution Statement
Highway Aesthetics, Highway Visual Quality, Aesthetics Planning, Aesthetic Design, Roadside Landscaping, Driver Performance, Roadside Design, Landscape Aesthetics, Highway Landscape Design	No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	94	

GUIDELINES FOR AESTHETIC DESIGN IN HIGHWAY CORRIDORS: TOOLS AND TREATMENTS FOR TEXAS HIGHWAYS

by

James R. Schutt
Assistant Research Scientist
Texas Transportation Institute

Kimberly L. Phillips
Associate Transportation Researcher
Texas Transportation Institute

and

Harlow C. Landphair
Research Scientist
Texas Transportation Institute

Report 2113-3
Project Number 0-2113
Research Project Title: Develop Cost-Effective Plans to Add Aesthetically Pleasing Features to Transportation Projects

Sponsored by the
Texas Department of Transportation
In Cooperation with the
U.S. Department of Transportation
Federal Highway Administration

September 2001

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Texas Department of Transportation (TxDOT) or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation. The United States government and the State of Texas do not endorse products or manufacturers. Trade or manufacturer's names appear herein solely because they are considered essential to the object of this report. The researcher in charge of the project was James R. Schutt.

There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract, including any art, method, process, machine, manufacture, design, or composition of matter, or any new useful improvement thereof, or any variety of plant, which is or may be patentable under the patent laws of the United States of America or any foreign country.

ACKNOWLEDGMENTS

The authors would like to thank the project director, Steve Walker, for his support and guidance on this project. Special thanks go to Bill Kirwin, Pat Haigh, Mark Bloshock, Herb Neiman, and Maury Jabob for their thoughtful reviews and insights. Thanks also to the district landscape architects and other personnel who graciously gave of their time to assist the project.

Finally, we wish to express our appreciation to TxDOT and the Federal Highway Administration for their financial support.

TABLE OF CONTENTS

LITERATURE REVIEW 1

Literature of Highway Aesthetics 1
Literature Regarding the Specifics of Aesthetic Elements 3

CUSTOMER SURVEY 7

Methodology 7
Results 7
Conclusions 9

NATIONAL CURRENT PRACTICE SURVEY 11

Methodology 11
Results 12
Acid Stain 12
Concrete Stain 12
Colored/Textured Concrete 12
Pavers 12
Stone 13
Material Finishes 13
Public Art 13
Form Liners 13
Ornamental Fencing 13
Trellis Systems 14
Lighting 14
Site Features 14
Other 14
Review of Printed Material 14
Conclusion 15

TxDOT LANDSCAPE ARCHITECTS SURVEY 17

Methodology 17
Results 17
Sealer Stain 17
Acid Stain 18
Integral Color 18
Hardened Colored Concrete 18
Thin-Set Pavers or Stone Applications 19
Texture 19
Patterned Concrete 19
Form Liners 19
Sandblasting 20
Rub Finish 20
Veneers 20
Concrete Masonry Walls 20

Modular Block 20
Brick Pavers 20
Concrete Pavers 21
Asphalt Paving 21
Traffic Barriers 21
Fencing 21
Lighting 21
Furniture 22
Artwork 22
Other 22
Conclusion 23

RECOMMENDATIONS FOR A METHODOLOGICAL APPROACH TO AESTHETICS DESIGN 25

Preference Framework 25

AESTHETIC GUIDELINES 29

Introduction 29
Where to Start in Aesthetics Design 29
Communication and Visual Perception 29
Visual Quality 30
Effects of Scale on Aesthetics Selection 34
The Community's Role in Highway Aesthetics 36

AESTHETIC TREATMENTS FOR TEXAS HIGHWAYS 37

Introduction 37
Technical Data Descriptions (Tech Sheets) 38

CONCLUSION 81

REFERENCES 83

LITERATURE REVIEW

LITERATURE OF HIGHWAY AESTHETICS

In 1920 there were nearly eight million automobiles throughout the United States, about one for every four families and these were traversing about 369,000 miles of roads (Lewis 1997). Even though highways were not new at this date, much of the aesthetics of the roadway was still found in the driving experience of itself. Indeed, some early roads were designed to function more like parks for the driving experience than for their utilitarian goals. These were the "parkways" of the early twentieth century. First proposed by Frederick Law Olmstead and Calvert Vaux, these parkways were made famous by Robert Moses and typified by his Long Island Parkway.

The parkway is characterized as "an organic integration of architecture, landscape design, and engineering. In the development of this vision, Moses ordered light poles and barrier posts to be hewn from massive logs. He wanted stained brown signs mounted on rustic wooden standards and each of the hundred bridges and overpasses to be faced with a different pattern of granite. Flowering bushes and dogwoods were planted along the roadway, and gasoline stations and maintenance buildings were to be built of stone and topped with slate and copper roofs (Lewis 1997). By the mid-1920s, however, increasing speeds and a growing usage began to turn parkways into wider highways.

By the end of World War I, the country's roads were in poor shape due to neglect during the war and damage caused by military vehicles. In 1919, Thomas MacDonald took over the existing Bureau of Public Roads, charged with the task of creating a national road system. The American Association of State Highway and Transportation Officials (AASHTO) had already been established in 1914, and MacDonald immediately established the Highway Research Board to study the economics, traffic, maintenance, and materials of the highway (Lewis 1997). As organization came to highway design and construction, aesthetics returned as an important element of roadway design.

The AASHTO Committee on Roadside Beautification held it first meeting in 1930 and adopted a resolution targeting roadside beautification. The resolution addressed conservation of natural growth, beautifying town entrances, roadside plantings, the establishment of parks and comfort stations, and the promotion of "activities that will improve and give the public better use of roadsides" (Neale 1937). The committee published reports that, in addition to the vegetation aspects of the roadside, focused on "the harmonious integration of engineering, architecture, and landscape design" (Neale 1944, Sutton 1947).

As the interstate highway system grew through the 1950s and became a commanding presence in some urban areas, the visual aspects of highway planning and design increasingly became an important issue. In the early 1960s some communities, alarmed at the impact some of the new highways were having on their urban centers, particularly areas of historical importance, forced significant changes to some proposed projects (Lewis 1997). Publications of the day began to focus increasingly on the impact of the highway on urban areas. Writers discussed how the highway was affecting settlement patterns and the need to harmonize the relationship between the highway, open-spaces, commercial developments, housing, and historical sites (Tunnard and Pushkarev 1963). Architectural designers, such as Appleyard, discussed the highway as a

platform for experiencing the city and considered the highway a corridor of motion that creates a sequential rhythm that they expressed in a unique notation system (Appleyard et al. 1964).

The emphasis on the design relationships between cities and transportation systems was further promoted in 1977 by the creation of the Task Force on Design, Art, and Architecture in Transportation in the Office of the Secretary of the U. S. Department of Transportation. The committee published three annual reports that focused on ways to incorporate art works and improved design into transportation facilities through research, increased funding, improved procedures, use of graphics, and training for designers (Swinburn 1979). These reports culminated in the publication of *Aesthetics in Transportation* (Heder and Shoshkes 1980). This set of guidelines focused heavily on the inclusion of art into transportation through the use of paintings, sculpture, murals, and unique materials in addition to the integration of highway form into the urban fabric. The guide did not provide a standardization of physical elements but provided case studies to act as guides for "best qualified artists and designers."

In recent years, the most comprehensive approaches to aesthetics in roadway design have been from the AASHTO and the Federal Highway Administration (FHWA 1997). AASHTO's early publication, *A Policy on Geometric Design of Rural Highways* in 1954 has evolved to what is known today as the "Green Book" and considered by many to be the "bible" of highway design, *A Policy on Geometric Design of Highways and Streets* (AASHTO 1994). The current edition includes specific reference to aesthetic design regarding alignment, interchanges, landscaping, and medians. A later companion publication, *Guide for Highway Landscape and Environmental Design* (AASHTO 1970), dealt more specifically with aesthetics in alignment and landscaping. This work was replaced by *A Guide for Transportation Landscape and Environmental Design* (AASHTO 1991), an informative, broad-brush reference on design aesthetics dealing with a wide range of roadway issues and structures.

The most recent effort to promote a comprehensive approach to roadway design and increase the focus on aesthetics is found in *Flexibility in Highway Design* (FHWA 1997). This manual covers many aspects of aesthetic consideration, including alignment, cross-sectional design, innovative use of materials, and design alternatives for accommodating pedestrian and bicycle users. The manual's goal is to demonstrate that the Green Book does not prevent unique design alternatives or the innovative use of materials. The manual relies heavily on case histories and provides a thorough discussion of design techniques but does not offer guidelines on specific application techniques.

The Intermodal Surface Transportation Act and the later Transportation Equity Act for the 21st Century (TEA-21), June 9, 1998, greatly increased the attention paid to highway aesthetics. More recent concepts such as Context Sensitive Design have further increased this emphasis, and the term "aesthetics" now appears in over 900 entries in transportation databases just since 1988 (Transport database of Winspirs). Many of these entries deal with bridge aesthetic design, principally issues of design form (Billington et al. 2000). Much of the more recent publications related to aesthetics deal with roadside planting and wildflowers, but a great number use the term without reference to any specific aspect of aesthetics but to the concept in general.

LITERATURE REGARDING THE SPECIFICS OF AESTHETIC ELEMENTS

The literature provides a wealth of information about roadway aesthetics expressed in design form (Federick 1963, Cron and Smith 1977, AASHTO 1991, Harbeson 1991). Unfortunately, alignment and super-elevation are tools that can only be applied in the design of new roadways. Even then, the design may be governed more by politics, land ownership, and budget than by aesthetic considerations.

With the exception of planting design, guidance on when and how to use specific aesthetic elements or treatments in the roadway is virtually non-existent although most DOTs have some sort of guide for planting along the roadside. The question of when, where, and why to use color, pattern, textures, art, lighting, etc., appears to be generally left to individual or group decision processes. The type of criteria used in these decision processes (other than safety and cost issues) is not known. Experience of the authors suggests that the most common criterion is probably consensus, embodied by the phrase: "Whatever everybody will agree to." Evidently this criterion is common (Kaplan 1988).

Using committees as the venue for aesthetics decision making has advantages. First, most people will feel more comfortable in a situation where responsibility for issues regarding taste is distributed within a group rather than dependent on them alone. Secondly, a group setting offers more individuals with experience or special visual or graphic skills to be included. Thirdly, allowing community members a voice in the process may allow the designers to completely remove themselves from some sensitive choices. However, this approach will likely lead to aesthetics being decided by vote rather than by any objective criteria.

This approach suggests that many may hold the preconception that aesthetic treatments are fairly benign, so that when it comes to the color of a paved surface or a bridge, one is as good as another. Without any clear reason to complicate the matter, this approach would seem to work satisfactorily in the majority of situations. Of course, this raises the question: "under what types of situations is this approach inadequate?"

In many situations the selection of aesthetic elements and treatments may not pose any significant issue. Obviously, however, since the roadway is a potentially dangerous environment, a clearer set of criteria (if it can be found) would be desirable to aid designers in this process. Two areas of study offer a framework for roadway aesthetics design. One is the area of Environmental Psychology and the other is Human Factors. Each is related to the other in that either uses research from both fields.

Environmental Psychology seeks to understand and describe mankind's relationship with the environment. Subsets of this field include environmental cognition and assessment, and environmental design. These disciplines study visual perception and communication, as well as emotional responses, and how these affect decision making in real-world environments (Garling et al. 1991) . This information also applies to deciding what is important in terms of cognition and the prediction of choices or preferences by an individual (Kaplan 1991). A large part of the study in this field attempts to describe this relationship in terms of scenic quality, our preferences for a certain aesthetic, the level of satisfaction we gain from a setting, or our comfort levels during certain activities. Much of the literature involves human responses to the natural environment and how positive experiences are maximized, particularly in urban settings.

One of the areas discussed in this literature that has an important relevance to the highway environment is the issue of mental fatigue. Mental fatigue is a state of discomfort and reduced effectiveness that follows intense mental effort. This effort is referred to as *directed attention* (Kaplan 1987). Research has shown that attention requires effort and a person can only invest a limited amount of effort in the attention process at any one time. Exceeding this limited amount of effort may result in an *information overload* and subsequently affects how individuals allocate attention (Cohen 1978). Demands on attention capacity increase with the rate of task-relevant signals. These demands cause individuals to focus attention on the most relevant input for tasks at hand at the cost of those less relevant (Kanarick and Petersen 1969).

It is suggested that mental fatigue may be relieved by restful activities, recovery periods where directed attention is allowed to rest through the use of micro-restorative experiences. These experiences may possess content different from the normally present concerns or provide some sort of fascination as a basis for resting directed attention. It is also noted that random fascinations can create confusion and distraction, and that a welcome experience on some occasions may be a distraction on others (Kaplan 1987).

Human Factors studies seek to assess human performance at a specific task in a specific type of situation. The central approach of human factors is the application of relevant information about human characteristics and behavior to the design of objects, facilities, and environments that people use (Granjean 1980). Human factors research includes the study of ergonomics, that is designing work environments for optimum human performance, safety, and productivity. A large body of work in human factors includes researching driver performance in different types of situations. Driving simulators are typical research tools for many studies and have focused on issues related to crash avoidance, training, alcohol effects, curve geometry, glare, the effects of driving time, stress, visual preference, and many others (Matthews et al. 1998, Scallen and Carmody 1999, Hulbert 1972).

Work conducted in the areas of driver perception (International Association of Traffic and Safety Science Research 1983), the visual quality of the driving environment (Hornbeck and Okerlund 1972), the effectiveness of signed communication (Noble and Sanders 1980, Mace and Pollack 1983), and driver performance related to visibility conditions (Allen and O'Hanlon 1979) is of particular interest to aesthetics study. These and other studies find that as the roadway becomes more cluttered, the conspicuousness of traffic control devices worsened (Jenkins and Cole 1985). This condition is termed visual complexity and occurs when the background and the number of objects in the scene combine to the point of creating an information load that is excessive, confusing, or ambiguous (Gallagher and Lerner 1985). The size of objects and their edge contrast are important determinants of conspicuity (Jenkins and Cole 1985). Contrast and luminance of the object with respect to the background and the surrounding area have a great impact on the perceptibility of objects (Adrian 1985, Mace and Pollack 1983). Brighter colors are recommended as a tool to increase both conspicuity and contrast (Scallen and Carmody 1999, Noble and Sanders 1980, Sekuler and Blake 1990).

Unfortunately, the application of much of this information to the realm of highway aesthetics is incomplete if not yet begun. Studies showing the effect of a particular aesthetic treatment and its effect on driver performance cannot be found. Much of the tantalizing research mentioned above

is gathered from studies using sound, noise, and crowding in controlled settings rather than in highway conditions. In the case of the micro-restorative experiences mentioned earlier, there has been no testing of these in the highway environment so it is not clear if a 550 yard section of heavy vegetation along a roadway would accomplish the desired effect. This area of research is in great need of further development.

CUSTOMER SURVEY

The project statement called for a survey of the traveling public to "determine which aesthetic treatments are preferred." Some of the committee later had reservations whether such a survey would actually be necessary. It was agreed that the research team would conduct a pilot survey to both demonstrate how a survey might be conducted and the information that would be gained. The survey was conducted on Tuesday, November 9, 2000, in Dallas using students from the Landscape Architecture Department at Texas A&M University. The weather was partly cloudy and mild on the day of the survey.

METHODOLOGY

The method selected requires polling drivers at various points throughout a city. Persons would be asked to identify sections of highway they considered attractive and the results tabulated to identify the most frequently selected sections. A site analysis of these areas would attempt to correlate these preferences to characteristics of the roadside, thereby providing insight into public perception of the aesthetic treatments.

The survey utilized an 11x17 inch, black and white map of Dallas County. People were asked to "Please indicate on the map the sections of freeway you consider attractive." Thirty-eight students secured 241 responses. The data collection points consisted of:

- Williams Square in Las Colinas,
- a Shell station in Las Colinas,
- Irving Mall,
- outside city offices in the downtown area,
- downtown parks and streets,
- strip shopping areas of University Park, and
- the children's hospital.

Because these sites were located within the central and northwest quadrant of the county, we would expect some regional bias. The responses seem to indicate this bias, although highways in all parts of the county were mentioned. (See map of responses.) Researchers finally selected these sites after survey teams were denied access to the malls on the eastern parts of the county. The researchers believe the results fairly indicate some patterns about the way drivers in the Dallas area perceive the highways they drive. Along with the indicated areas, the students were instructed to ask why a certain area was selected and record the response. Not all completed surveys included comments, however, either because the respondent did not have one or because they were not asked.

RESULTS

Based on the comments received, people appear to judge the "attractiveness" of the highway based principally on factors or conditions outside the right-of-way. Responses made to specific features of the roadway were in particular reference to the newest section of North Central Expressway. Comments about this area included references to the concrete balls, Texas emblems, walls, and landscaping.

Figure 1 shows a breakdown of responses. The shaded areas do not represent any hierarchy but are used to distinguish the corridor sections referred to by the respondents.

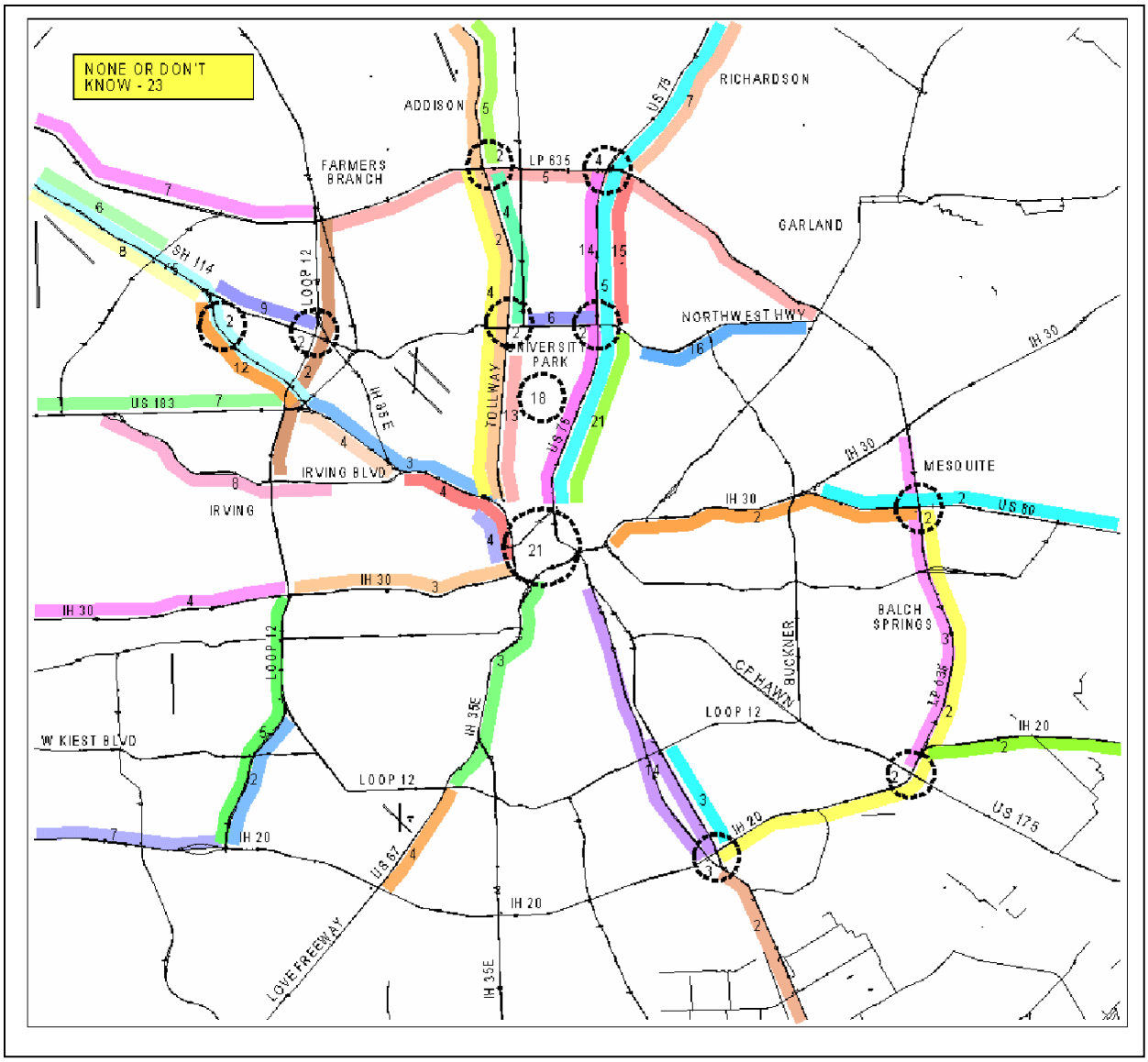

Figure 1. Dallas County Map Used in Driver Survey.

Table 1 provides a breakdown of the comments received and the number of times each was character was mentioned.

Table 1. Driver Survey Responses and Frequencies.

Comment	Number
None or don't know	23
Likes the buildings or the skyline of the downtown area	23
Area is less developed; more natural	22
Likes the University Park area	18
The roadway is newer	13
Landscape plantings in North Central Expressway	11
The nearby lake	10
There is less congestion	9
It is cleaner	8
Wildflowers	7
Manicured landscapes in Las Colinas	6
Walls in North Central Expressway	6
Parks	4
Shopping	3
Lack of construction	2
Restaurants	2
Feels safer	2
Historical significance	2
Landscaping outside the right-of-way	1
Accessibility	1
Houses in the area	1
Faster	1
Hills and vistas	1
Better road condition	1
Spread out	1
Less clutter	1
Dallas Cowboy football stadium	1

CONCLUSIONS

Based on our review of the survey data (including comments by the respondents) and our site reviews, we conclude that the information garnered from the survey does not provide sufficient specific data that is of value in meeting the goals of this project. This lack of usable data is due to several reasons:

- The great majority of those surveyed relate the aesthetics of the roadway to a combination of architecture and landscape offsite rather than to specific elements within the roadway.

- Many comments cited intangible characteristics such as safety, shopping, restaurants, cleanliness, overall neighborhood character, less congestion, etc.

- Respondents were often vague as to the precise location of an attractive feature, frequently indicating a corridor miles in length that is highly varied in character. The vague responses left much to the interpretation of the researchers as to what actual aesthetic character or element prompted favorable responses. (The researchers have witnessed this phenomenon in other conducted studies and surveys. It appears that most drivers will form an opinion of a highway based on only a small segment of a corridor. This opinion suggests that a significantly attractive visual element may "cancel out" the negative effects of other elements within the corridor. It also suggests, however, that significant negative elements may outweigh the effects of an aesthetic treatment.)

We cannot conclude that, based on the number of responses for a given area, most people prefer a particular aesthetic treatment. What is considered attractive appears strongly related to the corridor the respondent usually drives. Persons who drive through open, natural areas do not mention things such as walls, colors, or landscaping. It appears that persons who drive through an area where these items are present are more likely to mention them, suggesting that persons who responded negatively may be responding only to the routes they drive. They might consider the landscaping on North Central Expressway attractive if they were reminded of it. This is supported by the fact that few responses indicated more than one or two corridors.

The results do indicate that if aesthetic elements are included within a roadway, those who use that corridor will likely notice them. In the majority of cases though, in an urban context, the dominant character of the roadway noticed by the driver is generated by views beyond the roadway. The survey does provide a good indication of how drivers perceive their city. However, these preferences can only be interpreted in such gross terms as to be of limited value in determining the public's response to a specific aesthetic treatment.

NATIONAL CURRENT PRACTICE SURVEY

The intent of the national current practice survey was to identify specific aesthetic tools and treatments used by state Departments of Transportation (DOTs). Researchers also conducted an Internet search of state DOT websites in order to determine the type of online information agencies provided regarding aesthetics in general and to see what, if any, aesthetic manuals or guides appeared on-line.

METHODOLOGY

The current practice survey consisted of a national telephone survey involving 15 state DOTs. In some cases, more than one person from a state DOT was interviewed. For example, the California Department of Transportation (Caltrans) is very active in the area of transportation aesthetics and represents a very large state, therefore the research team decided to interview landscape architects from different areas of the state.

The team targeted personnel expected to be active in aesthetics development within the state DOTs. These personnel included staff landscape architects, design engineers, and bridge engineers. It was often difficult to find the correct department, section, or district that dealt with aesthetic issues in each state DOT. Every one is different with regard to how, or even if they deal with aesthetics, which often made it challenging to find the most appropriate person to interview in each attempt.

The survey asked interviewees to characterize the types of aesthetic treatments their DOT used in structural design or aesthetics projects. Each was asked to comment on a list of specific treatments to (1) determine if they were included in their program and (2) to describe the type of results they were getting from their use such as short-life or maintenance problems. Project photos were requested if available.

The research team developed a list of tools and treatments to discuss with each interviewee based on the initial literature review and the general palette used by TxDOT.

This list included:

- acid stain,
- concrete stain,
- colored/textured concrete,
- stamped concrete,
- pavers,
- stone,
- material finishes,
- public art,
- form liners,
- ornamental fencing,
- trellis systems,
- lighting,

- site features, and
- other.

This list better focused the interviewee on specific types of treatments and enabled the team to keep the questioning consistent. Once the list was reviewed with each interviewee, they were asked to identify any other types of tools or treatments they might use that were not included in the list, as well as discuss their experiences with those tools and treatments.

RESULTS

Acid Stain

Acid stain had been used or tested by very few of those interviewed. Many were aware of the technique but were unsure about using it in the highway environment.

Concrete Stain

Almost half of those interviewed have used concrete sealer stains. Personnel from the Wyoming Department of Transportation provided the research team with a copy of their special provisions for using sealer stain on recent projects. Their special provisions call for silicone acrylic concrete stain. Of those interviewees that have used concrete stain, none mentioned any significant problems with proper preparation and peeling.

Colored/Textured Concrete

Many interviewed expressed the use of colored/textured concrete or stamped concrete. Interestingly, 71 percent of interviewees have used some type of colored concrete, either integral color or color hardened concrete (dry-shake), but fewer (50 percent) have used stamped concrete. There were a few instances where stamped concrete had been used without color. Only one comment was made as to a preference for integral color over color-hardened concrete. The only maintenance concern raised regarding textured or stamped concrete was over freeze/thaw issues in the New York District. Wyoming DOT noted that they are only using stamped concrete in urban areas.

Pavers

Pavers are used by just over half of the DOTs interviewed. Generally, DOTs are using manufacturers' standard specifications and are encountering few maintenance problems. Maintenance concerns raised included occasional settling, weed problems, and ants in the sand between the joints. Virginia and Rhode Island DOTs both mentioned problems with pavers and snow removal. When snowplows are used, they often chip the edges of the pavers with the blades.

Stone

Most interviewees have used some type of stone as an aesthetic treatment. In most cases it is used in conjunction with a retaining or planter wall, either dry stack, mortared, or a facade. A local or regional stone is often used to add to the character or identity of a project. In Alabama, cobblestone is used in rest areas. There were no significant maintenance issues brought forward related to the use of stone.

Material Finishes

Thirty-three percent of respondents use special material finishes as an aesthetic treatment. Powder coating and painting of signal and light poles were most commonly mentioned. Also mentioned were anodized light poles, weathered steel or Cor-Ten steel guardrails, painted bollards, and reflective tape on light poles. Peeling on galvanized poles was the only maintenance issue mentioned.

Public Art

Most of those interviewed have not dealt with public art in relation to the highway environment. Of those that have, project sites were generally limited to rest areas, cultural resource centers, interpretive sites, and airports. The Indiana DOT gave an example of rebar sculptures in a wetland area. Caltrans used sculpture and bridge painting as public art. Oklahoma DOT provided two examples of public art projects. The Standing Bear Memorial project includes a sculpture and an eternal flame. The second project, labeled "land art," consists of three connected triangular concrete panels set in the slope of a small hill. Colored concrete was used to create patterns in the panels. Both projects have been well received by the public and are considered to be successful.

Form Liners

Several DOTs commonly use form liners. Projects typically included retaining walls and bridge columns. Caltrans provided an example of form liners and integral color used to give the impression of redwood planks on a concrete retaining wall. This technique helped to create a structure that would complement the surrounding view rather than becoming an imposing structure in the landscape. Rhode Island also provided an example, including specifications and details, of a project that incorporated the use of form liners on concrete median barriers. Both DOTs consider these projects very successful.

Ornamental Fencing

Survey responses indicated that DOTs seldom use ornamental fencing and often limit this treatment to rest areas or welcome centers or in urban areas if the city provides the funding. Standard manufacturer specifications and installation methods were used on the projects discussed. Respondents did not note any maintenance issues experienced in the examples provided.

Trellis Systems

Only three interviewees had used any type of trellis systems as an aesthetic treatment. Most of the examples discussed were very small in scale. Georgia DOT has used one with an arbor at a welcome center. There were no maintenance concerns expressed with using trellis systems.

Lighting

Just less than 50 percent of interviewees have used some type of lighting as an aesthetic treatment. Some will only incorporate lighting in urban projects if it is funded and maintained by the city. Other examples of lighting included accent lighting at welcome centers and rest stops.

Site Features

Less than half of those interviewed worked with the aesthetics of guardrails, concrete traffic barriers, and noise walls. Some have already been discussed, such as the use of form liners on concrete traffic/median barriers. The most common example given was the use of weathering steel or Cor-Ten steel on guardrails for a more rural or rustic look. Virginia DOT and Indiana DOT gave examples of painted noise walls or integral color used on noise walls.

Other

Under the category of 'Other,' stamped asphalt was one treatment often mentioned by interviewees, though only two interviewees, New York DOT and Arizona DOT, had actually used the treatment. Most of the other DOTs researched knew of the technique or had researched its possible use. There was some concern about asphalt losing its print or not leaving a very good impression when installed. New York DOT has used stamped asphalt with success and provided a copy of the specification used. New York DOT uses the manufacturers' standard specification.

Researchers asked interviewees with projects of particular interest for available plans, specifications, and/or photos. These examples ranged from a public art (land art) project in Oklahoma, to form liners used on concrete traffic barriers in Rhode Island. From these surveys, researchers found little dramatically different usage from what TxDOT has already used or experienced.

REVIEW OF PRINTED MATERIAL

Researchers collected several state DOT manuals and guides in order to (1) identify additional tools and treatments and (2) determine what types of manuals or guides are being used by other DOTs. The manuals and guides reviewed include:

Minnesota Department of Transportation
Aesthetic Design Guide for T.H. 212 Highway Corridor
Aesthetic Design Guide for T.H. 610 Highway Corridor
Inspection Guidelines Book
CD Plant Matrix

Florida Department of Transportation
Landscape Manual

California Department of Transportation
Standards Specifications and Standard Special Provisions
Highway Design Manual
Project Development Procedures Manual

Utah Department of Transportation
Design Manual (four pages on landscape plans)

Arizona Department of Transportation
Landscape Design Guidelines for Urban Highways

Wisconsin Department of Transportation
Roadside Manual

Although there are some general aesthetic guides being used, the researchers found nothing devoted solely to aesthetic tools and treatments and how to use them. No survey of current practices similar to the one being conducted was found to exist. Some DOTs are in the process of trying to create similar guides. NYDOT, for example, is currently rewriting their aesthetic guide and have identified a preliminary list of aesthetic tools to be used as statewide standards. Many of the DOT personnel interviewed were working on the development of a design or aesthetic manual, revising their current document, or considered their manual to be outdated or obsolete.

CONCLUSION

Table 2 presents the list of tools and treatments researchers discussed with each interviewee and identifies which DOTs noted experience using the different tools and treatments.

The extent of aesthetics innovation was found to be well below what was expected. TxDOT appears to be current and in some cases ahead of most DOTs regarding the use of aesthetic tools and treatments that have been tried as well as those that are commonly used. The researchers discovered little in terms of new technologies through the literature and industry searches, however some innovation was found in terms of how to use common techniques. One example is the incorporation of themes and "artwork" into wall surfaces. The technology is not new but the creativity regarding its use appears to be increasing.

Table 2. Current Practice Survey Results.

	Design/Aesthetics Manual	Acid Stain	Concrete Stain	Colored/Textured Concrete	Stamped Concrete	Pavers	Stone	Material Finishes	Public Art	Form Liners	Ornamental Fencing	Trellis Systems	Lighting	Site Features
NYDOT District 8	X		X			X	X			X	X	X		
NYDOT Design	X			X	X	X	X	X		X	X		X	X
NYDOT District 10	X		X	X	X		X	X		X			X	X
NYDOT District 7	X			X	X	X	X	X		X	X		X	X
MinDOT Env. Services, Landscape Program	X											X		
Florida DOT District 2	X		X	X	X	X								
WYDOT Environmental Services Eng.		X	X	X	X	X	X			X			X	X
WYDOT Assistant Bridge Eng.			X	X						X				
Virginia DOT Environmental Section	X						X							
Virginia DOT Environmental Section	X	X		X	X	X	X	X		X	X		X	X
Maine DOT - Bridge Design							X			X				
ODOT Special Projects Division				X	X	X	X			X				
AHTD (Arkansas) Maintenance	X			X		X	X							
ADOT (Arizona) Roadside Development	X		X	X	X	X	X	X	X	X	X			
ALDOT Maintenance Bureau			X	X	X		X		X				X	
ALDOT Bridge Division			X	X						X			X	
Caltrans District 1 Maintenance	X		X	X	X			X	X	X				
Caltrans District 2	X			X										
Georgia DOT - Maintenance Division					X	X				X		X	X	
Indiana DOT - Design Landscape Section				X		X	X	X	X	X			X	X
Connecticut DOT - Facilities Design			X		X	X	X	X	X		X		X	X
Rhode Island DOT				X		X	X			X			X	X
Caltrans - North Region	X	X		X										X
ODOT Bridge Design										X				X
Total surveyed	13	3	10	17	12	13	15	8	5	16	6	3	11	10
Total use (percent)	54%	13%	42%	71%	50%	54%	63%	33%	21%	67%	25%	13%	46%	42%

TxDOT LANDSCAPE ARCHITECTS SURVEY

Throughout this project, the research team has called on the experiences of TxDOT landscape architects in the development of the tech sheets. In creating the list of aesthetic tools and treatments to address, the research team relied on the review of the literature, the national survey of current practice, the team's own experience, and most importantly the experiences of the TxDOT landscape architects.

The list of subjects discussed in this section differs slightly from those subjects used in the national survey. This variety is due to different usage by individuals and districts around the country. Terminology was found to vary between common usage and bid item title, which can also lead to confusion. The terms below are more consistent among the TxDOT districts although some variation may occur in actual practice. For clarification, the reader should compare the descriptions, as well as titles.

METHODOLOGY

The research team began the TxDOT landscape architects survey when the initial literature review and national DOT surveys were completed and a preliminary list of tools and techniques for the tech sheets was developed. This survey of all TxDOT district landscape architects was used to discern specific experiences with each tool and technique to be addressed. In addition, the researchers wanted to determine if there were any gaps in the working list of tech sheets.

The survey consisted of telephone interviews with all TxDOT landscape architects. The research team initially sent out an e-mail requesting their help in refining its list and information on the tools and techniques to be addressed in the tech sheets. A brief description of the project was attached to this e-mail, along with a description of the tech sheets. The researchers also included an outline of the tech sheet topics and the types of questions that would be asked. This preliminary information gave participants a chance to look over the types of questions that would be asked during the phone interviews.

The format of these interviews varied from that used in the national survey. The main objective of the national survey was to find what was being used in other states and to find any new or innovative tools or techniques that should be considered for use by TxDOT. The main objective of the TxDOT surveys was to gain information on each tool or technique regarding issues such as contracting, maintenance, installation, or durability. The following lists each tool or technique discussed with the interviewees and describes the findings from this survey.

RESULTS

Sealer Stain

The biggest issues regarding sealer stains seem to center around bad preparation. Some landscape architects have been encouraged by their districts not to use sealer stains, either because of first-hand experience with poor preparation or because of a fear of misapplication. In situations where proper preparation and application have occurred, the results have been very successful, with no peeling or little fading. Sealer stains are most often used on overpass

structures to incorporate color, but have also been used frequently on curb cuts and ramps for compliance with the Americans with Disabilities Act (ADA). One suggestion for application control and color consistency was to always require a sample panel be completed prior to staining the structure.

Stain was more often preferred over paint because of problems with peeling, but in the case of a concrete structure that has already been painted, stain cannot be used. The same type of material would have to be used to change the color. Two landscape architects who worked in West Texas preferred the look of paint to stain. Because of the climate and the low humidity, paint peeling doesn't seem to be much of an issue in this area. Humidity is a major consideration for the rest of the state.

Acid Stain

Many TxDOT landscape architects have researched acid stain, but few have actually used it. The Austin District has used it on one project where integral color was specified but left out in construction. They were unable to achieve the color desired with the acid stain. Another complaint was that there were too many steps, and the process was too labor intensive. Others have experimented with acid stain, but did not give enough color reading on existing concrete and again did not think the option was worth the labor intensity involved. Another concern was that it could create a slick surface if used on a horizontal plane.

Integral Color

The reviews seem to be split on the use of integral color versus hardened colored concrete. The most commonly mentioned concerns with integral color were color consistency on large-scale projects and cost. If the project is relatively small and different batches of concrete don't have to be used, then the issue of color consistency is eliminated. Also, if integral color is used on horizontal surfaces it is less noticeable if there are any variations in color. The Bryan District recommends using 2/3 white to gray concrete to help with color consistency. Some landscape architects are not concerned with the modeled look and even incorporate the effect into their designs. Another issue mentioned dealt with the selection of color. One example given used a black integral color on the ends of a median that became difficult to see at night because the color was so similar to the asphalt on the roadway.

Hardened Colored Concrete

Hardened colored concrete is often preferred over integral color because many designers believe they can get a more consistent color. It is one of the only options to use with stencils, and the cost is generally less expensive than integral color. Some of the reasons for not using hardened colored concrete include labor intensity, sensitivity to contractor's experience, color can fade, and only penetrates the surface of the concrete. One interviewee only uses integral color because "hardened colored concrete looks fake." As mentioned earlier, the reviews seem to be split on integral color and hardened colored concrete. Most of the landscape architects have a definite opinion about why they use one over the other.

Thin-set Pavers or Stone Applications

This topic was discussed with interviewees in terms of thin-setting pavers or stone on existing concrete. Only a few have experimented with this type of technique, but the results have been successful where applied. In the Houston and Tyler Districts, pavers were use on existing concrete riprap to create a mural out of concrete pavers. Also, one project in Las Colinas, in the Dallas District, used Millsap stones thin-set onto existing concrete riprap.

Texture

Texture on concrete was only mentioned if the project called for coordination with an existing structure. Scoring or hand tooling is most often used only if the work needs to match an existing adjacent structure.

Patterned Concrete

Patterned concrete is a common tool used by many districts with generally good results. The Pharr District has a policy requiring stamped concrete on all new riprap. This policy helps deter graffiti. Stamped or patterned concrete does not provide a desirable canvas for graffiti. Many districts require a sample panel be created to check for pattern imprint and consistency. Some interviewees have had problems with the types of mats used for imprinting. One prefers rigid mats to flexible mats for a more consistent imprint, where another stated that flexible mats are a good alternative for odd dimensioned areas. Again, it seems to be an issue of contractor experience and expertise. It takes more effort and skill to create a consistent pattern imprint with a flexible mat than a rigid mat. In addition, many landscape architects will not allow rollers to be used to create patterns because of problems with consistent patterns and imprints in this case as well. Another concern about patterned concrete was that it could set up too fast in extreme heat. It was recommended that districts be conscious of this problem and plan installations accordingly. Finally, caution was advised when using stamped concrete on walking surfaces. The designer should take care in selecting a pattern and depth of imprint that will not be troublesome to wheelchairs or high-heeled shoes.

Form Liners

The amount to which landscape architects are involved in the use and development of form liners varies from district to district. In some districts, form liners are the sole responsibility of the bridge section. In other districts, the landscape architects are incorporating the use of form liners regularly. Those that have worked with form liners were generally very pleased with their use as an aesthetic alternative that is not cost prohibitive in most cases.

Sandblasting

Sandblasting is not generally used as an aesthetic treatment by TxDOT designers. It is used most commonly as a repair option to give a little texture or to smooth out form liner lines. The Waco District is looking into using sandblasting as an alternative to stain in the future. The district used sandblasting in the preparation of a recent staining project and was so pleased with the look of the concrete after the sandblasting that they are considering using this as an aesthetic treatment in the future.

Rub Finish

Only one example of rub finish on concrete was offered. It was used to smooth out form liner lines in this case.

Veneers

The most common use of veneers in TxDOT has been stone veneers on a Poured-in-Place concrete structure or concrete masonry unit structure. Other examples of veneers are rough-faced cinder blocks and brick and tile, but again stone is definitely the most common technique used. The advice offered from interviewees included always requiring a stone mason and always using a wall cap for a finished look. Occasional cracking was the only maintenance issue raised. One interviewee had concerns about using veneers at all do to the concern of not being able to inspect what is behind the wall if damage occurs. Veneers are often seen as being hard to repair.

Concrete Masonry Walls

Concrete masonry units or cinder blocks are most often used as backing for veneer on planters or retaining walls, but are occasionally used alone as an aesthetic element. In the Amarillo District a concrete masonry wall with burnished blocks was used to construct an entry sign. The burnished block creates a smooth, shiny finish that looks similar to granite.

Modular Block

Modular block is a widely used aesthetic tool throughout TxDOT. Most of those interviewed that have used modular block have had little or no problems. Those that did report problems could usually trace the problems back to improper installation or lack of proper consideration for steeper slopes or high runoff areas. Many of those interviewed expressed the need for a good contractor with experience using modular block. The majority of those interviewed were very happy with the use of modular block as an aesthetic alternative.

Brick Pavers

Very few of the landscape architects interviewed have used brick pavers. Those interviewees that noted the use of brick pavers cited cases of removing and relaying existing brick pavers, or cases where the design needed to incorporate brick pavers to coordinate with existing elements.

Concrete Pavers

A majority of those interviewed used concrete pavers with good results. Most of the designers rely on standard specifications, but some have adapted those to respond to specific problems they face. For instance, some landscape architects will require 6 to 12 inches of cement-stabilized sand under the pavers and behind any curb to minimize sinking. Maintenance issues raised about pavers included settling, weeds between pavers, and sinking due to surface being driven on. Several interviewees mentioned that the contractor's work should be monitored in order to make sure the pallets are well mixed in multicolor patterns during installation. When this does not happen colors are clumped together, and the random pattern is not achieved. Another interesting point related to concrete pavers brought up by the Fort Worth District was a case in which the historical commission wouldn't allow pavers in a federal project in Mineral Wells. The commission did not feel concrete pavers were historically acceptable and required the district to use brick pavers.

Asphalt Paving

None of the interviewees have used stamped asphalt as an aesthetic treatment.

Traffic Barriers

A popular form of traffic barrier with aesthetic treatment is the weathered steel or Cor-Ten steel railing with wooden posts. This type of rail quickly self oxidizes to give a rusted or weathered finish. This technique has been a useful option for many designers within TxDOT trying to work within a more rural or rustic setting. Another traffic barrier option used by TxDOT designers is the concrete traffic barrier (CTB) or Jersey barrier. Many districts, like Laredo, have used color on CTBs that separate the opposing lanes of traffic. One project on I35 in Laredo uses a blue color on the CTB in the median with a state of Texas inset used at each overpass. Other designers have also incorporated color and form liners in the use of CTBs. In the Dallas District, raking is being used with the slip form to create a horizontal pattern on the CTB.

Fencing

Chain-link fencing is used in many districts for projects such as pedestrian overpasses and rest areas. Many interviewees recommended aluminum fencing to prevent rusting or a vinyl coated fencing for color. Thermally fused coatings were suggested for durability. Some ornamental fencing has also been used in rest areas.

Lighting

The most common type of lighting mentioned by interviewees was ornamental street lighting in urban areas and powder coating or painting of light and signal poles. These are often included in designs if the city pays the difference for the treatment used. For painting and powder coating, cleaning was often mentioned as a key issue to ensure proper application. The Dallas District recommended using a vinegar or acid bath to treat or prime the surface. In the San Angelo District, pedestrian lighting was used on a pedestrian overpass to deter vandalism. Up lighting is used by some districts. This type of lighting highlights retaining walls, flagpoles, bridge

columns, and even public art. The most unusual type of aesthetic lighting mentioned was fiber optics. Fiber optics have been used successfully in the El Paso District. Fiber optics is considered a specialized tool with limited application. It mimics neon, but is not as bright. When nicked or damaged, the tubing becomes dim in that spot. The tubing collects a lot of dust and requires cleaning once a year. The Austin District has fiber optics specified on an upcoming project to backlight bronze stars on a Mechanically Stabilized Earth (MSE) wall. The Pharr District has been researching Light Emitting Diodes (LED) as an alternative to fiber optics, but has not used it on a project at this time.

Furniture

Most of the street furniture used by TxDOT districts has been fairly standard and readily available from a variety of vendors. Benches, trash receptacles, and tree grates were all mentioned under this topic. Most experiences have been successful. Some recommendations made by the Dallas District included using an open mesh design on benches to prevent graffiti and using wide openings on trash receptacles. Closed hoppers on receptacles often keep people from actually using them. Benches with slats made of recycled material have been used successfully in the Amarillo District. Several issues related to tree grates came up in the interviews. The San Angelo District is using plastic tree grates on an upcoming project. This cost is significantly less than the metal alternative, but it is too soon to know how the durability will compare. There are problems associated with tree grates. Sometimes, the contractor does not center the tree before placement of the tree grate. Grates are hard to cut or trim and often leave rough edges and weeds often become a problem in the tree wells. The San Angelo District was also the only district to mention the use of gazebos. They are being used in many rest stops and TEA-21 projects. There have been no significant maintenance issues related to the use of gazebos in this district.

Artwork

Artwork or public art has been limited in the right-of-way. The most common type mentioned was the use of murals. Some districts allow murals only if they are completed by the initiating entity. Some districts cited bad experiences with the use of murals. Murals are sometimes not completed or maintained properly. In the Dallas District, Art Park is a site where TxDOT provided concrete surfaces to be painted by local artists. Some districts have provided a location or site for public art to be located by a city. Examples of this include sculpture on the right-of-way in the Bryan District and the wool capital landmark in the San Angelo District. Occasionally TxDOT designers have initiated works of public art, as in the case of the buffalo monument at Buffalo Gap in the Abilene District. Most districts do not incorporate public art, or they prefer only to create a venue for the community to provide the public art.

Other

Once all of the tools and techniques on the preliminary list were discussed, each landscape architect was asked if there were any other tools or techniques used or any other issues that might be significant. Two interviewees mentioned the use of boulders and rock. Some designers have used gravel as groundcover. The Laredo District has recently installed a rock landscape, but suggests waiting to recommend it as an aesthetic alternative until it can be determined

whether or not this type of project is actually maintenance friendly. The Dallas District has used CTBs as planters, but they ran into a problem. The planters often dry out and require frequent watering. The district does not recommend using planters. Spray-crete has been tested in the Waco District. The project is considered successful, although the process is rather labor intensive. Spraying over ground boxes became a problem with this technique. The Waco District has also used seal coat rock with limited success. The coating isn't holding up as well as anticipated. It is suspected that the product may have been applied incorrectly. This technique has also been used in the Austin District with a more successful application and durability.

CONCLUSION

Table 3 presents the list of tools and treatments discussed with each interviewee and identifies which TxDOT landscape architects noted experience with the different tools and treatments.

Few tools or treatments are used uniformly throughout TxDOT. Their use is based on such factors as personal biases, tradition, past experience, and even local climates. Concrete pavers were the only treatment noted as being used by all of the interviewees. Others, such as hardened colored concrete, modular block walls, and various types of lighting were used by most. In contrast, a few interviewees had researched colored or stamped asphalt, but none had used the treatment in a project. Only one respondent had used acid stain with limited success. Special concrete finishes and sandblasting appear to be limited in their use as well. These types of treatments were generally used when trying to match or blend with an existing structure.

In addition to identifying which tools and treatments are used by TxDOT landscape architects, the interviews provided greater detail about issues such as installation, use, maintenance, and durability that affect the decisions to use or not to use a particular aesthetic tool or treatment. This information was used to finalize the tech sheets and to make sure the tech sheets were as comprehensive as possible.

Table 3. TxDOT Current Practice Survey Results.

	Sealer Stain	Acid Stain	Integral Color	Hardened Colored Concrete	Thin Set Applications	Concrete Finishes	Sandblasting	Patterned Concrete	Form Liners	Veneers	Concrete Masonry Unit Walls	Modular Block Walls	Brick Pavers	Concrete Pavers	Colored/Stamped Asphalt	Concrete Traffic Barriers	Metal Guardrail	Fencing	Lighting	Furniture	Artwork/Public Art
Amarillo District											X	X	X	X			X		X	X	
Austin District	X	X			X	X			X	X	X	X		X					X		
Houston District	X		X	X	X				X	X	X	X		X		X				X	X
Dallas District	X		X	X	X			X		X	X	X		X				X	X	X	X
El Paso District	X			X				X	X	X	X	X		X		X			X		X
Bryan District			X					X						X		X	X		X		X
Abilene District	X			X		X		X		X	X	X	X	X				X	X	X	X
Laredo District	X			X	X			X	X	X		X		X		X			X		X
Paris District				X										X						X	
Fort Worth District												X		X							
Waco District	X		X	X			X	X		X		X		X					X		
San Angelo District			X	X		X		X		X				X				X	X	X	X
Pharr District	X		X	X			X	X	X			X		X			X	X	X	X	X
Odessa District	X		X	X	X			X		X		X		X					X	X	X
Total surveyed	9	1	7	10	5	3	2	9	5	9	6	11	2	14	0	4	3	4	11	8	9
Total use	64%	7%	50%	71%	36%	21%	14%	64%	36%	64%	43%	79%	14%	100%	0%	29%	21%	29%	79%	57%	64%

RECOMMENDATIONS FOR A METHODOLOGICAL APPROACH TO AESTHETICS DESIGN

It may not be possible (or desirable) to reduce the application of all aesthetic efforts to an objective formula. In many cases it may not be warranted. The earlier mention of aesthetic treatments as benign may be true in enough cases to be considered just that way. On the other hand, the need to achieve optimum driver performance as it is affected by visual perception is clearly, and always, paramount in designing safe highway use.

PREFERENCE FRAMEWORK

In combination, the two fields of study discussed above contain both the art and the science of human/environment relationships. A methodology to understand and to gauge the effects of proposed aesthetic enhancements is suggested in the work of Stephen Kaplan (Kaplan 1988). Using his own work and the work of others in the field, Kaplan created a framework that offers insight into the design and management of the natural environment. Although heavily focused on the natural environment, the concepts employed embody many basic design rules that are applicable both in the aesthetic sense as well as perception and communication by and to a highway user. Kaplan used a "preference framework" (Table 4) to describe four informational factors in which humans perceive their environment and how these factors may combine to predict a particular response.

Table 4. Preference Matrix (Kaplan, R. et al. 1998).

	Understanding	Exploration
2-D	**Coherence**	**Complexity**
3-D	**Legibility**	**Mystery**

Kaplan explains the two-dimensional (2-D) factors of coherence and complexity as viewing a flat image as in a photograph.

Complexity refers to how much is going on as determined by the diversity and number of elements in the image.

Coherency (how easy the picture is to organize or comprehend) is based on the patterns of light and dark and how many major objects or areas these form. Readily identifiable objects result in greater coherence. Kaplan notes that humans can only hold so many major units of information or "chunks" at one time and that research indicates *five* such units is the norm.

Understood in these terms, it is easy to see the relationship between the two. A scene can be complex (have a lot of things in it) but still be coherent (arranged in a few large chunks). This relationship suggests that in visually complex scenes, ways might be sought to define logical areas as distinct units. This may be done by screening some elements, using textures or colors to separate important elements from the background, or removing some elements to create a simpler visual unit.

Kaplan uses legibility and mystery to explain how humans use simple 2-D informational data to decide how they will chose to interact within it (a mental 3-D exercise).

Legibility is "making sense" of 3-D space with the intention of functioning safely within it. A highly legible scene is described as one that is easy to oversee and to form a cognitive map of. Depth and well-defined space increases legibility. Landmarks aid legibility by providing easy understanding of one's position relative to prominent elements.

Mystery involves the anticipation of something to come next based on the present scene. This term should be contrasted with the concepts of novelty and surprise. In the highway environment, a degree of novelty may be appropriate in special cases (as in art pieces) but surprises in the driving environment are highly undesirable. Kaplan defines scenes that are high in mystery as being characterized by *continuity*, a connection between what is seen and what is anticipated. He also notes that the term "mystery" often is understood by many to mean ambiguous or incoherent. For the purposes of this report and to avoid misunderstanding of the term, future use of the model will use the term *anticipation* since it embodies the essence of Kaplan's model but is less likely to be misinterpreted.

Kaplan's model of visual perception and interpretation and their relationship to a response or an action offers a reasonably simple method to evaluate aesthetic design in the roadway. It can form the basis for not only identifying how a proposed enhancement may affect the scene but also how a scene may be improved. The latter application then places the aesthetic effort in the proper context: *how can aesthetics be utilized to improve the driving function*.

A distinction is appropriate here between the type of decision that is being made and its reliability. Although these concepts are based on scientific research, in terms of aesthetics design, it is highly unlikely they can be reduced to an objective formula. This means that individual insight based on experience and training will still be fundamentally important to the design process. This is the art part of the endeavor.

Summarizing this approach: legibility and mystery involve interpreting visual information in order to function in it such as finding one's way or anticipating an upcoming task. The quality of visual information for these tasks is determined by the complexity and coherency of the scene.

The significance of this model is that it provides a framework for creating specific design objectives within a selected site that are based on the type and quality of visual information occurring or needing to occur. For example, suppose that a section of highway corridor may be considered for a tree planting along the base of the slope of a depressed section. If the section also contains a merging lane, then creating a larger visual unit to contain the lane may suggest placing the screening behind that unit to screen a more complex urban scene beyond. This might have the possible effect of making the area containing the merging lane less complex and more coherent, important in terms of legibility and ultimately, performance.

Even though these concepts have not been objectively tested in terms of aesthetics in the roadway, they are well demonstrated in terms of signed information and driver behavioral studies as discussed above. Also, despite the fact that it would be very difficult to develop objective criteria based on these concepts, this approach offers the best guidance yet available to consider substantive issues beyond what simply looks good or that everyone agrees to. The remainder of this work will utilize this approach to meet the goals of this project.

AESTHETIC GUIDELINES

INTRODUCTION

Designers who have not been trained in the visual arts (and some who are) may feel a bit apprehensive when it comes to making choices regarding aesthetic treatments (color, texture, pattern, etc.). Some persons may feel that aesthetics is a highly subjective matter as typified by the oft-quoted statement: "Beauty is in the eye of the beholder." Some may feel intimidated by having their aesthetic decisions subject to public comment, and others may not feel qualified or don't know how to evaluate aesthetics and are reluctant to give their opinions.

The intent of this section is to provide some guidance to aid the designer in making sound aesthetic judgments. The critical issues in aesthetic decision making involve improving the transportation function first and artistic enhancements second. The goal of these guidelines is to provide a way to understand aesthetics in the roadway and some straightforward approaches to decide what is and is not appropriate in a given situation. No background in the arts is necessary, though the use of a trained design professional is often needed to assist in final judgments.

WHERE TO START IN AESTHETICS DESIGN

The first task in aesthetic planning or design is to identify and address anticipated or existing problems. Just adding an element or new color will not, by itself, transform most sites. It is important to try to understand what, if any, conditions are contributing to a less than desirable image. This task is most easily accomplished if the aesthetics of the roadway are understood in terms of the overall image and character of a site or corridor section.

In many cases, aesthetic improvements need not be dramatic or dazzling to be effective and appreciated. Often, small touches or additions can make a big improvement. In many cases, increased mowing and litter pickup may solve many problems. Adding a unique color or pattern to a concrete wall without addressing the weeds at its base will probably not result in the desired effect. In other cases, simply cleaning the accumulation of staining from a bridge may be adequate.

In order to understand and deal with the overall image of the roadway, it is necessary to properly phrase the task at hand. First and foremost, as with any structural element used in the roadway, aesthetic design must be evaluated by its effect on the transportation function, specifically driver performance and safety. The two issues most related to or affected by aesthetic character that impact these are communication and visual perception.

Communication and Visual Perception

Communication begins when information is made available to the user. This begins with signs and signals to either direct or control movement but also includes the un-signed visual clues, such as when a lane will end or merge, the distance available to make a decision, the announcement of a decision point, and many others.

Visual perception is the ability of the user to gather the information provided (signed and un-signed), completing the communication exchange. The information must be gathered at the proper time so that driving (and walking) decisions can be safely and efficiently executed.

The design and safe use of any roadway is dependent on visual perception. Visual information is ordered by our brains to create a sensible scene, one that we can understand and negotiate. As visual information becomes more complex we may lose some of the sense of order and the scene becomes more difficult to understand. In the worst cases, this difficulty can lead to confusion and perhaps a hazardous situation. Because of the speed at which activities occur and the severe consequences of a wrong choice, the visual quality of the roadway is an important issue.

It is through visual information gathering that we are able to understand our surroundings, feel comfortable in a different place, and perceive what is happening around us. Roadways with clearly delineated edges, and/or easily perceived changes such as exits, entrances, intersections, and lane changes are safer roadways and invariably are more pleasant to drive. It will almost always be found that an aesthetically pleasing roadway will most likely be safer and that safer roadways are usually more aesthetically pleasing.

Although it will be impossible to take into account all the information available to a user, answers to three basic questions will aid the designer in identifying possible conflicts or opportunities.

1. Does the element or treatment have any effect on the way other communication devices such as signs, signals, or information boards are perceived?

2. How does the element or treatment affect the outline or profile of lanes or structures?

3. Does the element or treatment require special consideration for installation or safely accessible maintenance?

With these guides in mind, the designer can begin to make some general decisions about the approach for a specific location. All that is needed is a method of understanding how visual information perceived and what determines the *visual quality* of an environment.

Visual Quality

The goal of aesthetics design in the highway environment is to maximize both the safety and efficiency of the transportation function as well as create a pleasurable experience for the user and a positive contribution to the visual character of the community. For the designer, these tasks may be understood better by perceiving them in two different but related types of visual communication. One is aesthetic quality and the other is visual quality.

Aesthetic quality is the character of the visual scene in terms of its qualities of beauty such as form, proportion, line, mass, etc. Aesthetic quality is strongly related to the preferences of the viewer and so is often “in the eye of the beholder.” Instruction in the artistic value of an aesthetic element would require much more space than is appropriate in these guidelines. The designer is encouraged to make use of the vast library of information in such subject areas as landscape

architecture, architectural design, visual arts, and color theory. A simple alternative would be to include on the design team individuals trained in these disciplines.

Visual quality, for the purposes of these guidelines, is defined as the character of the visual scene in terms of its capability of being seen and understood by the user. Visual quality concerns "making sense" of what going on and is determined by the clarity of information supplied to the viewer. The viewer uses this information to (1) understand what is around them and (2) decide how best to perform or react as they make their way through the space. Visual quality may be easily understood through four information factors: coherence, complexity, legibility, and anticipation.

Complexity refers to how much is going on in a scene as determined by the diversity and number of elements. As the number of elements in a scene increases, more effort in discernment is necessary on the part of the viewer to select the information needed at that time. The visual complexity of a scene may be reduced by:

- removing some elements from the scene,
- simplifying the scene with uniform textures or colors,
- combining or relocating some elements,
- screening distracting elements, and/or
- highlighting elements through color contrast with surrounding elements.

Coherency (how easy the picture is to organize or comprehend, also termed "order") is based on the patterns of light and dark and how many major objects or areas these form. Normally, humans can only hold *five* major units of information or "chunks" at one time (Figure 2). Readily identifiable objects result in greater coherence.

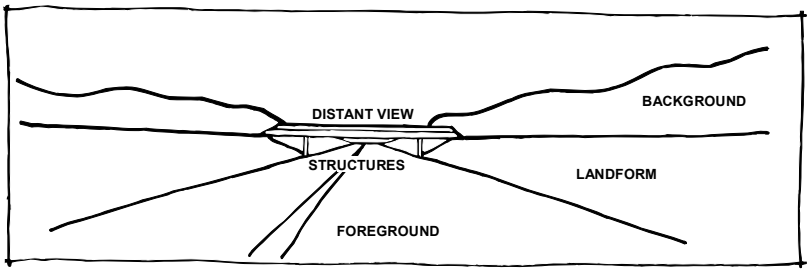

Figure 2. Normally, persons can hold up to five sets of visual information in memory.

To create visually coherent scenes, seek ways to define logical areas as distinct units. This may be done by:

- screening some elements,
- using textures or colors to separate important elements from the background,
- removing some elements to create a simpler visual unit, or
- grouping smaller landscape elements to preserve views of major elements.

A scene can be complex (have a lot of things in it) (Figure 3) but still be coherent (arranged in a few large chunks) (Figure 4).

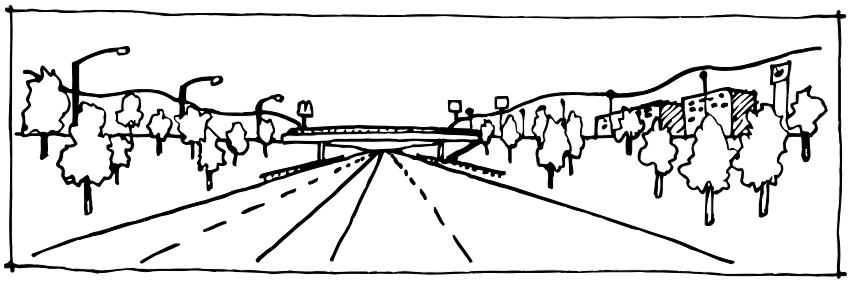

Figure 3. In a visually complex scene, the number of distinct elements makes it difficult to discern spaces.

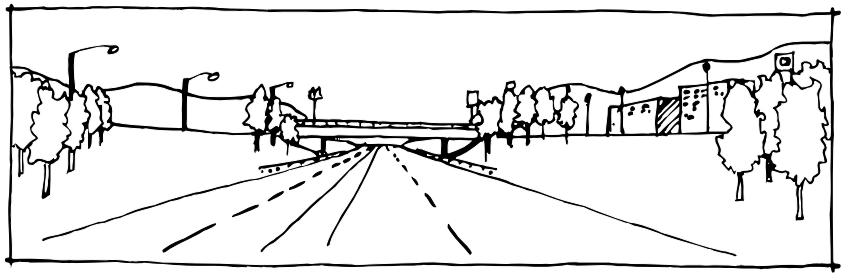

Figure 4. Organizing elements to create manageable units of view simplifies the scene and requires less attention in order for the user to understand what is going on around them.

Legibility is the ability to understand three-dimensional space with the intention of functioning safely within it. Legibility is affected by depth perception, spatial definition, and orientation. Textures and colors of elements and view units will have a great influence on legibility (Figure 5). If elements or view units are not clearly distinguishable from others around it, the viewer must work harder at understanding the scene. The viewer does this by devoting more *attention* to a particular part of the scene, perhaps neglecting other information.

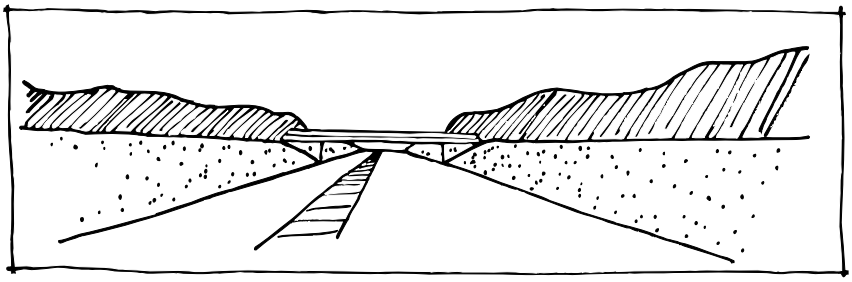

Figure 5. A scene is more legible when parts of the view are clearly distinguishable from one another, usually due to the effect of color and or texture differences.

A highly legible scene is easy to understand, and the user can quickly form an accurate mental map to clearly distinguish where they are and where they will be going.

Depth perception is improved by:

- incorporating same-sized elements within the same scene;
- using consistent spacing or uniform dimensions to visually prominent, repeating elements; or
- avoiding random or unexpected changes to the sizes and proportions of major elements or view units.

Spatial definition may be improved by:

- contrasting the color or texture of view units, or
- highlighting the edges spaces or elements.

Orientation may be improved by highlighting distinctive elements to provide landmarks to aid the user in understanding their position, relative to their route.

Anticipation involves the expectation of something to come next based on the present scene. Scenes high in anticipation value are characterized by *continuity*, a connection between what is seen and what is anticipated. This continuity includes the consistent use of an element or treatment to announce a specific activity or another element. The opposite of anticipation is novelty and surprise. Anticipation value may be improved by:

- using specific elements in consistent arrangement and location through a corridor,
- repeating colors or textures in similar instances throughout a corridor, and
- combining unique elements to signal important tasks whenever they occur.

In summary, decisions about aesthetic treatments or elements are made no different than any other decision involving the design of safe transportation. In the case of aesthetics, decisions regarding taste, appropriateness, interest value, and public preference must be separated from the issue of driver performance. The concepts discussed above provide a method to assess a roadway environment based on the quality and character of a scene as units of visual information the driver needs for decision making. Simply stated, the designer identifies the critical viewing positions based on the:

- type of information needed by the user,
- critical time at which the information is needed,
- character of the background or surrounding information, and
- overall information load on the user.

There is no technology that will automatically gauge the quality of information contained in a scene as dynamic and as critical as a highway roadway. While not completely subjective, this approach requires the exercise of individual judgment. The tools necessary include attention to visual detail, experience, an understanding of the driving task, and an awareness of driver performance.

Effects of Scale on Aesthetics Selection

These visual information factors can be used to assess any highway environment. The applicability of any single factor will change as the roadway changes. For example, urban roadways will contain more issues of visual complexity than will most rural roadways. The suitability or appropriateness of any specific element or treatment is also dependent on the type of roadway.

To have the desired effect, an aesthetic treatment or element must be visible to the target audience. Atmospheric conditions play a role, but visibility in the roadway is largely dependent on the distance and speed at which it is viewed relative to the size or contrast of the element or treatment. The designer uses a simplified classification system to decide what types of treatments are used:

1. Roadways characterized by high speeds, wide thoroughfares, and long views.
2. Roadways with low-speed traffic, narrower right-of-way, shorter views, controlled intersections, and usually the presence of pedestrian traffic.

High-speed, wide highways

The scale of treatments in this type of roadway is always larger since the scene is large, with views ranging from a few hundred feet to miles.

- Areas of color will be viewed from greater distance so they must be larger, as well as more saturated (deeper color, not darker).

- Light or pastel colors seen against the sky will blend with the sky, causing the element to disappear or at least to become less visible.

- The contrast between elements and their background are key factors in selecting color.

- Details of texture must be larger, rougher, or deeper. In order for textures to be seen, they must have enough relief to create shadows within themselves. As the distance between the viewer and the element increases, so must the depth or coarseness of the texture. Fine detail will not be noticed at high speeds and long distances.

- The edges of structures are very important, particularly if they are seen against the sky. In fact, any element viewed against the sky will become a dominant element within the scene. Elements that would not normally be highly visible, such as a decorative light pole and fixture, will be highly dominant if aligned on a bridge and silhouetted against the sky. Other items include bridge railings, elevated ramps, utility poles, trees, and billboards.

- Vistas and views may be dominant in these corridors and may either be preserved or screened depending on the visual quality of the scene.

- Small details will be less visible in these spaces but many small elements may be viewed as a whole. The distance from which it is viewed and the size of the element will determine its legibility.

- The connection between structures and the ground vegetation is a critical interface. If this edge is uniform (height is not as important as uniformity) the connection (and hence the scene) will appear more neat and orderly. If not, the connection becomes a ragged, unkempt line that may be visible from a great distance.

Low-speed highways

In these types of roadways, elements are seen at close-up distances, sometimes only a few feet. At slow speeds, textures at the scale of a brick paver can still be distinguished at distances of about 100 ft, although this is affected by their color. For this reason, attention to textures and colors are more critical at slower speeds.

Visual complexity (the number of elements within a scene) is more important in these conditions than in high-speed corridors. Often, there is more activity, more types of transportation (pedestrian, bus, and bicycle), and more visual information to interpret. In some cases, the scene can become so complex as to make it difficult for a user to perceive all the desired information:

- Use a finer, more elaborate detail.

- The contrast between adjacent colors and textures will affect their prominence as well as the visual order of the scene.

- Litter and general dirtiness are much more visible in these sites, particularly where traffic is stopped at intersections. Improving the cleanliness of a site may improve many aesthetics problems.

- Pedestrian activity should be highlighted through the use of colors and textures on pavement surfaces.

- Amenities, such as benches, waste receptacles, and decorative lighting can add interest, variety, and uniqueness to a site.

- Use special finishes and materials to create an intimate connection between the roadway and the community. (Examples include historic districts, neighborhoods, industrial districts, unique natural features, etc.)

THE COMMUNITY'S ROLE IN HIGHWAY AESTHETICS

Use community input to develop a set of aesthetic goals (or goal) for a site. This input helps assure that the improvements will be appreciated by the community and in some cases, even cared for. In most cases today communities are actively pressing for more attractive roadways so their participation is critical from the beginning.

Each community will have a different idea about how to accomplish these goals, so the alternatives for elements and treatment vary widely. Conducting meetings and workshops to discuss ideas and needs is an excellent way to foster community understanding of TxDOT's needs as well as TxDOT's understanding of community concerns.

These types of partnerships have proven very successful in numerous districts throughout the state. Some districts have established ad hoc aesthetic committees that contain membership from the community in addition to the TxDOT members.

Community participation builds community ownership and responsibility and helps to establish a positive relationship between the community and TxDOT. Although doing so involves added meetings and an additional layer of decision making, the long-term effect will likely lead to a better project in all respects.

AESTHETIC TREATMENTS FOR TEXAS HIGHWAYS

INTRODUCTION

A Guide to Issues, Techniques, and Options

The use of aesthetic design alternatives has generally been widespread but spotty across the state. Some designers have used some practices routinely while others may have never used them, probably due to unfamiliarity with the practice.

This section provides technical data for a range of aesthetic treatments or elements that designers may consider for use on highway projects. They are designed to provide fundamental information about their character, their advantages, disadvantages, costs, and maintenance implications. Design guidelines are also provided, as well as websites or addresses where more information may be sought from manufacturers.

The list represents practices that either have been used in roadways in the past, have the potential for use, or that the designer may come in contact with, but is as yet unproven. The information is basic in nature and should be considered only the first step in gauging a particular treatment or element's suitability for a specific site. Designers are encouraged to share their experiences with these and other alternatives so that the knowledge base can grow, improving usage of some practices and perhaps eliminating others that prove impractical over time.

Manufacturers appear as examples of the representative information available for a particular treatment. The authors do not endorse any manufacturer or product included in the following material. Thorough investigation will determine the suitability of any treatments included here.

The following topics are also available online on the TxDOT web page (http://manuals.dot.state.tx.us/dynaweb/). Each section is individually downloadable as a PDF file and graphic examples are included.

Concrete (Poured-in-Place) – Coatings and Coloring
- Sealer Stains
- Acid Stains
- Integral Color
- Color-Hardened Concrete
- Thin-Set Surface Coatings

Concrete (Poured-in-Place) – Textures
- Sandblasting
- Colored, textured Concrete
- Form Liner Finishes

Veneers
- Brick and Stone
- Tile

Concrete (Modular) – Walls
- Concrete Masonry Units
- Modular Block

Paving
- Brick Pavers
- Concrete Pavers

Traffic Barriers
- Movable Concrete
- Interior Planter Support System

Asphalt – Textures
- Patterned Asphalt

Asphalt – Color
- Surface-Coated
- Integral Color

Pedestrian Barriers
- Railings
- Fences

Lighting
- Accent Lighting
- Fiber-Optic Lighting
- Specialty Street Lighting

Site Amenities

Public Art Projects

TECHNICAL DATA DESCRIPTIONS (TECH SHEETS)

Concrete (Poured-in-Place) — Coatings and Coloring

Sealer Stains

Description

There are two forms of colored coatings specified for use by TxDOT. Type I is defined as a textured Acrylate resin *solvent-based* material, and Type II is an un-textured Acrylic resin *water-based* material.

Type I stains contain volatile organic compounds (VOC). The EPA regulates the amount of VOCs in all products. Applicable rules for highway uses are found in 40 CFR Part 59, National Volatile Organic Compound Emission Standards for Architectural Coatings, dated September 11, 1998. Type II coatings contain no or very few VOCs.

Two classifications are applicable to Type I coatings: "Concrete Curing and Sealing Compounds" and "Stains." Each has its own VOC limits. Sealing compounds carry an approved VOC content of 700 grams per liter or 5.8 lb/gal. Stains are approved up to 350 grams per liter or 2.9 lb/gal.

Type II waterborne coatings are not very widely used or recommended for concrete because acrylic and latex tend to peel. This problem is primarily related to the degree and quality of the surface preparation in removing surface impurities.

Advantages
Relatively inexpensive.
Easily contracted.
Immediate visual impact.
Well-received by the public.

Disadvantages
Improper installation can lead to peeling and costly repair.

Safety issues for public use
None.

Cost
$0.35 - $0.50 per sq ft with standard blast cleaning.
Add $2.00 to $4.00 per sq ft for light sandblasting.

Environmental
Sealer stains pose no hazard to the environment when handled and disposed of properly.

Maintenance issues
Colored coatings may fade over long periods of time and require reapplication. Improper application may lead to peeling surfaces later.

Installation
Installation includes a surface cleaning followed by application of the coating using either spray or rollers. Rollers are most commonly used to avoid drift and conserve the material.

Specifications
The coloring of existing or new concrete is paid under item 427, Surface Finishes for Concrete.

Guidelines
Sealer stains are well suited to vertical surfaces and riprap. Pedestrian usage will quickly degrade the finish. Sealers on horizontal surfaces may also result in a fairly glossy finish, possibly leading to a slippery surface when wet.

High VOC sealers adhere well to concrete and are durable for long periods but surface preparation is still critical to long life. Poor preparation will hasten the deterioration of any coating. Item 427 calls for blast cleaning, which, if done

thoroughly, will result in a good surface. Low VOC or latex-acrylic coatings have proven very durable in drier climates when accompanied with proper surface preparation.

The type of preparation for a concrete surface is determined by the nature of the surface contamination. Industry guidelines make the following recommendations:

Grease or oil	De-greasing solution
Mold/mildew	Water/bleach solution
Loose paint	High-pressure wash
Mill scale dirt	High-pressure wash
Foreign matter	High-pressure wash
Rust	Liquid rust remover
Efflorescence	High-pressure wash
Severe efflorescence	Acid etching

In situations where one or more condition is present, such as oily residue and a flaking surface, a light sandblasting may be desirable. Each type of preparation should follow manufacturers' recommendations for the process, especially those involving the use of acids and other caustic preparations.

When selecting color, consider any surrounding buildings or nearby highway structures. While the proposed color need not match the surrounding structures, they should compliment them.

Colors that have the highest contrast with the surrounding landscape will make the structure more visually prominent. Muted, low-contrast colors will cause the structure to be less prominent, tending to fade into the landscape. Light colors such as tans, beiges, light blues, etc., will blur the edges of the structure when viewed against the sky. Darker colors in these areas highlight the edge and line of the structure.

Due to the long distance in which most structures are viewed, atmospheric conditions will cause a color in a highway corridor to become muted. To ensure high visibility, use higher intensity colors than would normally be selected for close-up viewing. It is recommended that a test of the color options be tried in the field to accurately judge the effect and make the final color selection.

Manufacturer's information
http://www.concretecoatingsinc.com/
http://sherwin.com/
http://www.decorativeconcretepro.com/catalog.htm

Acid Stains

Description
Acid stains are waterborne compounds of metallic ion pigments, wetting agents, and hydrochloric acid. When applied to concrete surfaces, the acid interacts with the calcium carbonates in the cement, changing their color depending on the pigment used. Since the carbonates are not evenly distributed in the concrete surface, the color is darker where more carbonate is present and lighter where there is less. The final color is also affected by the length of time the solution is left on the surface.

Advantages
Rich, mottled colors.
Very unique appearance.

Disadvantages
Installation is very skill-dependent.
Color varies with cement content; high variation is normal.
An acid product that requires careful handling.
Thought to be permanent but some contractors report fading over time.
Difficult to use in vertical applications.
Color will highlight form lines.

Safety issues for public use
Sealer stains pose no safety hazard to the driving public once installed but as an acid product, care in application is required.

Cost
There are no reliable estimates for highway applications, but indications are that the cost will be high.

Environmental
Acid residues may wash into drainage areas.

Maintenance issues
Although said to be permanent, some reports indicate that colors will fade over time unless sealed. Since the solution interacts with only a few millimeters of the surface, damage to the surface will reveal the normal concrete color. This may be difficult to repair.

Guidelines
This technique is not recommended for use in the right-of-way at this time due to the caustic nature of the material and cost.

Manufacturer's information

Kemiko
http://www.kemiko.com/

Plastiforms Renew-Crete Systems
http://www.plasticforms.com/

Integral Color

Description
Integral color in concrete utilizes inorganic metallic ions as the basis for the coloring agent. These metal compounds are necessary due to the harsh chemical composition of the concrete itself and the exposure to ultraviolet radiation of the sun.

Industry terminology makes a distinction between "integral color" and "dyes" when referring to the coloring of concrete. Dyes are pigments typically used to color textiles and other products. These may be derived from a number of sources, some organic in nature, but most are not suited to use in concrete.

Integral color is also available for pre-cast concrete from architectural pre-cast panel producers. Non-architectural elements such as concrete traffic barriers may also be candidates for integral color although manufacturers may not have extensive experience with this application.

Advantages
Adds color to concrete without the danger of peeling associated with some types of pigmented coatings.
Chipped areas show same color as surface.
Permanent.

Disadvantages
Inconsistencies in mix will cause color variations.
Limited to pastel color shades.
Mixing procedures must be followed carefully to achieve consistent color, slump, and curing.

Safety issues for public use
None.

Cost
Color pigments are added to concrete based on pounds of pigment per sack-mix of the concrete and vary depending on the color. These may range from about $1.00 up to $2.00 per pound for most pigments. Therefore, a six-sack mix that requires 3lb of pigment per sack will add $18 per cubic yard to the cost of the concrete.

In practical application, however, the costs for the coloring agent at a ready-mix plant are lumped with the additional costs associated with adding the agents and the cleaning of trucks. This is typically charged at the rate of an additional $50 per cubic yard for integral color batches. This price may be less in areas where integral color is frequently used or for larger pours.

Maintenance issues
The finished concrete surface requires sealing to maintain best appearance. Resealing may be required every 18 to 36 months depending on location, weather, and traffic.

Installation
Coloring agents are added at the time of preparation of the ready-mix batch and the truck must be thoroughly cleaned after each pour. The coloring agent must be added in a set procedure to ensure proper distribution in the mix. Mixing plants are provided with instructions on this procedure, and control should generally be good.

Specifications
Integral color may be made subsidiary to the concrete item being used. Specific guidelines and specifications should be provided through plan notes and should address the following:

Integral colors used must conform to ASTM C-979.

The addition of a powered coloring agent changes the character of the concrete, including the slump as well as final color. Consistent color will be best achieved through the use of factory-prepared mixes that are formulated to compensate for the expected changes in the concrete mix and still maintain the proper slump and flow characteristics. This will also be the best assurance that the final color will closely match the color from the color charts of the manufacturer.

Make sure that the specification notes the pigment as being derived from inorganic metallic compounds.

Changes in aggregate sources will change the color of the batch. Specify a single source and aggregate composition for all integral color pours within a project.

Integral colors are not recommended for use with fly ash.

Guidelines
Integral color may be used for any concrete application, either vertical or horizontal. The use of integral color may not be economically justifiable for very thick structures since a high percentage of the color will never be seen. In these cases, exterior stains may be more appropriate.

For flat concrete surfaces in areas such as riprap, traffic islands, and medians, integral color will prove more durable than pigmented coatings such as stains and pigmented sealers.

Select the color based on the desired amount of attention the area is to receive. In the case of medians and traffic islands, contrast with the driving lanes is paramount. Color for riprap may be more muted, perhaps to reduce glare or to approximate the colors of nearby buildings.

Manufacturer's information
QC Construction Products, LLC
http://www.qcconprod.com/main_index.html

Architectural Precast Association
http://www.archprecast.org/indstandards.html

ChemSystems, Inc.
Houston, TX
713-329-9066

L.M. Scofield Company
Los Angeles, CA 90040
800-800-9900

Color-Hardened Concrete

Description
Premixed, dry powders are used to color and harden freshly placed concrete flatwork. They are typically composed of mineral oxide pigments, cement, and graded aggregates. Other conditioning admixtures may also be included to improve workability.

Advantages
Available in a wide range of colors that can be made quite dark.
Very durable since the color is part of the concrete surface.
Can be utilized with salt finishes, broom finishes, and rotary finishes.
Good resistance to abrasion and UV degradation.

Disadvantages
Not practical for use on large areas of vertical surfaces.
Do not use with concrete mixes containing calcium chloride.
Inconsistencies in job site conditions, finishing practices, and curing methods may produce variations in the color of the finished product.

Safety issues for public use
None.
Contains Portland cement and free silica. See Material Safety Data Sheets for complete information.

Cost
Approximately $0.50 to $0.75 per sq ft additional to the pavement surface.

Maintenance issues
Most manufacturers recommend an inspection every 18 to 36 months and the surface cleaned or resealed as required by volume and intensity of traffic. The need will depend on a number of factors including traffic conditions, geographical location, and weather. However, the most common use of this technique is in residential and commercial applications and may not be as critical an issue in roadway applications.

Installation
Powders used on color-hardened concrete are shaken as a dry powder on a freshly poured concrete surface, perhaps as two applications with floating performed between the two. It may be left as a surface color only, but is often used with a stamp to texture the surface. When a stamp is used, a release agent is also applied to facilitate removal of the stamping tool.

Most manufacturers recommend using a sealer on the finished to preserve the color for a longer period.

Specifications
Powders used in color-hardened concrete are specified by the number of pounds per square feet of poured surface. The amount of powder used will depend on the color and the intensity desired. Darker colors require less pigment than lighter colors. Each manufacturer will have specific guidelines for their product.

Use Item 5559, Colored, Textured, Concrete.

Guidelines
This is a fairly low-tech procedure that has become more common in the industry over last few years. It is typically used in association with stamped concrete but may be used on plain surfaces also. The expertise among contractors is generally good.

Manufacturer's information
QC Construction Products, LLC
http://www.qcconprod.com/main_index.html

Bomanite Corporation
http://www.bomanite.com/index.html

The Stamp Store
http://www.thestampstore.com/

ChemSystems, Inc.
Houston, TX
713-329-9066

L.M. Scofield Company
Los Angeles, CA 90040
800-800-9900

Thin-Set Surface Finishes

Description
This treatment is a thin coat of a mixture containing a high percentage of Portland cement (8,000 – 10,000 psi) with additives such as polymers, surfactants, silica sand, and fiber reinforcing. It is installed at a depth of 1/4 to 3/8 inch depth and often imprinted with pattern stamping tools. Color is usually included with the mix.

This type of product has seen wide application in residential and commercial applications. Typically found as a "stucco" type finish on commercial buildings, it is also commonly used as a topping for paving along the edge of swimming pools.

Advantages
Durable, hard surface.
Useful for adding color to an existing pavement or structure.
Horizontal applications may be patterned with stamping tools.
Can withstand pedestrian and vehicle traffic.
Can be used on vertical surfaces.

Disadvantages
May fade under use unless sealed at regular intervals.
Relatively expensive.

Safety issues for public use
None.

Cost
Depending on the size of the installation, costs may range from $4.00 to $5.75 per sq ft.

Maintenance issues
Requires sealing and resealing over time to retain the original color.

Installation
Installation is a two-step process after the cleaning of the site. The first is the application of a bond coat, a powder mixed with water, applied and spread with a squeegee and allowed to dry. The final topping is mixed with water according to instructions and applied to the area using a gauge rake and normal concrete finishing tools to create a smooth surface.

The surface may be left in this condition or imprinting tools used at this time. If imprinting is to be performed, a release agent (either powder or liquid) is applied to facilitate removing the stamping tool.

The final surface resembles a broom finish as the liquid components settle around the fine silica sand, providing a not-slip texture.

Specifications
This technique has been used in TxDOT projects; applied under Item 427, Surface Finishes for Concrete, Class A finish.

Reference to colors or patterns may be added to the general notes directing the contractor to the plan sheets for specific information.

It is recommended that test panels be required. Three 3 x 3 ft panels will allow testing of different colors and application procedures.

Guidelines
This technique may be most suitable for traffic islands and medians where the introduction of a color or pattern will improve the appearance of the roadway and be durable under pedestrian traffic.

The high cost of this product is due to the generally small size of historically residential applications and may come down at larger quantities. The square footage required might be reduced by applying the product in the form of a large banded pattern where a relatively smaller portion of the concrete surface receives the coating.

This technique will be most suitable in high-visibility areas where the aesthetic character is desired in existing islands or medians and where the use of pavers or stamped concrete would require the removal and replacement of existing concrete.

This material may also be applied as a spray with a similar, though modified, formula. The sprayed material is typically used with removable and reusable stencils. This technique has been successfully used in the Waco District but the use of stencils was found to be too labor intensive for projects of highway scale.

Manufacturer's information
Bomanite Corporation
http://www.bomanite.com/index.html

The Stamp Store
http://www.thestampstore.com/

Concrete (Poured-in-Place) – Textures

Sandblasting

Description
Sandblasting exposes the aggregate of concrete by removing the surface cement matrix, creating a softer texture that contrasts with the adjacent smooth surface of formed concrete. The depth of removal will determine the degree of texture and the color.

Advantages
Softens the hard appearance of poured concrete.
Minimizes crazing by removing the cement skin at the surface of the concrete.
Textured surfaces tend to forgive minor surface imperfections when viewed at normal viewing distances.
Introduces color variation by removing the cement surface allowing the aggregate to determine more of the color.

Disadvantages
Sandblasting hardened surfaces is time consuming and expensive.
Effect is influenced by the skill of the technician. Consistency throughout the job may be difficult to control.

Safety issues for public use
Sandblasting requires care in control of blowing dust near traffic lanes.

Cost
The sandblasting technique costs $2.00 to $4.00 per sq ft depending on the size of the job, access, and any masking of nearby surfaces that may be necessary. See "Guidelines" below.

Maintenance issues
Textured surfaces tend to distribute water more evenly over the surface, reducing streaking from normal weathering patterns. Textured surfaces under bridge drains may hold stains more than smooth finishes. It may be more difficult to remove graffiti from textured surfaces. Anti-graffiti coatings should be used in areas prone to vandalism.

Installation
Variation in the blasted surface can be a problem, particularly when multiple technicians are involved. Sample panels should be required to determine and set the standard for depth of blasting, particle size, and air pressure.

Specifications
Sandblasting may be made subsidiary to the concrete item being used. Specific guidelines and specifications should be provided through plan notes.

Guidelines
Sandblasting may be use to add texture and contrast to poured concrete surfaces, softening the visual impact of large amounts of concrete, particularly walls. Do not sandblast the corners of structures as this results in a very noticeable non-uniform edge.

Sandblasting may also be used to create patterns or art images in concrete surfaces through the use of masking materials. This technique is accomplished by applying a material called "resist" to the surface prior to blasting. The resist for sandblasting is similar to applying masking when painting a surface.

Resist is specified by its thickness stated in mils, and also by the type of material, typically vinyl or rubber. Resist with a medium tack adhesive (regular grip) is used on non-porous smooth surfaces such as glass, plastic, and glazed tile. High tack adhesive (high grip) is used on porous rough surfaces such as stone, brick, and unglazed tile. Resist for concrete surfaces should be at least 30 mil in thickness with a suitable adhesive and may cost about $2.00 per sq ft.

Colored, Textured Concrete

Description
Patterned concrete is obtained through the use of stamps or imprinted mats to impart a particular pattern such as brick or stone into the concrete just before it has hardened. Prior to patterning, colored dyes (see Color-Hardened Concrete) are typically applied in addition to a release agent to allow for easy removal of the stamping tool. To preserve the color, a sealer may be added as a final step.

Advantages
Easy method to get dramatic visual impact from concrete surfaces.
Cost is reasonable.
Widely used process so contractor skill levels are generally good.
Wide range of patterns and colors available.

Disadvantages
Difficult to match when repair is needed.

Safety issues for public use

Patterns used should not be so deep as to provide difficulty for pedestrian or bicycle traffic.

Cost

Approximately $45.00 per square yard. The cost may vary depending on the size of the job and the pattern used.

Maintenance issues

The color can fade under heavy use. Manufacturers recommend reapplying sealers every 18 to 36 months.

Installation

The concrete is placed, stamped, and screeded as usual. A release agent, usually a powder, is applied to the surface. The stamping tool (varies in size but usually 2 to 3 ft square) is pressed into the concrete. This process is repeated until the entire surface is imprinted. A color-hardening agent, also a powder, is applied and the concrete allowed to set. Excess powder is later removed.

Specifications

This process is paid for under Special Specification 5559, Colored-Textured Concrete.

Guidelines

Patterned concrete is relatively low-cost method of adding visual interest to an area as well as adding contrast to make traffic islands and medians more visible.

The technique is now widely used in the commercial sector, and many good contractors exist. It is recommended that the contractor be required to construct at least two test panels (at least twice the size of the proposed stamping tool) to evaluate the color and set the approved construction standard.

Do not use patterns with deep impressions that might cause problems for narrow-heeled shoes, walking canes, and bicycle and wheelchair tires.

Do not allow poly sheeting to be used as a release tool for the imprinting process since it leaves unsightly folds in the finished surface.

Manufacturers provide detailed procedures for this work and their instructions may be referred to in plan notes.

Manufacturer's information
Bomanite Corporation
http://www.bomanite.com/index.html

The Stamp Store
http://www.thestampstore.com/

Form Liner Finishes

Description
Textures or patterns imparted to new concrete using patterned liners placed inside the concrete forms.

Advantages
Unlimited effects or textures can be achieved.
Proven technology.
Contractor familiarity is very high.
Can be combined with other effects such as colored coatings and sandblasting.

Disadvantages
Factory liners come in fixed sizes. Joints are difficult to hide.
The finished surface is usually difficult to repair.
Some liners may be expensive.

Cost
Typically made subsidiary to Items 420 or 423. The cost will vary depending on the amount of detail or size of the texture. A general rule of thumb is 3-5 percent additional cost of the structure for a typical installation.

Maintenance issues
Damaged finishes may be difficult to repair.
Rough textures that become stained under bridge drains will be difficult to clean.

Installation
The selected pattern is either glued, nailed, or screwed to the forms based on the form manufacturer's specification.

Specifications
Form liners are available in three basic grades. Single use, medium reuse, and heavy reuse. The single-use grades are made of high-impact plastic, and the heavier grades (100 uses) are made from flexible elastomeric plastic.

Liners are available up to 32 ft long and 8 ft wide.

Specify minimum of a 2 inch cover over steel reinforcement to allow for the depth of the form liner pattern.

Guidelines
When adding form liner treatments to a project, the designer should pay special attention to the segmental nature of building bridge and retaining wall structures. A good rule of thumb is to keep all design patterns within 4 or 8 ft increments, both vertical and horizontal. Keep in mind the design pattern should match the size of the segmental steel forms for bridge bents.

Require the contractor to prepare sample panels for approval. These should be at least 4 ft x 4 ft. If the liners will be used edge-to-edge, creating a joint, consider a larger panel to include the joint. Doing so affords the opportunity to gauge the effects of the joint and how it will be finished.

Designs include ribbed patterns, aggregate and fractured, masonry, wood, and other designs. Custom designs are also offered. Keep in mind that some pattern designs, such as stone or wood, may require a color coating to keep the character of the raw concrete surface from negating the visual effects of the liner texture. In most cases, specialty liner designs should be in stone or masonry rather than wood patterns.

Panel design may also include actual stone or brick modules included in the face. See the tech sheet on Veneers.

The range of special designs using custom forms is unlimited, and a wide range of detail is possible. This technique is proving to be a cost-effective method to achieve a dramatic visual effect on vertical bridge structures.

Manufacturer's information
Greenstreak, Inc.
St. Louis, MO
http://www.greenstreak.com/

Custom Rock International
St. Paul, MN
http://www.custom-rock.com/

Fitzgerald Formliners
Santa Ana, CA
http://www.formliners.com/Index.htm

Symons Corporation
Des Plains, IL
http://www.symons.com/products/formlinr.htm

Concrete Veneers

Brick and Stone

Description

Non-structural, molded concrete units that are cast to resemble stone or brick. Integral color is added to the mix and surface colors added later to the surface to mimic actual stone or brick. Some brick veneers are actual brick faces sawn to about 1 inch thickness.

Constructed with Portland Cement and lightweight fiber reinforcing, the product weighs 8 to 10 pounds per sq ft. The thickness of the pieces ranges from 1-3/4 inches to 3 inches.

Advantages

Rich textures and colors of stone and brick.
Very high aesthetic character.
Lightweight.
Carries manufacturer warranty of 30+ years.
Easily repaired.
Wide range of styles and colors.

Disadvantages

None serious.

Safety issues for public use

None.

Cost

Material costs are approximately $2.75 per sq ft for flat pieces, and $3.75 per sq ft for corner pieces. Installation costs in the Dallas area have ranged from $4.00 to $5.00 per sq ft.

Maintenance issues

Over time, dust may accumulate on top edge of pieces, which may be rinsed off with water.

Installation

Concrete surfaces should be clean with no release agent oils present. Type N mortar is applied to the wall, some to the back of the stone and the piece pressed onto the wall surface. After setup a grout bag is used to fill the joints between units and raked when crumbly.

Specifications
In new construction the product may be made subsidiary to the concrete or wall pay item being used. Retrofit projects may be paid under Item 427, Surface Finish for Concrete as a Special Surface Finish (427.8).

Manufacturers provide detailed specifications regarding the character of the product as well as installation procedures. Specific reference to patterns and colors can be provided in the plan notes.

Guidelines
This product is manufactured by a number of companies in the United States; at least one is located in Texas.

This product is well proven in residential and commercial applications. Stucco contractors appear to be doing most of the installations. The installation of this product is faster than real stone since it weighs much less and requires no dressing of individual units before installation.

The finished product is virtually indistinguishable from true stone and brick surfaces.

Manufacturer's information
Arrowhead Stone Mfg. Company
http://www.arrowheadstone.com/

Cultured Stone
http://www.culturedstone.com/

Cast-N-Stone
http://cast-n-stone.uswestdex.com/

Coronado Stone Products
http://www.coronado.com/index.html

Eldorado Stone
http://eldoradostone.com/home/b_home.html

Tile

Description
Molded clay units baked with a surface color or pattern. Available in sizes ranging from 1 to 12 inches, usually square but also available in other shapes.

Advantages
Wide range of colors available. Colors are available in very vibrant and bold hues.

Durable, non-fading.
Can be used to create mosaic patterns.
Small damage is easy to repair.

Disadvantages
Small texture of the tile means a fairly large amount is necessary to be visible at significant distances.

Safety issues to the public
None.

Cost
Material costs for tile vary and may range from $2.50 to $6.50 per sq ft depending on finish and pattern. Some colors are more expensive than others.

Labor costs typically range from $2.50 to $3.00 per sq ft.

Maintenance issues
Replacement of damaged tiles if needed. Individual tiles can be replaced.

Installation
Installation involves applying a scratch coat of mortar on the surface to be covered and applying the tile to the mortar. The scratch coat should be latex modified to gain the highest adhesive capabilities.

Surface preparation should include removal of any oils and dust prior to the application of the scratch coat.

Tile should be installed without a joint that will require a joint filler.
Specify tile that does not have a spacer built into the edge of the tile to get as thin a joint as possible.

Specifications
In new construction the product may be made subsidiary to the concrete or wall pay item being used. Retrofit projects may be paid under Item 427, Surface Finish for Concrete as a Special Surface Finish (427.8).

Guidelines
Tile is recommended for vertical surfaces only. Tile has been successfully used in a few TxDOT districts. The best effect will be those areas of high usage and lower speeds where the color and patterns of the tile can be perceived.

Manufacturer's information
Floorbiz.com
http://www.floorbiz.com/default.asp

Ceramic tile.com
http://www.ceramic-tile.com/

Concrete (Modular) — Walls

Concrete Masonry Unit

Description
Hollow or solid molded concrete structural blocks of various sizes but typically seen as 8 x 8 x 16 inch units. Units are joined with mortar to form a face wall or a structural backing for veneers such as brick, stone, or tile.

Advantages
Wide range of textures, colors, and sizes available.
Simple technology that is easily contracted.

Disadvantages
None.

Safety issues for public use
None.

Cost
Costs vary with the region of the state. Stand-alone walls with a plain finish start at $5 to $7 per sq ft. Split-face block and specialty finishes can run up to $20 per sq ft in the Dallas area and $13 in the Corpus Christi area. The Featherlite Products Division of Acme Brick Corporation provides a free on-line cost estimating page for different block types in different cities.

Maintenance issues
None significant.

Installation
Blocks are installed on concrete foundation designed for the anticipated height and windload.

Specifications
When used as backing for brick or stone veneer walls, the material is paid as part of Item 423, Retaining Walls and specific construction information such as size, joints, and reinforcing included in the details. A special specification (5601, Concrete masonry Unit Retaining Wall) has been used where the units were not placed with another material.

Concrete Masonry Units (CMU) used as free-standing walls such as a screen or sound wall have been installed under special specification items 5420, Sound

Walls and 5345 Sound Wall. Item 5420 provides a detailed Construction Methods description along with references to applicable ATSM numbers.

Guidelines
Concrete Masonry Units are very flexible as a design tool. Manufacturers offer a wide range of surface finishes, texture, patterns, and colors. By mixing these within the same wall surface, the possibilities for unique design are endless.

The material is very durable and requires little if any maintenance. CMUs make excellent visual screens as well as sound walls.

The relatively smooth surface of CMU walls may make an attractive target for graffiti. Where graffiti is likely, consider rough surface textures (large textures usually discourage most graffiti) or the use of graffiti-removal coatings.

Manufacturer's information
Featherlite Building Products Corporation
http://www.acmebrick.com/home-flt.htm

Anchor Concrete Products
http://www.anchorconcreteproducts.com/

Modular Block

Description
Retaining wall system using formed concrete units dry-stacked and designed to interlock with the lower course. Units are available in a variety of shapes, sizes, and face patterns through proprietary design. Individual units may weigh up to 75 lbs.

Advantages
Very stable in small and large applications.
Less expensive and quicker installation than poured-in-place walls.
Unit faces come in a variety of shapes, textures, and colors.
Large pool of qualified contractors.

Disadvantages
None significant.

Safety issues for public use
None.

Cost
$18.00 to $25.00 per sq ft.

Environmental
There are no environmental issues associated with this product.

Maintenance issues
Some unit face shapes create recessed corners which are difficult to access for grass trimming. Installations of concrete mow strips facilitate mowing and edging.

Mowing equipment near the top of the wall may dislodge upper course units. On steep backslopes provide a mow strip behind the top of the wall to keep equipment at a safe distance.

Installation
Concrete units may be laid on compacted subgrade, compacted aggregate base, or concrete pad depending on design height and soil conditions. Units may be locked to lower unit with fiberglass pins or interlocking lip. Walls over 3 to 4 ft tall utilize geo-grid webbing that anchors between the units and extends into the backfill soil a specified distance.

Depending on the manufacturer, units may fit tightly together or leave a noticeable gap. In some cases the gaps may be large enough to lose backfill through the wall. If this condition is of concern for the style of unit being used, install a silt fabric between the units and the backfill.

Even where gaps between the units exist, gravel backfill around rigid or flexible pipe behind the wall should be used. Drain these through the front of the wall by core-drilling a unit or by leaving a unit out and filling the cavity around the weep with concrete. If a significant amount of water is expected to drain to the wall, consider installing a concrete valley gutter behind the top of the wall and connect it to the behind-the-wall drain system.

Specifications
Modular concrete walls are paid under Item 423, Retaining Walls.

Guidelines
Modular concrete walls are very suitable for most low wall applications where the height will not exceed 4 ft. This standard may be modified by soil and water loads at a particular site. In such cases, manufacturer guidelines should be consulted. Beyond the 4 ft wall height, grid reinforcing is generally required based on soil and loading characteristics. Free-standing walls may be constructed using two walls placed back-to-back.

Manufacturer's information
Keystone Retaining Wall Systems
http://www.keystonewalls.com/pages/body.html

Foltz Precast
http://www.foltzprecast.com/learn.html

Pavestone Company
http://www.landscapeonline.com/-pavestone/pavestone.htm

Paving

Brick Pavers

Description
Extruded clay that has been fired to form a high-density ceramic brick. These "hard fired" bricks have a higher compressive strength (10,000 to 12,000 psi) than concrete pavers (about 8,000 psi). The compressive strength comes from the extrusion process (as opposed to "formed"), which removes more moisture from the unit before firing. Formed bricks are typically softer.

Advantages
Visual character suggests old-time look, very human-scaled.
Adds color to an urban scene, range of colors possible.
Since the color is integral, it will hold its color well.
Can be removed and replaced for repairs.

Disadvantages
Cost and time for installation.
Can be dislodged by heavy equipment.
Some brick surface may be slick in wet conditions.

Safety issues for public use
Uneven settling may create "toe-grabbers." Good base preparation is essential.

Due to their hardness, the surface of brick pavers may become more slippery when areas of oil accumulation become wet. "Wire-cut" brick has a rougher surface.

Cost
Comparable to concrete pavers, approximately $4.50 sq ft.

Environmental
No environmental issues are associated with this product.

Maintenance issues
Wind-blown seed may establish in the paver joints requiring hand removal or herbicide spray followed by removal of dead plant. This can be a significant problem. Use pre-emergent herbicides to prevent weeds from getting started.

Herbicide-impregnated fabrics placed below the sand-leveling course are effective but may add up to $2.50 per sq ft to the cost. Installing weed barrier or plastic sheeting below the pavers is not effective and is not recommended.

Installation
Because of their small size, brick paving units require a well-prepared subgrade and laying course. Poor base preparation will lead to settling and degradation of the surface.

Subgrade soils should be compacted to 95 percent of optimum and overlaid with a minimum of 6 inches of compacted limestone aggregate for vehicular use and minimum 4 inches for pedestrian and bicycle use.

Specifications
Brick pavers may be paid for under Special Specification 5019, Landscape Pavers.

Guidelines
Brick pavers add texture and color to paved surfaces. Their small size is very well suited to pedestrian-scaled spaces and sidewalks.

Brick pavers require an edge-restraint system to hold them in place. Commercially available braces are available. Concrete edges at least 8 inches in width also perform well.

Pavers can be placed as bands, shapes, or patterns within larger areas of concrete paving, adding visual interest and reducing the apparent size of the paved area. Mosaics of locally relevant icons can also be laid using different colored units.

Brick pavers are available in rich terra cotta reds, browns, and beiges.

A distinction should be noted: soft clay bricks absorb and hold water leading to deterioration of the units and algae growth in damp, shaded locations. Soft clay bricks are not suited for use in the roadway.

Manufacturer's information
Richtex Brick
http://www.richtex.com/index.html

Concrete Pavers

Description
Molded concrete, paving units of various shapes typically 2-3/8 inches in thickness.

Advantages
High density, very durable.
Suitable for pedestrian and vehicular use.
Rougher texture than brick.
Wide industry skill pool.
Specialized equipment for laying large areas.
Wide range of patterns and colors available.

Disadvantages
Textured surface may discolor by holding stains and tire marks.
Requires very good subgrade preparation.

Safety issues for public use
Uneven settling may create "toe-grabbers."

Cost
Approximately $4.50 per sq ft.

Maintenance issues
Wind-blown seed may establish in the paver joints requiring hand removal or herbicide spray followed by removal of dead plant. This can be a significant problem. Use pre-emergent herbicides to prevent weeds from getting started. Herbicide-impregnated fabrics placed below the sand-leveling course are effective but may add up to $2.50 per sq ft to the cost. Installing weed barrier or plastic sheeting below the pavers is not effective and is not recommended.

Installation
Because of their small size, concrete paving units require a well-prepared subgrade and laying course. Poor base preparation will lead to settling and degradation of the surface.

Subgrade soils should be compacted to 95 percent of optimum and overlaid with a minimum of 6 inches of compacted limestone aggregate for vehicular use and minimum 4 inches for pedestrian and bicycle use.

Specifications
Concrete pavers are paid for under Special Specification 5019, Landscape Pavers.

Guidelines
Pavers add texture and color to paved surfaces. Their small size is very well suited to pedestrian-scaled spaces and sidewalks. Their texture and color variation may highlight crosswalks.

Pavers require an edge-restraint system to hold them in place. Commercially available braces are available. Concrete edges at least 8 inches in width also perform well.

Pavers can be placed as bands, shapes, or patterns within larger areas of concrete paving, adding visual interest and reducing the apparent size of the paved area. Mosaics of locally relevant icons can also be laid using different colored units.

Manufacturer's information
Pavex Corporation
http://pavex.com/

Pavestone Company
http://pavestone.com

Traffic Barriers

Traffic Barriers

Description
Movable or permanent concrete structures designed to absorb or deflect vehicle impacts that have formed face textures resembling stone, brick, or other patterns. May be applied to "block type" or "jersey type" barriers.

Advantages
Improves the appearance of construction sites.
Number of patterns available.
Can be colored.
Low cost.

Disadvantages
Textured surface may hold stains and tire marks.

Safety issues for public use
A very coarse surface character on concrete traffic barriers may influence the behavior of vehicles on impact at high speeds.

Patterns and associated colors should not impair visibility of the units.

Cost
Approximately 1-1/2 to 3 percent added to cost of a single barrier when purchased in lots of about 50 or more. Form liners last about 100 pours and cost $30 to $40 each.

Installation
Barrier faces are achieved by installing a urethane form liner into the barrier forms. One or two sides can be treated. (Cost above is for one side.)

Color may be added after completion and is usually performed by a different contractor. Acid stain (see Acid Stains) may be appropriate in this case for

durability and the fact that staining may be performed in a yard rather than a roadside. Typical sealer stains may also be used. Color may add significantly to the cost of each unit.

Specifications
Specified by selecting and requesting a form be added during barrier fabrication.

Guidelines
Construction sites are often very chaotic and unattractive and often viewed by travelers in a slow-moving vehicle. The aesthetics of a construction site is a new area for consideration. Since many sites may endure for long periods of time, efforts to improve their aesthetic character may improve the public's tolerance of an inconvenience due to construction.

This alternative may be most appropriate for construction sites in historic districts and urban centers.

Manufacturer's information
Design Pro, Inc.
http://www.designproforms.com/#

Custom Rock International
http://www.custom-rock.com/

Commercial Forms, Inc.
11293 State Hwy. 19, N.
Athens, TX 75751
903-675-2511
800-256-4511

Behar Concrete Works
Judson Rd. P.O. Box 700250
San Antonio, TX 78270
210-497-3773

Interior Planter Support System

Description
Concrete traffic barriers (typically "Jersey-type" barriers) have been used as containment for planting areas in the medians of some highways. The system consists of two barriers separated by a distance and filled with a suitable soil for maintaining plants.

Advantages
Provides an opportunity to add plants to what is usually a wide expanse of paving.
Raises plants above the impact zone of automobiles so driver safety is not negatively impacted.

Disadvantages
Cost per square foot may be expensive.
Maintenance access may difficult.
Heat and exhaust fumes create a difficult growth environment; plant losses may be high for some species.

Safety issues for public use
Tree limbs may pose a hazard if not properly maintained. Trees in areas subject to high winds may fall into travel lanes.

Cost
Based on a 10 ft wide planting area, material costs for an interior median planter is estimated to be between $90 and $100 per linear ft, with the barriers themselves comprising $60 ($30 per linear ft of each barrier) of that amount. This figure includes an allowance for solid sod, a single tree every 30 ft, and an irrigation system. Gravel, filter fabric, and Styrofoam insulation board are also included.

Labor will be variable based on the location of the site, access, and the length of the planter. Planters installed as part of new construction may be much less expensive, especially since water access for the irrigation system will be made easier by sleeving before the pavement is laid.

Installation
Drainage is a prime consideration for planters, both for plant health and for storm water from the traffic lanes. If the median contains a grate inlet, a break in the base of the barriers may be constructed, and a blocked-out opening created to the drain in order to allow water from the shoulder access to the drain from the shoulder.

Gravel covered with a filter fabric is mandatory to allow water to drain from the planter soil. This gravel is necessary even if the planter is installed over soil. Insulating Styrofoam must be placed along the inside edge to prevent the heat gain in the barriers radiating to the soil.

Specifications
This feature may be paid as a special specification after the particulars of the site are known, or each component may be paid as a separate item. The gravel and insulation may be subsidiary to the entire project.

The amended backfill should be well drained, but hold enough moisture to prevent rapid drying. Include a portion of clay or silt with the specified soil mix.

A mix may be divided as follows: 60 percent composted mulch, 20 percent clay or silt, and 20 percent fine sand.

The Styrofoam board comes in 2 ft x 8 ft sheets in 2 inch thickness. Gravel for drainage should be 1-1/2 inch septic gravel at a minimum depth of 4 inches.

A typical detail for a median planter should contain the arrangement shown in Figure 6. Actual dimensions and drainage information should be added based on site conditions.

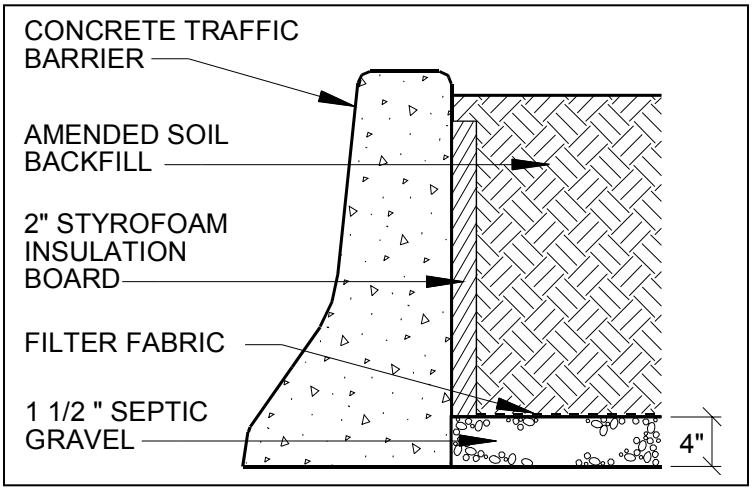

Figure 6. Median planter detail.

Guidelines

Interior planters are an effective way to add plant material to a roadway to break up wide expanses of pavement or to reduce headlight glare if shrub hedges are used.

Concrete traffic barriers may be segmental (usually 30 ft long) or slip-formed. The joints in segmental barriers can provide drainage but the gaps should be caulked to within 6 inches of the ground line to prevent excess drainage and weeping.

Minimum inside width of planters should be 5 ft if only shrubs are used and 10 ft for trees. These figures are only for the minimum soil area needed for the plant type, not a safety minimum or maximum. In all cases, the trees should not extend beyond the front of the barriers to avoid dangers from overhanging limbs or limbs falling on to the traffic lanes.

Concrete traffic barriers will absorb high amounts of heat and transfer it to the interior soil, possibly killing plant roots. Insulation is required.

Irrigation systems in the planters will be necessary to keep plants alive. The system should not throw water into the air. Rather, subsurface soaker or drip systems should be used.

If sod will be installed, provide access for mowing equipment at one or both ends.

If installed during new roadway construction, do not allow the planter to be used as a disposal for rubble and waste.

Manufacturer's information

Concrete traffic barriers are typically available from many concrete contractors.

Asphalt - Texture

Patterned Asphalt

Description
Brick or stone patterns pressed into freshly poured asphalt with a steel-wheel roller over large templates. Finished surfaces are sealed with colored coatings or dyes (see Asphalt Colors).

Advantages
Low-cost alternative to achieve the look of brick paving.
Low-technology.

Disadvantages
May show deformation under heavy loads during times of extreme heat. Does not appear suited for highway traffic lane use.

Safety issues for public use
None.

Cost
Approximately $3.00 to $5.00 per sq ft. Rate will be affected by access and the amount of edge-work. Installation rate for a four-man crew ranges from $4,000 to $10,000 per sq ft per day.

Environmental
This technique poses no environmental hazard.

Maintenance issues
Typical to common asphalt-paved surfaces.

Installation
Large, reusable steel templates of heavy gauge wire are laid on new asphalt and pressed into the surface using a steel wheel roller and/or a large vibrating plate compactor.

After the asphalt has cured for several days, a colored coating is both sprayed and brushed onto the surface. This coating is typically a Portland Cement/Acrylic blend containing aggregates and pigments.

Specifications
Pay as subsidiary to the item used for asphalt paving.

Guidelines
Cases of DOT use have been in non-traffic bearing applications. Some cities in northern states have used it neighborhoods with reasonable success.

Best used for pedestrian areas or for areas not typically used for frequent, heavy vehicular traffic. Though tested at high temperatures (95 degrees) in some northern states, the higher temperatures in Texas make this technique questionable for any traffic lanes. Best application areas may include gore points, medians, traffic islands, shoulders, phone call boxes, and for areas beneath bridges and overpasses.

Manufacturer's information
Integrated Paving Concepts, Inc.
http://www.streetprintmidwest.com/
936 Peace Portal Dr.
P.O. Box 8014 - #48
Blaine, WA 98231
800-688-5652.

Asphalt – Color

Surface-Coated

Description
Color added to the surface of existing asphalt paving through the application of a dyed coating. Alternatives include dyes which may be added to an asphalt emulsion or water-based, pre-mixed solutions. Coatings may be an acrylic and have sand added for slip resistance.

Advantages
Alters typical asphalt appearance.
Bold colors available.

Disadvantages
None serious.

Safety issues for public use
Coating may become slippery in damp conditions. Add materials for skid resistance or use a textured pavement in pedestrian areas.

Cost
Approximately $0.10 to $0.25 per sq ft. Size of area to be treated affects cost with lower price for large area.

Maintenance issues
Colors may fade over a period of year. Re-sealing is optional.

Installation
Asphalt emulsions are applied with standard seal-coat equipment. Pre-mixed solutions are applied with a squeegee or spray.

Specifications
Paid under Item 315, Emulsified Asphalt Seal. Specify additive dye or pre-mixed, water-based emulsion in general notes.

Pre-mixed products may include sand for improved traction.

Guidelines
This technique is generally applied to smaller, low-traffic and no-traffic areas such as bike paths, gore points, medians, islands, drop-off areas, etc., where the interest and contrast of color can highlight a specific activity.

As with all seal coats, the intensity wears noticeably after a few years as the aggregate works through the coating. The result may not be undesirable and re-sealing is optional.

Manufacturer's information
Asphacolor Corporation
http://www.asphacolor.com/index_main.html

Sealmaster
http://www.sealmaster.net/

DecoAsphalt
http://www.decoasphalt.com/index4.html

Integral Color

Description
Powered dyes added to asphalt hot mix prior to installation.
Advantages
More durable alternative than colored seal-coat.

Disadvantages
Cost is relatively high.

Safety issues for public use
None.

Cost
Approximately $1.30 per sq ft.

Maintenance issues
None.

Installation
Dye added to the hot mix at the batch plant. Some plants may be reluctant to insert dye for fear of contaminating subsequent batches. Cost estimate quoted includes $20 per ton charge to run and waste one ton to clean mixer.

Specifications
Paid by the asphalt topping item being used. Specify color additive in general notes.

Guidelines
After a few years the aggregate works through the surface coating and the color may become less intense. The result may not be undesirable and re-sealing is optional.

Due to relatively high cost, the best use location for color asphalt pavement will be in smaller, low-traffic and no-traffic areas such as bike paths, gore points, medians, islands, drop-off areas, etc., where the interest and contrast of color can highlight a specific activity.

Manufacturer's information
Asphacolor Corporation
http://www.asphacolor.com/index_main.html

Pedestrian Barriers

Railings

Description
Specialty railings for bridges and pedestrian areas constructed of decorative metals.

Advantages
Distinctive detailing adds interest and uniqueness to the structure.
Wide design possibilities and many pre-fabricated designs available.

Disadvantages
May be more expensive.
Not for high-speed overpasses due to less crash-worthiness.

Safety issues for public use
Must be designed for the site to make sure safety needs for vehicles and pedestrians are met.

Cost
Variable depending on design.

Maintenance issues
Coatings should be durable and not subject to peeling or flaking.

Installation
Dependent on design.

Specifications
May be paid under Item 450, Railing. May request shop drawing to be provided.

Guidelines
Decorative steel fences and rails are most appropriate on bridges at signal-controlled intersections in urban areas, particularly when near residential areas with high pedestrian use.

Decorative railings offer an opportunity to introduce architectural detailing and color accents not normally associated with highway bridges. They provide a more human-scaled feeling to the structure for pedestrians.

Railings may also be incorporated with specialty lighting.

Manufacturer's information
Universal Industrial Sales, Inc.
http://www.universalindustrialsales.com/bridgerail/bridgerail.htm#top

Fences

Chain-link

Description
Color-coated chain-link fencing for lane separation and bridge safety.

Color on the fence is provided in two ways. The chain is coated with a vinyl coating, and posts are coated with a powder coating.

Advantages
Low-cost alternative to providing long-term protection against unattractive rusty fences.

Disadvantages
None.

Safety issues for public use
None.

Cost
Material costs may be as high as 49 percent additional for vinyl coated fence.

Maintenance issues
Coating typically warranted for 15 years or longer.

Installation
There is no change in installation procedures from TxDOT standard specifications.

Specifications
Chain-link fences are paid under Item 550. Specify coating type (vinyl-coated, epoxy coated, etc.) matching posts, and desired color.

Guidelines
Chain link fencing often occupies a large portion of the drivers view in urban areas, especially at overpasses. Fences that rust over time create stains on other parts of the structure in addition to making the structure look dilapidated.

Manufacturer's information
Master Halco Inc.
http://www.fenceonline.com/branchlocator.html

Ameristar Fence Products
Tulsa, OK
http://www.ameristarfenceproducts.com/

Lighting

Accent

Description
Lighting for special applications not associated with roadway lighting, usually up-lighting of walls, trees, flagpoles, etc., or path lighting in pedestrian use areas.

Advantages
Extends visibility of site elements for night viewing.
Improve safety for pedestrians by lighting steps, etc.

Disadvantages
None

Safety issues for public use
Always consider other light sources within the site to be sure that these fixtures do not combine with other lighting to create glare which can interfere with signal or directional lighting.

This type of lighting is not intended to direct light into the faces of drivers or pedestrians. Doing so may conflict with other lighting or visibility needs in the site.

Cost
Up-lights, step-lights, and bollard lights vary in cost depending on the size of the fixture, the wattage of the bulbs (usually 100 to 150 watts), and the type of bulb (fluorescent, incandescent, mercury vapor, or metal halide). Other features include light cut-off shields to prevent light from straying to unwanted areas, directional adjustments, and cover guards for the lenses. The costs provided below are for fixtures only.

In-ground up-lights can range from $100 to $400.
Step-lights can range from $100 to $300.
Bollard lights can range from $300 to $700.

Maintenance issues
Added number of lamps for bulb replacement.

Installation
Manufacturers typically provide standard details for each fixture type.

Specifications
This item should be paid under Item 610, Roadway Illumination Assemblies (SPL). The style, color, and example products should be described in the general notes or plan sheets.

Guidelines
The addition of accent lighting and pathway lighting can greatly improve the character of the site by increasing the visibility of an element or its usability by persons after dark.

The best application of accent lighting is to provide added visibility in critical areas to improve pedestrian safety. This may include adding light at steps and grade changes in ramps. Flagpoles, walls, and trees are common elements that benefit from lighting. Bollards, retaining walls, and planter walls are candidates for flush-mounted, downward focused path lighting in urban areas.

Manufacturer's information
Kim Lighting
City of Industry, CA
http://www.kimlighting.com/

General Electric Corp.
http://www.gelighting.com/na/business/

Fiber Optic

Description
Fiber-optic lighting utilizes an electrical light source from which fiber-optic cables of various sizes convey light to a remote location or emit it from the side of the cable giving an effect similar to a neon fixture. Neither the cable nor end fixture is electrically charged.

Advantages
No bulb fixtures that can break.
Fixtures are not electrically charged.
Light can change color with a color wheel.

Disadvantages
Source bulbs will need to be changed as they burn out.
Source light must be protected to prevent vandalism.
Damage to the fiber optic cable in the form of denting (rather than severing) may result in "hot spots" of bright light. These are not considered serious but they cannot be repaired.

Safety issues for public use
Always consider other light sources within the site to be sure that these fixtures do not combine with other lighting to create glare, which can interfere with signal or directional lighting. Fiber-optic lighting is an accent-type lighting and not suitable for area lighting.

Cost

Fiber-optic systems are priced based on the various components used. Basic systems require an illuminator (source light), a harness (attaches the cable to the illuminator), cable (sizes range from 0.3 to 0.7 inches diameter), and a device to attach the cable to a surface.

Material costs for a basic installation may be approximately $25 per linear ft. Labor costs are highly site specific but a 2x material cost increment ($50 per linear ft) may be used for rough estimation purposes.

Maintenance issues

Bulbs will burn out and need to be replaced so access must be considered. Bulb life ranges from 700 to 2,000 hours depending on type of bulb and wattage. Place light sources in areas accessible without the use of special equipment such as bucket trucks, or in places that would require lane closures.

Installation

Side-emitting light cables are mounted to structures in attachable tracks, stand-offs, or clips. Cables with end-emitting light are mounted in fixtures of various sizes and finishes.

An important characteristic of side-emitting fiber-optic lighting is the fact that the light dims as it gets farther from the illuminator. The maximum recommended distance for a single, dead-end run of cable is 50 ft. If the cable end is to be connected to another illuminator, the cable can be 100 ft long. A cable may be 100 ft long if it is looped back to the illuminator.

Specifications

Bulbs of source lights may be quartz halogen (4,000 hours) or metal halide (10,000 hours). Metal halide lamps are recommended for highway projects to reduce the amount of maintenance in bulb exchange.

Cable is designated by its location of use. The composition of indoor cable is not suited for outdoor use. Specify UV Stabilized Cable for all highway projects.

Guidelines

Fiber-optic lighting can add unique and interesting effects to structures and landscapes. They may be used to outline structures, highlight parts or detailing of a structure, and used as backlighting to design elements.

Recent advances of this technology include special fixtures that allow the end of the cable to be set into pavers or concrete. This creates a series of light-dots that might be used to highlight pedestrian crossings, direct traffic, highlight curb faces, or other areas where the visibility of an object or activity is critical.

Because the cable itself is safe to handle, it is susceptible to tampering if not vandalism. For this reason, cables and source light boxes should be placed where

they are relatively inaccessible to casual pedestrian traffic and mounted out of reach from the ground or other nearby surface.

Manufacturer's information
Lumenyte International Corporation
Irvine, CA
http://www.lumenyte.com/default.htm

Fiberstars Inc.
Freemont, CA
www.fiberstars.com

Specialty Street Lighting

Description
Light poles and fixtures (luminaires) that have a unique design or finish usually of a historic design style, typically intended for lighting pedestrian use areas in urban locations.

Advantages
Adds distinctive touch of design or color to a site. Can be used to accent or complement architecture of nearby buildings.

Disadvantages
Can be expensive depending on the style selected.
Generally not advisable unless roadway illumination is present or will be added in the same project.

Safety issues for public use
These types of illumination assemblies are lower in height and depending on their location may not throw enough light to reach vehicle travel lanes. If no other roadway illumination is present, the glare from these lower fixtures may make the roadway harder to see and much less safe. In some of these cases, a taller roadway illumination assembly may be included on some of the pedestrian height poles. The spacing for these extended assemblies will be determined by the roadway width, other lighting in the area, lighting pattern, etc. In all cases, roadway illumination must be addressed when adding pedestrian lighting.

Cost
The cost for decorative pole assemblies varies widely depending on style, finish, and type of bulb. Luminaires may range from $500 up to $2,000. Poles may range from $700 up to a few thousand. The higher costs are usually associated with custom designs or include detailed scroll-work, arms, or curved poles.

Maintenance issues
Maintenance is the same as that for typical pole and light fixtures. Bulb changing is the most common maintenance task and will be affected by bulb type and life.

Installation
Installation of specialty poles and luminaires follow standard industry practices.

Specifications
This item should be paid under Item 610, Roadway Illumination Assemblies (SPL). The style, color, and example products should be described in the general notes or plan sheets.

The Traffic Division has pre-selected three models of fixtures that will meet state law using AASHTO criteria. The fixtures can be mixed with different pole styles, but the height is a critical factor that must be determined based on the site conditions. Contact them for model and specification data on these fixtures.

Although either type is suitable, glass fixtures are preferred over acrylic.

Guidelines
Specialty lighting is often used to evoke a historic theme and is very popular with many cities. Fixtures such as these are highly visible, adding color and accent to urban street scenes.

Some brands include options such as matching signs for street names, no parking signs, bus stops, etc.

Lighting within the highway corridor is a critical issue because of its effect on user safety. TxDOT must adhere to AASHTO guidelines that provide detailed design guidelines for meeting these requirements. These are expressed as state laws governing the amount and direction of light emanating from a fixture to lessen light pollution in urban areas. Traffic engineers should review proposed illumination assemblies to be sure that a particular fixture and spacing will conform to state law.

Manufacturer's information
Lumec
http://www.lumec.com/

Hadco Lighting
Littlestown, PA
http://www.hadcolighting.com/

Sternberg Vintage Lighting
Niles, IL
http://www.sternberglighting.com/home.html

Sentry Electric Corporation
Freeport, NY
http://www.sentrylighting.com/SentryHome.htm

Valmont Industries, Inc.
Omaha, NE
http://www.valmont.com/home3.html

Bassco Colonial Light, Inc.
Philadelphia, PA
http://www.basscocolonial.com/

Site Furniture

Site Amenities

Description
Convenience elements associated with areas of high pedestrian use such as transit stations, picnic and rest areas, urban centers, etc. These elements include benches, bike racks, tables, and trash receptacles.

Advantages
User convenience.
Adds visual interest and color to site.

Disadvantages
May be subjected to vandalism.
May require cleaning.

Safety issues for public use
Well-secured structures, avoidance of sharp edges, proper placement in the right-of-way. Tree grates should not allow bicycle tires to become caught in their openings.

Cost
With so many suppliers of these elements, costs vary greatly. The less expensive items such as trash receptacles and bike racks start at less than $100 for plain, galvanized finishes. Higher quality benches that feature heavier construction and powder-coat finishes may range as high as $1,500.

Transit shelters vary also. For example, 4 x 6 ft models may start at about $2,700; 6 x12 ft models can be found for about $5,000.

Maintenance issues
Possible refinishing if damaged or vandalized.

Installation
Any bench, table, or receptacle must be firmly secured to an immovable footing to avoid theft. This is a common feature offered by manufacturers, and they typically can provide the appropriate installation details.

Specifications
Site furnishings are specified through a Special Specification. A standard specification outline is available in which an example of the item can be noted along with headings for structural specifics.

Non-structural elements such tree grates may be specified as subsidiary to a related item.

Guidelines
Site furnishings come in a variety of materials including wood, steel, cast iron, aluminum, plastic, recycled materials, plastic-coated steel, and concrete or a combination of any of these.

Finishes may include paint on metal surfaces and integral dyes on plastic materials. Electrostatically applied powder coats are also available. A wide range of colors is available for just about any material.

Open mesh designs for metal benches may deter graffiti better than continuous surfaces.

Manufacturers or other information location
The Frederick Bench
Frederick, MD
http://www.frederickbench.com/

Victor Stanley, Inc.
Dunkirk, MD
http://www.victorstanley.com/

Webcoat Products
McAlester, OK
http://www.webcoat.com/contact.html

Keystone Ridge Designs
Butler, PA
http://www.keystoneridgedesigns.com/

PlasticBenches, Inc.
Elgin, IL
http://www.plasticbenches.com/
Brasco International, Inc.
Detroit, MI
http://www.brasco.com/index.html

Belson Outdoors, Inc.
North Aurora, IL
http://www.belson.com/bss.htm

Artwork

Public Art Projects

Description
Art elements or graphics placed in the roadside or on structures.

Advantages
Adds distinctive character to that section of corridor.
Allows a community to express some aspect of their culture or aspirations.
Often a good way to build good relationships with the community.

Disadvantages
Requires careful attention to detail, added time in meetings, and communication with community groups. Selection of themes can lead to dissention between groups.

Safety issues for public use
Depending on the type of art, pedestrians may be attracted into unsafe areas of the roadway. Placement and security must be addressed.

Cost
Highly variable. Murals may cost $40 to $60 per sq ft. Object art can run into the tens of thousands or even higher. In most cases, the cost of art projects should be borne by the community.

Maintenance issues
Maintenance issues include repair of fading of colors or finishes and damage from vandalism although past art projects in TxDOT right-of-ways have typically not been targets of graffitists or vandals.

These tasks should be the responsibility of the sponsoring community and addressed in a written agreement.

Installation
Dependent on the type of project; highly variable.

Specifications
The pay items for these types of projects are also variable. In most cases, individual parts of a project may be paid under the appropriate item rather than as a single item. In the case of highly unique elements, a special specification is recommended.

Guidelines
The *TxDOT Landscape and Aesthetics Design Manual*, Section 11 – Public Art, provides a detailed outline of the issues to be considered in selection and developing art projects with the roadway.

CONCLUSION

Aesthetics has been considered an important issue throughout the history of automobile transportation. Unfortunately, what was once a pleasurable drive in the country is often characterized today by fast, stressful driving. The early approaches to aesthetic highway design of using a carefully thought out alignment and super-elevation which takes advantages of the optimal views is as valid today as it was then, perhaps even more needed. Today, however, there are fewer new highways being built and highway designers must deal with many complex and existing conditions as right-of-ways become more and more constricted.

Designers can expect to be asked to make an increasing number of decisions about aesthetic quality as an increased number of communities seek to participate in determining the character of the transportation systems where they live. The decision making process must be structured so that the critical issues of driver performance and safety can be addressed. The recommendations included in this report offer a start at such a process. This process offers a simple way for the designer to look at the roadway and ask relevant questions about how proposed improvements may fit within not only the visual character but also the functional parameters of the highway.

These recommendations reflect sound scientific research in a number of fields, but lack actual field verification of their application to the roadway. Although simulator studies are able to provide much inferential data, real-world studies are needed to confirm and clarify the role of visual information used by the highway user. This will become an increasingly important issue as our driving population ages.

REFERENCES

AASHTO. 1970. *Guide for Highway Landscape and Environmental Design*. Washington, D.C.: American Association of State Highway and Transportation Officials.

AASHTO. 1991. *A Guide for Transportation Landscape and Environmental Design*. Washington, D.C.: American Association of State Highway and Transportation Officials.

AASHTO. 1994. *A Policy on the Geometric Design of Highways and Streets*. Washington D.C.: American Association of State Highway and Transportation Officials.

Adrian, W.K. 1985. "Visual Performance under Night Driving Conditions." *Transportation Research Circular* 297:5-6.

Allen, R.W., and J.F. O'Hanlon. 1979. "Effects of Roadway Delineation and Visibility Conditions on Driver Steering Performance." *Transportation Research Record* 739:5-8.

Appleyard, D., K. Lynch, and J.R. Myer, 1964. *The View from the Road*: Massachusetts Institute Technology, USA.

Billington, S.L., S.B. Ratchye, J.E. Breen, D.A. Vernooy. 2000. "Example Applications of Aesthetics and Efficiency Guidelines." *Concrete International* (2000/02. 22(2)):66-75.

Cohen, S. 1978. Environmental Load and the Allocation of Attention. In *Advances in Environmental Psychology*, edited by A. Baum, J. Singer, and S. Valins. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Cron, F.W., and B.L Smith. 1977. *Practical Highway Esthetics*. New York, NY: American Society of Civil Engineers.

Federick, J.C. 1963. "Aesthetic Considerations in Urban Arterial Route Planning." *Highway Research Record, Highway Research Board*.

FHWA. 1997. *Flexibility in Highway Design.* Washington, D.C.: Federal Highway Administration.

Gallagher, V.P., and N.D. Lerner. 1985. "Measuring the Visual Complexity of Nighttime Roadways." *Transportation Research Circular* 297:13-14.

Garling, T., E. Lindberg, G. Torell, and G.W. Evans. 1991. From Environmental to Ecological Cognition. In *Environment, Cognition, and Action.* New York: Oxford University Press.

Granjean, E.E. 1980. Developing Effective Human Factors Design Guidelines, Sitting Posture of Car Drivers from the Point of View of Ergonomics. In *Human Factors in Transport Research*, New York: Academic Press.

Harbeson, P.C. 1991. Architecture in Bridge Design. In *Bridge Aesthetics Around the World*, edited by unknown. Washington D.C.: Transportation Research Board.

Heder, L., and E. Shoshkes. 1980. *Aesthetics in Transportation: Guidelines for Incorporating Design, Art and Architecture into Transportation Facilities.* Washington, D.C.: Government Printing Office, Superintendent of Documents.

Hornbeck, P.L., and G.A. Okerlund. 1972. “Visual Quality for the Highway User: A Study of the Relation of Factors of Visual Quality to Route Design.” *Highway Research Record* 410:52-63.

Hulbert, S. 1972. *Human Factors in Highway Traffic Safety Research*. New York: John Wiley & Sons.

International Association of Traffic & Safety Science Research. 1983. *Roadscape. The Analysis of Visual-Perceptual Mechanism.* Tokyo: International Association of Traffic & Safety Science.

Jenkins, S.E., and B.L. Cole. 1985. “Daytime Conspicuity of Road Traffic Control Devices.” *Transportation Research Circular* 297:14-15.

Kanarick, A.F., and R.C. Petersen. 1969. "Effects of Value on the Monitoring of Multichannel Displays." *Human Factors* 11:313-320.

Kaplan, R. 1991. Environmental Description and Prediction: A Conceptual Analysis. In *Environment, Cognition, and Action*, edited by T. Garling and G. Evans. New York: Oxford University Press.

Kaplan, R., S. Kaplan, and R.L. Ryan. 1998. *With People in Mind, Design and Management of Everyday Nature*. Washington, D.C.: Island Press.

Kaplan, Stephen. 1987. Mental Fatigue and the Designed Environment. Paper presented at Environmental Design Research Association Conference, Ottawa, Canada.

Kaplan, Stephen. 1988. Perception and Landscape: Conceptions and Misconceptions. In *Environmental Aesthetics, Theory, Research, and Applications*, edited by J. Nasar. Cambridge: Cambridge University Press.

Lewis, T. 1997. *Divided Highways: Building the Interstate Highways, Transforming American Life.* NY: Penguin Group.

Mace, D.J., and L. Pollack. 1983. “Visual Complexity and Sign Brightness in Detection and Recognition of Traffic Signs.” *Transportation Research Record* 904:33-41.

Matthews, G., L. Dorn, T.W. Hoyes, R.D. Davies, I.A. Glendon, and R.G. Taylor. 1998. “Driver Stress and Performance on a Driving Simulator.” *Human Factors* 40 (1):136-149.

Neale, H.J. 1937. *Excerpts from Opening Address-St. Louis.* Highway Research Board Roadside Development Committee Reports.

Neale, H.J. 1944. *Report of the Committee on Roadside Development*: Highway Research Board Roadside Development Committee Reports.

Noble, M., and A.F. Sanders. 1980. “Searching for Traffic Signals while Engaged in Compensatory Tracking.” *Human Factors* 1 (22): 89-102.

Scallen, S., and J. Carmody. 1999. *Investigating the Effects of Roadway Design on Driver Behavior: Applications for Minnesota Highway Design.* Minnesota Department of Transportation.

Sekuler, R. and R. Blake. 1990. *Perception*. Second ed. New York: McGraw-Hill.

Sutton, C.R. 1947. “Essential Factors in the Design of Wayside Areas.” *Highway Research Abstracts, Highway Research Board.*

Swinburn, C. 1979. *Design Art and Architecture in Transportation*. Washington, D.C.: Department of Transportation.

Tunnard, C. and B. Pushkarev. 1963. *Man-Made America: Chaos or Control?* Yale University.