TORREY PINES ROAD PRELIMINARY ENGINEERING STUDY

TECHNICAL MEMORANDUM FOR

GUARDRAIL AND BOLLARDS

By

TRAN CONSULTING ENGINEERS

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I. TOPIC DESCRIPTION

Technical items in Torrey Pines Road are being evaluated for a proposed improvement project between Prospect Place and La Jolla Shores Drive. Within the project area some areas have been identified for installation of barriers to protect the safety of pedestrians and motorists in the project area by installing guardrail and/or bollards. Guardrail and bollards are discussed in the corridor study between Prospect Place and Coast walk and guardrail at the tee intersection with Amalfi Street on the north side of the road.

Two locations have been identified in the project area that require guardrail. These locations are shown in Figure 1 below.

This technical memorandum looks at providing safety to pedestrians and motorists while identifying decorative guardrails and making guardrail recommendations at specific locations.

II. DISCUSSIONS OF FINDINGS

II.1. Why Guardrail and Bollards?

Guardrails are needed along portions of the project for safety reasons. In locations where a steep drop off occurs on the north side of the road, a guardrail could prevent out-of-control vehicles from falling over the side. On the other hand, there is no evidence that this has been a problem in the recent past as evidenced by the old chain link fences in such locations that are undamaged.

Upon project completion, pedestrians will walk in sidewalks along both sides of the road. An 18" parkway is planned between the road curb and the sidewalk in several locations that may allow for construction of guardrails. But in approximately 50% of the project the sidewalk will be adjacent to the roadway curb without any space for guardrail.

Guardrails are recommended by TCE over bollards to prevent occasional out-of-control vehicles. Bollards are common where a clear delineation between slow moving vehicular traffic (such as in parking areas) and pedestrians is desired, and where bollards are removable to provide occasional access to an area (such as maintenance vehicles or fire trucks). Bollards are not recommended along Torrey Pines Road.

II.2. Standards for Guardrail

The City's Regional Standard Drawings states, "For Guardrail Standards Use: Caltrans "Standard Plans for Construction of Local Streets and Roads"

Recently Caltrans issued a report on California Highway Barrier Aesthetics which dealt with ways to provide safe guardrail systems that provided a more appealing look on California highways. Guardrails reviewed in this technical memorandum are selected from this report. Several divisions, offices and disciplines such as State Landscape Architecture, Headquarters Traffic Operations, and Division of Engineering Services, Materials Engineering and Testing Services, Office of Structural Materials provided input into various guardrail systems.

Any modifications to Caltrans standards must be approved prior to moving forward with construction

FIGURE 1

Aerial View of Project Showing Proposed Locations of Guardrails

(Yellow lines represent locations of proposed guardrail; Line locations are approximate and line widths are not intended to represent guardrail size)

II.3. Guardrail Options

II.3.1. Embankment Guardrails

Portions of Torrey Pines Road are adjacent to steep embankments. According to the Traffic Manual, Chapter 7, Traffic Safety Systems, embankment guardrails should be considered at locations with a history of accidents or high accident potential. The accident history, which can be an important factor whether to use guardrail or not, was not available for this study. The factors that are considered for high accident potential are given on pages 7-4 and 7-5 of the traffic manual. Four of these factors pertain to this project:

1. Volume of Traffic – Torrey Pines Road has a high volume of traffic, and the speed limit is higher than a normal city street.
2. Roadside Recovery Area – the embankments do not leave much width for recovery.
3. Climatic Conditions – Dense fog is one of the conditions that are definitely present along the coast that could contribute to accidents.
4. Severity – According to Figure 7-1 guardrails are generally less severe when the embankments are 7 feet high with a 1:1 slope, or 10 feet high with a 1.5:1 slope. Two locations on this project meet this condition.

II.3.2. Guardrail Alternatives

The alternatives considered are those approved by Caltrans, which are the following types:

- Thrie Beam Barrier
- Three-Cable Barrier
- Concrete Barrier (Type 60)
- Timber Guardrail
- Precast Concrete Guardwall

Information regarding each of these approved guardrails is given in the publication *California Highway Barrier Aesthetics*, by Caltrans, June 2002, and is a major source of the comparison below.

II.3.2.1. Thrie Beam Barrier

The Thrie Beam Barrier is shown below and is common on California highways. It is relatively less expensive than other types of barriers, but may not be visually compatible in metropolitan areas. The construction cost is approximately $80/foot.

Thrie Beam Barrier along a highway

II.3.2.2. Three Cable Barrier

The Three-Cable Barrier is not a good choice for Torrey Pines Road because of several disadvantages: higher maintenance costs compared to other types of barriers, special trained maintenance personnel, and large space needed for installation.

II.3.2.3. Type 60 Concrete Barrier

The Type 60 concrete barrier offers several positive attributes, including long life and durability, low maintenance costs, less exposure for maintenance workers, a clean urban character, and aesthetic surface treatment capabilities. Some communities consider these barriers to have a negative visual impact because the mass and form of the common K-type temporary rail barrier is not compatible with the surrounding landscape. The cost is approximately $300 per foot.

Type 60 Concrete Barrier with aesthetic treatment

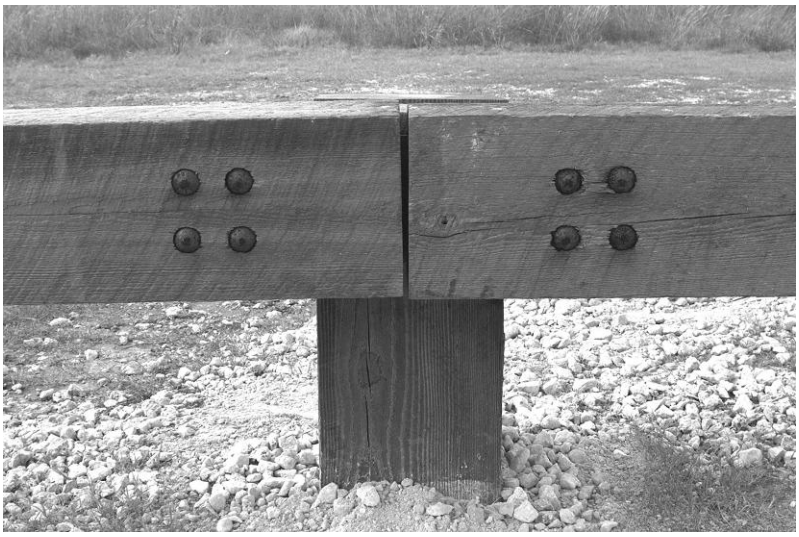
Caltrans approves the use of color admixtures, chemical staining, painting, acid etching, textures, and spraying with bituminous emulsion for a faux “granite” finish to improve the appearance of concrete barriers. Aesthetic treatments, such as sandblasting painted concrete to reveal graphic images have been used to enhance the barrier appearance and respond to local concerns for context sensitive solutions.

The type 60 barrier has a unique guardrail in that when a car runs into it at a 25 degree horizontal angle or less to the line of the barrier and at 60 mph or less the car will safely return to the street because kinetic energy becomes potential energy as the wheel rises up the inclined surface of the barrier.

II.3.2.4. Timber Guardrail

The Timber Guardrail is a rustic alternative to the standard metal beam guardrail. A steel plate provides the needed tensile strength with the wood members providing a rustic appearance. The wood block-outs help with the crash worthiness of the system. It is approved for design speeds of 60 miles per hour and less. The cost is approximately $100 per foot.

This guardrail has no approved terminal design. The end treatment will need crash cushions, must be buried in the embankment, or will require some other approved terminal design.



Timber Guardrail Post Detail

Timber Guardrail Installation

II.3.2.5. Precast Concrete Guardwall

The Precast Concrete Guardwall has been approved by Caltrans, but it is not used much due to its very high construction costs. The cost is approximately $500 per foot. Like the Timber Guardrail this guardrail has no approved terminal design. The end treatment will need crash cushions or will require some other approved terminal design.

The finish treatment is a simulated stone surface on both sides and ends of the guardwall. The surface of the guardwall is stained to simulate individual stones. To meet federal standards, the Precast Concrete Guardwall must be fabricated in a precast concrete production facility certified by the National Precast Concrete Association.

A Precast Concrete Guardwall Installation

III. Guardrail Locations

Per the Caltrans Traffic Manual, page 7-11, "To prevent a vehicle from vaulting over guardrail when it is used in conjunction with a curb or dike, the guardrail face should be on a vertical line with the curb face or on line no more than 2 inches behind the flowline of the dike."

Therefore the location will be directly behind the curb. Between Stations 11+80 to 16+20 the guardrail will be in the parkway area. Between Station 21+40 and 23+50 the guardrail will be between the sidewalk and the curb, which may impact the width of the sidewalk for this short stretch.

The alternative placement of a guardrail away from the road on the far side of the sidewalk would not protect pedestrians, nor would it conform to the State Traffic Manual recommendations.

Therefore guardrail is recommended at the following two locations:

- North side of the road from Station 11+80 to 16+20 where the embankment is almost a 1:1 slope (more than 7 feet high), the road has a high volume of traffic and the speed limit is higher than a normal city street, and occasionally has dense fog.
- North side of the road from Station 21+40 to 23+50 where the embankment is more than a 10-foot drop, the road has a high volume of traffic and the speed limit is higher than a normal city street, and occasionally has dense fog.

IV. Guardrail Analysis for This Application and Estimate of Unit Costs

A Summary of the advantages and disadvantages of the guardrail alternatives is provided below

Type of Barrier	Cost/Ft	Advantages	Disadvantages
Thrie Beam Barrier	$120	Common, easy construction	Not visually compatible Higher O&M than concrete
Three-Cable Barrier	$50	Inexpensive Minimal visual impact	Special O&M, not used in CA. Wide median area
Type 60 Concrete Barrier	$300	Low maintenance cost Various aesthetic treatments	May block views
Timber Guardrail	$300	Minimal visual impact	No approved terminal design
Precast Concrete Guardwall	$1500+	Various aesthetic treatments Long life and durability	Very high cost No approved terminal design

V. Recommendations and Estimated Costs

The three cable barrier is not an ideal alternative for this project for the reasons identified above.

As a scenic urban corridor the thrie beam barrier may be a poor alternative for aesthetic reasons and there is limited space for approach flares at both guardrail locations, however this guardrail is relatively low visual impact.

Although the precast concrete guardwall is highly desirable for aesthetic reasons. The cost far exceeds other barriers that provide the same protection.

A timber barrier in this area will provide adequate protection however the end termination design would require the end of the timber to be buried in the ground. Since this is an urban corridor the aesthetics of the timber guardrail should be evaluated

A type 60 concrete barrier is a very safe barrier for both locations because the design of this barrier makes it safer for traffic to return to the traveled way. From the perspective of cost this barrier is reasonable. With the additional option of providing an aesthetic treatment this would be a highly attractive alternative.

Costs associated with decorative type 60 guardrail for 440 feet at 11+80 to 16+20 and 210 feet at Sta. 21+40-23+50 would be approximately $132,000 and $63,000 respectively.

VI. Appendices to Technical Memorandum

1. Caltrans Report on California Highway barrier Aesthetics June 2002 Edition 1a
2. Caltrans California Highway Barrier Aesthetics Fact Sheet
3. Federal Highway Administration Letter on Aesthetic Guardrail Dec 20, 2002

APPENDICES

REPORT

June 2002
Edition 1a

CALIFORNIA HIGHWAY BARRIER AESTHETICS

Caltrans

California Highway Barrier Aesthetics

This report will familiarize designers with current barrier design options, and encourage appropriate aesthetic considerations to develop visually pleasing context sensitive solutions for highway projects. The development of alternative barriers that are aesthetically pleasing is a continuing process. The Division of Design, Office of State Landscape Architecture, Headquarters Traffic Operations, and Division of Engineering Services, Materials Engineering and Testing Services, Office of Structural Materials will continue to develop technical guidelines and guidance documents for alternative barriers and surface treatments for concrete barriers.

Technical guidelines allow integral color, paint, stain, and subtle textures to be incorporated with concrete barriers placed on highway transportation projects. These guidelines address highway corridor aesthetic issues, and respond to concerns from local communities and agencies for more barrier design alternatives that are context sensitive without compromising safety considerations.

Efforts are continuing to crash test additional aesthetic design solutions to increase the variety of options available for barrier treatments. These tests comply with the National Cooperative Highway Research Program (NCHRP) Report 350 criteria. Crash testing is being performed on various formliner patterns for concrete barriers that mimic stone masonry or provide relief graphics into the surface of the concrete. Patterns and textures with subtle relief, set into the surface of the barrier or limited to the top portion of the barrier, have shown encouraging results and guidelines for their use have been approved. Alternatively, crash test results indicate that some patterns and textures with high relief extending from the base to the top of the barrier may cause excessive passenger compartment deformation to the vehicle. Future use of these high relief surface treatments is doubtful. The technical guidelines for use of textures on concrete barriers will continue to evolve based on crash test results, maintenance and construction issues.

There is additional cost associated with some alternative barriers and surface aesthetic treatments when compared to the Department's standard barriers. Designers should use discretion when selecting alternative designs. Local funding may be required to offset additional costs associated with alternative barrier designs. Barriers are available in several different types and materials providing an opportunity to select the most appropriate barrier for a particular condition. Barrier types and design considerations discussed in this report include:

- Thrie Beam Barrier
- Three-Cable Barrier
- Type 60 Concrete Barrier
  - Approved Concrete Barrier Aesthetics
  - Developing Textures and Patterns
- Timber Guardrail
- Precast Concrete Guardwall
- Stone Masonry Guardwall
- Barriers and Landscaping

The Thrie Beam Barrier and Type 60 Concrete Barrier are available in the Department's Standard Plans and Specifications. The other barrier types will require approval for use until such time they become approved standards. See "Attachment A" for information on the non-standard approval process. For further information on California Highway Barrier Aesthetics and the status of new design alternatives please contact the Office of State Landscape Architecture at (916) 653-3170, Headquarters Traffic Operations at (916) 654-5147, or Materials Testing and Engineering at (916) 227-7000.

Thrie Beam Barrier

The Thrie Beam barrier is widely used as a median barrier on California's roadways. It is relatively inexpensive to install when compared to other barriers. Typically, fewer drainage modifications are required than for placement of concrete barriers. Use of this barrier type may allow for preservation of existing median planting and can minimize visual impacts. Thrie Beam barrier may be aesthetically pleasing to some rural communities because of its less "urban" character. Design modifications to the Thrie Beam barrier, such as placing asphalt or concrete beneath the barrier to eliminate weed growth, are being reviewed by Traffic Operations for approval. Not only will this improve the visual appearance of the barrier, it will also eliminate the need for repetitive manual vegetation control by maintenance forces. To reduce maintenance costs, this barrier should not be used in medians less than 11-meters wide.

This barrier meets NCHRP Report 350 criteria.

Advantages

- Approved by the Department for use
- Standard Plans and Specifications available
- Minimal visual impact
- Rural character
- Accommodates small animal crossing
- Preserves/protects median planting

Disadvantages

- Not visually compatible in metropolitan areas
- Increased construction time
- Life cycle costs higher than rigid/concrete barriers
- Additional roadside maintenance tasks compared to Type 60 Concrete barrier

Costs (November 2001)

- $61.00 per meter for Double Thrie Beam Barrier
- Maintenance cost is $33.00 per meter each year for segments requiring repair (segments average 30 meters)

Three-Cable Barrier

The Three-Cable barrier has not been used in California because of maintenance concerns. Currently, considerations are being made on a case-by-case basis for temporary use only. Three-Cable barrier is flexible, consisting of three steel cables stretched between metal posts. This barrier requires a minimum of 7 meters of flat median area, free of woody or mounding vegetation to allow for deflection movement when hit.

The Three-Cable barrier's primary advantage is quick installation and low initial cost. This system minimizes visual impacts, requires little or no drainage modifications, and fits well visually in rural environments. This system should not be used with median plantings.

The Three–Cable barrier meets the crash test requirements of NRCHP Report 350 criteria, test level 3.

Three-Cable barrier installed in Oregon.

Advantages

- Electronic drawings and specifications are available
- Minimal visual impact
- Rural character
- Accommodates small animal crossing
- Low installation cost

Disadvantages

- Non-standard approval required
- Standard Plans and Specifications unavailable
- Not visually compatible in metropolitan areas
- Life cycle costs higher than rigid/concrete barriers
- Additional roadside maintenance tasks compared to Type 60 Concrete barrier
- Inoperative once hit

Disadvantages of the Three-Cable barrier system are the maintenance costs required, as compared to other barrier types. Some maintenance tasks include routine checking of cable tension and repair of long runs of barrier when hit. Timely repair is necessary because the barrier can become inoperative once hit. The Three-Cable barrier is not recommended on tight curves, high truck traffic routes, or any locations where frequent hits are expected. Maintenance personnel are not trained, nor staffed to manage this type of system. Use of this barrier system may require approval from the Maintenance Division.

Costs (October 2001)

- $26.00 per meter
- Maintenance cost is $24.00 per meter each year for segments requiring repair (segments average 30 meters)
- High life cycle cost when compared to other barrier types

Type 60 Concrete Barrier

Approved Concrete Barrier Aesthetics

The Type 60 Concrete barrier has been used increasingly by the Department as median widths have become narrower. This coincides with safety concerns becoming more prevalent for maintenance workers and motorists. The Type 60 concrete barrier offers several positive attributes, including long life and durability, low maintenance costs, less exposure for maintenance workers, a clean urban character, and aesthetic surface treatment capabilities. Like the Thrie Beam barrier, two rows of Type 60 Concrete barrier can be placed in a wide median to preserve existing median planting.

The Department currently approves the use of color admixtures, chemical staining, painting, acid etching, textures, and spraying with bituminous emulsion for a faux "granite" finish to improve the appearance of concrete barriers. Aesthetic treatments, such as sandblasting painted concrete to reveal graphic images, have been used to enhance the barrier appearance and respond to local concerns for context sensitive solutions.

Concrete barrier with paving to the base allows maintenance to mechanically sweep the shoulder.

Sandblasting creates a seagull motif in a coastal community. This aesthetic treatment cost $17,000 per KM.

Concrete barriers have higher installation costs than Thrie Beam barriers and, in some cases, require extensive drainage modification. Retrofitting an existing barrier with superficial aesthetic treatments is less costly than installing a new barrier.

Some communities consider these barriers to have a negative visual impact because the mass and form are not compatible with the surrounding landscape.

Advantages

- Approved by the Department for use
- Standard Plans and Specifications available
- Aesthetic treatment for context sensitive designs
- Preserves/protects median planting
- Long life and durability
- Low maintenance cost
- Existing barriers can receive aesthetic treatments

Disadvantages

- May require drainage modifications
- High installation costs

Costs (November 2001)

- $150 per meter, aesthetic treatments are additional
- Maintenance cost of aesthetic treatments not known

Type 60 Concrete Barrier

Developing Textures and Patterns

A wide array of design possibilities are being developed and crash tested to allow for textures, patterns, and graphics that enhance the appearance of Type 60 Concrete barriers. Before authorizing textured surface treatments to concrete barriers, the proposed treatments must be tested for safety, and reviewed for constructability and maintainability issues. The Department's Engineering Services Division of Materials Engineering and Testing Services, Office of Structural Materials performs these tests by crashing a vehicle, under controlled conditions, into a section of the textured concrete barrier.

The results of each crash test are analyzed and a determination is made as to whether the textured barrier passes or fails established performance criteria - NCHRP Report 350 criteria, test level 3. From crash test results the Department has developed preliminary technical guidelines for the use of textures on concrete barriers. The Department will continue to perform additional crash tests to further expand these preliminary technical guidelines.

Dry stacked rock design was recently crash tested and received approval for use in California.

Pending approved design guidelines, graphics could become an integral part of concrete barrier design.

The next few pages of this report discuss textures that designers may use to address site specific, context sensitive solutions for concrete barriers. Specific textures will not be approved or disapproved but the depth, protrusions, angle of patterns, etc. will be governed by technical guidelines.

Details of recent test results are contained in the Department Study #F2001Tl17 "*Interim Report, Crash Testing of Various Textured Barriers*." Contact Materials Testing and Engineering at (916) 227-7000 for a copy.

Type 60 Concrete Barrier

Developing Textures and Patterns, continued

The Federal Highway Administration (FHWA) has granted approval (December 2002) of the Department's technical guidelines for textures and patterns for use on Type 60 Concrete barriers. Departmental approval is needed for the use of textures and patterns on every project. The following surface textures and patterns have been crash tested:

- Rock cobble pattern above 610 mm of smooth surface barrier. **PASSED CRASH TEST**
- "Mission Arch" pattern. **PASSED CRASH TEST**
- Dry stacked rock pattern. **PASSED CRASH TEST**
- Fractured granite pattern. **PASSED CRASH TEST**

- Rock cobble pattern on the entire face of the barrier. **FAILED CRASH TEST**
- Diagonal flute pattern. **FAILED CRASH TEST**

The preliminary technical guidelines allow:

Light to heavy sandblast textures.
Any pattern or texture with a maximum relief of 64 mm or less, located 610 mm or higher above the base of the barrier; the lower 610 mm shall be smooth or a "light to heavy sand blast" texture. The pattern or texture on the upper face of the barrier shall have smooth (rounded or beveled) leading edges to prevent vehicle snagging.
Geometric patterns inset into the face of the barrier 25mm or less. Chamfered or beveled edges to prevent vehicle snagging, especially on the downstream edges. Such patterns shall not feature long upward-climbing edges that could contribute to wheel climb.

This is the mission arch design with beveled edge and light sandblast.

Shown here is rock cobble pattern with 610 mm of light sandblast on the bottom of the barrier.

Advantages

- Aesthetic treatment for context sensitive solutions
- Preserves/protects median planting
- Long life and durability

Disadvantages

- Non-standard approval required
- Standard Plans and Specifications not available
- Increases installation costs
- Increases construction time
- Additional repair work to match textures

Costs (June 2002)

- $115 to $150 per meter, depending upon aesthetic treatments and color. The average price of a Concrete Barrier (type 60) is $91.39 per meter.
- Maintenance cost of aesthetic treatments not known

Timber Guardrail

The Timber Guardrail is a rustic alternative to the standard metal beam guardrail. The Timber Guardrail is in use along Federal highways on the East Coast and is approved for use on California highways. A steel plate provides the needed tensile strength with the wood members providing a rustic appearance. The wood block-outs help with the crash worthiness of the system. This guardrail has no approved terminal design. The end treatment will need crash cushions, must be buried in the embankment, or will require some other approved terminal design.

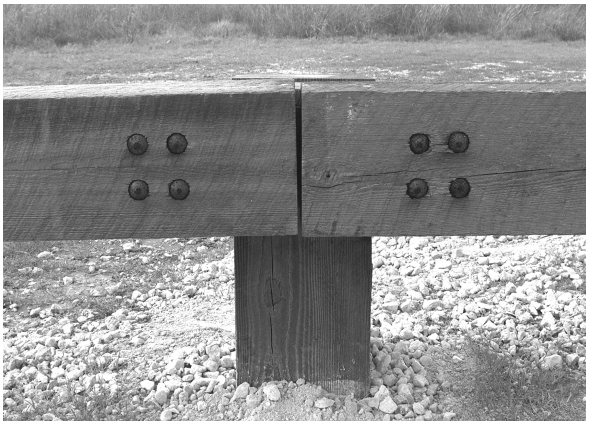
There are two versions of this system, both are accepted for use on Federal highways by the FHWA, and meet the NRCHP Report 350, test level 3:

Type 1 Steel Backed Timber Guardrail (SBTG) with wooden post
Type 2 Merritt Parkway Guardrail (MPG) with steel post

Both the Steel Backed Timber Guardrail and Merritt Parkway Guardrail are approved for design speeds of 100 km/h and less.

The potential for corrosion of the non-galvanized steel elements of the guardrails are a concern in coastal settings or areas with high rainfall. The Department's policy is that in areas of eight inches or greater annual rainfall galvanized steel posts must be used. The galvanized steel may be painted to blend with the timbers. Further information including electronic drawings, specifications and other information on this barrier can be found at www.efl.fhwa.dot.gov.

Contact Headquarters Traffic Operations at (916) 654-5147 with specific questions regarding Timber Guardrails.



Advantages

- Electronic drawings and specifications are available
- Minimal visual impact
- Rural character
- Accommodates small animal crossing
- Preserves/protects median planting

Disadvantages

- Non-standard approval required
- Standard plans and specifications not available
- Life cycle costs higher than rigid/concrete barriers
- Additional roadside maintenance tasks, compared to Type 60 Concrete barrier
- Wood safety devises may be subject to burning

Costs (January 2002)

- $160 per meter. Cost is based on installations in the Eastern US and may vary for California
- Maintenance cost not known; likely to be higher than metal beam guardrail

Precast Concrete Guardwall

This barrier system is being reviewed for approval by the Department's Highway Safety Features New Products Committee for use on California's highway system. This precast concrete guardwall has not yet been used in California due to very high construction costs. This guardrail has no approved terminal design. The end treatment will need crash cushions, must be buried in the embankment, or will require some other approved terminal design.

The finish treatment is a simulated stone surface on both sides and ends of the guardwall. The surface of the guardwall is stained to simulate individual stones. The design details include a precast concrete mowing strip. This strip may be placed in medians that will not be paved to the face of the guardwall. To meet federal standards, the Precast Concrete Guardwall must be fabricated in a precast concrete production facility certified by the National Precast Concrete Association.

The Precast Concrete Guardwall has been crash tested and meets the requirements of NCHRP Report 230. Though never crash tested to NRCHP Report 350 test level 3, the FHWA has accepted this guardwall for use on Federal highways. This artificial stone system is approved for design speeds of 100km/h or less. Further information regarding this barrier, such as electronic drawings, specifications and other information, may be found at www.efl.fhwa.dot.gov.

Advantages

- Electronic drawings and specifications are available
- Rural character
- Aesthetic treatment for context sensitive solutions
- Long life and durability

This guardwall is installed on the Federal highway system in the East Coast.

Disadvantages

- Non-standard approval required
- Standard Plans and Specifications not available
- Requires drainage modifications
- Very high installation costs
- Additional roadside maintenance tasks compared to Type 60 Concrete barrier

Costs (February 2002)

- $740 per meter. Shipping cost to the project site from the manufacturer is not included in this estimate
- Maintenance cost is not known

Stone Masonry Guardwall

The Stone Masonry Guardwall was approved by the Department's Highway Safety Features New Products Committee for use on California's highway system. The Stone Masonry Guardwall has not yet been used in California due to the very high construction cost. The stone fascia, mortared in place, provides a natural appearance and can incorporate local rock to match the surrounding area. The Federal Lands Highway Office must approve any modifications to Federal Lands Highway Standards for the Stone Masonry Guardwall. This guardrail has no approved terminal design. The end treatment will need crash cushions, must be buried in the embankment, or will require some other approved terminal design.

The Stone Masonry Guardwall consists of a concrete core faced and capped with natural stone. The Stone Masonry Guardwall has been crash tested and meets the requirements of NCHRP Report 230 and is accepted by the FHWA for use on the federal highway system. The FHWA has accepted it to meet the requirements of NRCHP Report 350 criteria, test level 3. This barrier system is approved for design speeds of 100 km/h or less.

Specifications define maximum projections to be 38 mm beyond the neat line, 50 mm deep joints, and mortar beds 50 to 75 mm thick. Stone faces with critical dimensions greater than those listed above are not considered crashworthy. A smooth-faced wall with shallower projections, and rake joints and beds is also approved.

Further information on this barrier can be found at www.efl.fhwa.dot.gov

Advantages

- Electronic drawings and specifications are available
- Minimal visual impact
- Rural character
- Context sensitive solutions
- Preserves/protects median planting
- Long life and durability

Disadvantages

- Non-standard approval required
- Standard plans and specifications not available
- Requires drainage modifications
- Very high installation costs
- Increased construction time
- Additional roadside maintenance tasks compared to Type 60 Concrete barrier

Costs (February 2002)

- $830 per meter
- Cost will vary depending upon the type of rock used. Availability of rock and proximity to the project area will be a factor. Labor costs may significantly impact the actual construction cost.
- Maintenance cost not known; likely to be high

Median Barriers and Landscaping

Existing median planting, mostly oleander shrubs, were planted in California beginning in the 1950's and have become an asset to the Department and the communities in which they grow. Median plantings provide glare screening for headlights of oncoming traffic, provide greenery and flowers, and minimize the visual width of the roadway. When roadway-widening projects threaten the removal of these plantings, local communities often voice concerns for preservation of the planting.

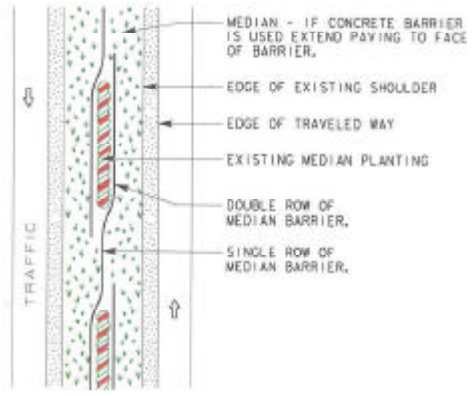
This is a concrete barrier with paving to the face of the barrier and landscaping in the median.

Median planting provides aesthetics in rural areas where no other highway planting exists.

The Department considers median planting to be an asset to the highway corridor and recommends removal only when other viable options are not available. Median barriers are being used when necessary and where feasible to protect these shrubs. Median barriers, regardless of system type, can be installed to preserve plantings, satisfying the desires of communities, and provide safety for maintenance workers and the traveling public. Options to median plantings should be considered, such as replacement of median planting with roadside planting along the right of way. The maintenance costs involved with median plantings are factors that must be considered.

During design of a median, consideration should be given to retaining all or portions of the existing planting. Healthy sections of planting can be protected with two rows of barriers, while unhealthy planting can be removed and a single barrier installed.

Only when the median width allows, the retention of existing median planting can be achieved by installing one row of barrier. When this option is possible, significant cost savings will be achieved for both the construction project and for long-term maintenance. Traffic Operations must be consulted to insure that all current standards are met.



Portions of existing median planting protected by median barrier.

Attachment A

Non-Standard Approval Process

Some of the barriers in this report are currently not approved as standards by the Department for use on California's highway system. However, all of the unapproved barriers included in this report are being reviewed for approval.

There are three categories of non-standard barriers:

1) Barriers that are not in the Standard Plans but which are approved by the Department. For example, this would include Type 60 Concrete barrier with a rock texture called "dry stacked."
2) Barriers that have been accepted by FHWA but have not been approved by the Department. For example, this would include the Stone Masonry Guardwall and Pre-cast Concrete Guardwall.
3) Barriers with merit that have not been crash tested or approved by either agency. This includes any new product that would be proposed as a barrier, or a change or modification to an approved barrier that could affect the safety and crash worthiness of the barrier.

Depending upon the proposal, a series of requirements need to be met prior to receiving approval to install a non-standard barrier on a project. For some proposals, such as texture on a Type 60 Concrete barrier that conforms to the approved guidelines, the proposal would not require steps one through four. A simplified version of the approval process is:

1) The barrier must meet crash test criteria established by NRCHP Report 350.
2) Once a proposed barrier has passed the crash testing criteria then it must be accepted by the FHWA for use on the Federal Highway system. Typically, if FHWA accepts a barrier, they will also participate in the funding of that element when it is included on a capital improvement project that has federal participation.
3) After the barrier has been accepted by the FHWA, then it must be reviewed and approved by the Caltrans Highway Safety Features New Products Committee (HSFNPC) before it can be considered for use on California's highway system. This process allows various Department Divisions, such as, Office of State Landscape Architecture, Headquarters Traffic Operations, Construction, Maintenance, and Structures, the opportunity for review and comment on the proposal. For more information on the HSFNPC and their role, contact the Chairperson of the HSFNPC at (916) 654-2465.
4) Once a non-standard barrier has been reviewed by the HSFNPC, the committee's conclusions and recommendations are forwarded to Headquarters Traffic Operations for a final recommendation. If the proposal is acceptable, a letter of approval for use is signed by the Chief, Division of Traffic Operations. Depending on the proposal, the non-standard barrier may be approved as a pilot or may require a letter of approval to be signed by the District Director.
5) Once a non-standard barrier has been approved for use, non-standard plans and specifications will require review and approval from the various district functional units and the Headquarters office that is the "owner" of the Standards, such as, Structures Office of Design, or Office State Landscape Architect

Once these criteria are met, a non-standard barrier may be included in a highway project.

California Highway Barrier Aesthetics

California Highway Barrier Aesthetics Report

A report titled "California Highway Barrier Aesthetics" is available on the Web at *http://projdel.dot.ca.gov/design/landscape/*
The report identifies current barrier design options for highway projects and encourages appropriate aesthetic considerations that are context sensitive.

Various materials and styles can be used to provide an opportunity to select the most appropriate barrier for a particular condition. Barrier types discussed in the report include: Thrie Beam Barrier, Three-Cable Barrier, Concrete Barrier (Type 60), Timber Guardrail, Precast Concrete Guardwall, Stone Masonry Guardwall, Barriers and Landscaping.

Texture and Coloring of Concrete Barriers

Integral color, paint, stain, and textures for concrete barriers placed on highway transportation projects are allowed.
Caltrans standard Concrete Barrier (Type 60) has been crash tested with various surface textures. This research resulted in guidelines that govern the textural treatment that may be applied to a concrete barrier. Attached is a memorandum of the approved guidelines for applying texture to a Concrete Barrier (Type 60).

Innovative Construction of Textured Concrete Barriers or Walls

This photo depicts Concrete Barrier (Type 60) with color and texture that is being slip formed.
The statewide average cost, based on 2002 data, for a Concrete Barrier (Type 60) is $115 per linear meter. Texture and color would increase this coast by an estimated $50 to $85 per linear meter above the average cost of a non-textured, non-colored barrier.

A potential drawback to providing texture to concrete walls, especially a Concrete Barrier (Type 60), is the construction process. In the recent past, this would require labor-intensive formwork to be used. This problem can be overcome thanks to an innovative slip form concrete texturing process. Today's concrete barriers are commonly built using a machine that can extrude concrete through a slip form that eliminates the need for costly formwork. By adding a drum roller with texture to the typical slip form concrete machine a texturing of an extruded concrete wall can be achieved.

For more information contact
Jack Broadbent at (916) 653-3170
Landscape Architecture Program

Caltrans

U.S. Department
of Transportation
**Federal Highway
Administration**

DEC 20 2002

400 Seventh St., S.W.
Washington, D.C. 20590

Refer to: HSA-10/B-110

Mr. Rich Peter, Chief
Roadside Safety Technology Branch
Materials Engineering and Testing Services
5900 Folsom Boulevard
Sacramento, California 95819-4612

Dear Mr. Peter:

In late September, you sent me one copy of a California Department of Transportation test report dated September 2002 entitled "Crash Testing of Various Textured Barriers" and one set of videotapes showing each of the tests you conducted. Based on the results of these tests, you developed general guidelines for the architectural treatment of single-slope barriers and requested formal acceptance of these guidelines.

All of the textured designs were formed over and parallel to California's Type 60 concrete barrier, which has a constant slope approximately 9 degrees from vertical. Seven different textured designs were tested. Four of these tests met all appropriate Report 350 evaluation criteria at test level 3 and three were considered unsuccessful. A summary (and reference photograph) of each tested design follows:

- Deep Cobblestone design (Enclosure 1) – not acceptable, due to excessive occupant compartment intrusion (2000P vehicle)
- Fluted Rib at 45 degrees (Enclosure 2) – not acceptable, due to rollover (820C vehicle)
- Mission Arch (Enclosure 3) – acceptable performance when tested with 820C vehicle. 2000P test waived
- Deep Cobblestone Reveal (Enclosure 4) – acceptable performance with 2000P vehicle. 820C test waived
- Drystack (Enclosure 5) – acceptable performance with 2000P vehicle. 820C test waived
- Fractured Granite (Enclosure 6) – acceptable performance with 2000P vehicle. 820C test waived
- Shallow Cobblestone (Enclosure 7) – deemed not acceptable due to 2000P vehicle driveshaft separation in crash. Report 350 evaluation criteria were met, however

Based on analysis of all test results, you proposed the following general texture guidelines for use on single-slope concrete barriers in California:

1. Sandblast textures with a maximum relief of 9.5 mm.
2. Images or geometric patterns inset into the face of the barrier 25 mm or less and having 45-degree or flatter chamfered or beveled edges to minimize vehicular sheet metal or wheel snagging.
3. Textures or patterns of any shape and length inset into the face of the barrier up the 13-mm deep and 25-mm in width.
4. Any pattern or texture with gradual undulations that have a maximum relief of 20 mm over a distance of 300 mm.
5. Gaps, slots, grooves or joints of any depth with a maximum width of 20 mm and a maximum surface differential across these features of 5 mm or less.
6. Any pattern or texture with a maximum relief of 64 mm, if such pattern begins 610 mm or higher above the base of the barrier and all leading edges are rounded or sloped to minimize any vehicle snagging potential. No part of this pattern or texture should protrude above the plane of the lower, untextured portion of the barrier.

Based on my staff's review of the information you submitted, I agree that the above guidelines for concrete barrier texturing are acceptable and will not adversely affect the NCHRP Report 350 test level of the barrier to which a texture or pattern is applied. I also agree that any texture or pattern meeting these guidelines can be applied to all crashworthy single slope or vertical wall designs. It is clear from the crash test results that textured barriers can result in more vehicular body damage in a crash due to increased friction even if their crash performance remains within acceptable limits. Although the barriers you tested were 1220-mm and 1422-mm tall, review of the crash and post-crash vehicle trajectories indicate that these guidelines may also be applied to vertical walls as low as 685 mm and to any single-sloped barrier at the standard 813-mm height or higher. These treatments may prove acceptable on New Jersey and F-shape concrete barriers if the treatment is applied only to the upper sloped face of the barriers, but some crash testing would be advisable to verify good performance with these shapes. I understand that anyone wishing detailed design drawings for any of the tested patterns may contact you by telephone at (916) 227-7257 or via e-mail at rich_peter@dot.ca.gov.

Finally, I wish to commend you on this very timely research. Today, more state and municipal transportation agencies are seeking aesthetic traffic barriers that are also crashworthy for use in historic and environmentally sensitive areas. The above

guidelines provide a means for satisfying both goals without additional crash testing and increased project delays and costs.

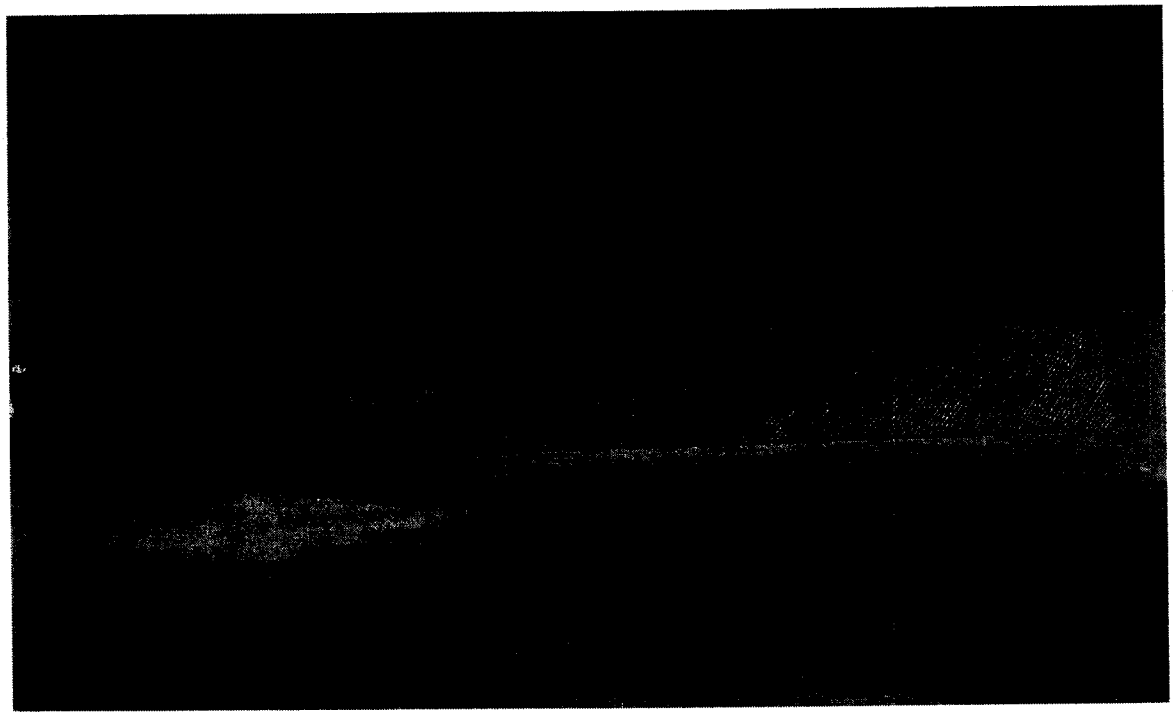
Sincerely yours,

Harry W. Taylor

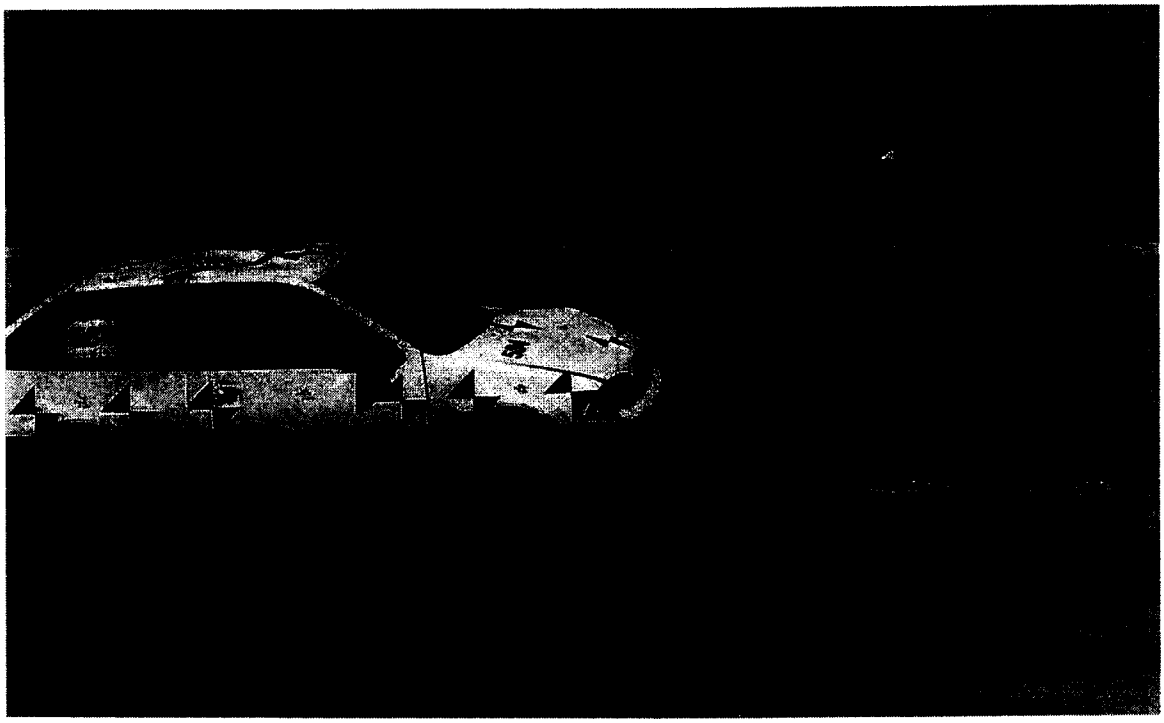
Harry W. Taylor
Acting Director, Office of Safety Design

7 Enclosures

ENCLOSURE 1



ENCLOSURE 2



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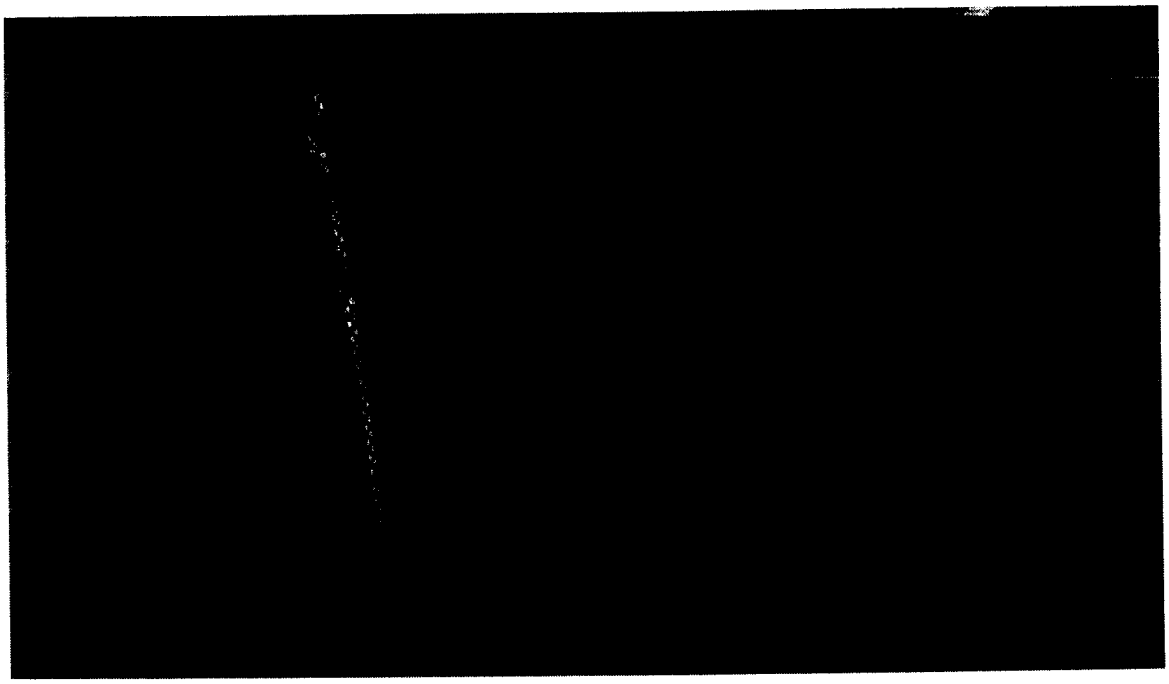

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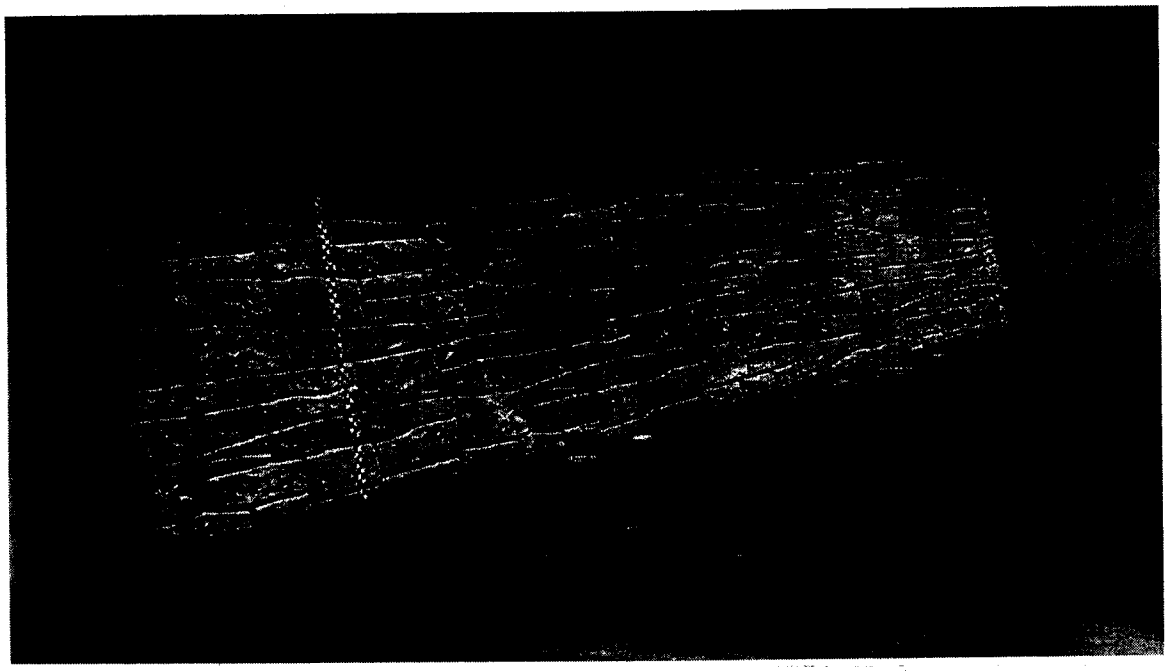
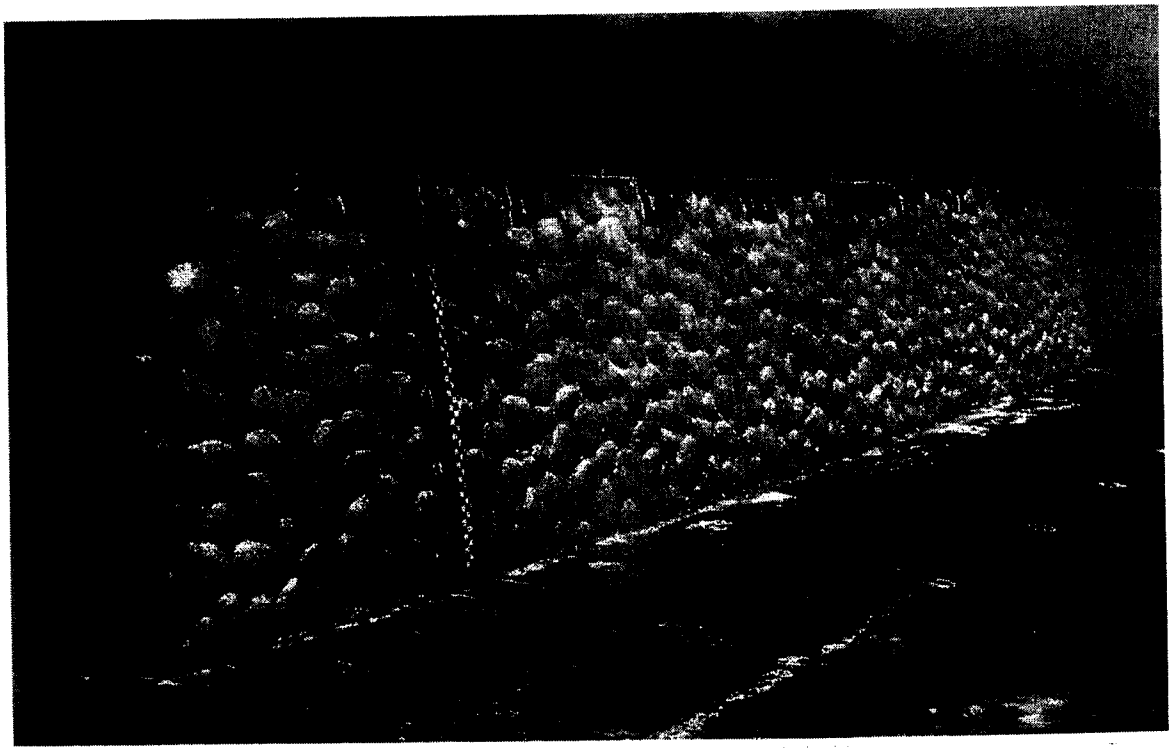


ENCLOSURE 5

ENCLOSURE 6



ENCLOSURE 7