



MERVIN C. GIACOMINI, P.E.
DISTRICT ENGINEER

Jan 13, 1998
For: Jan 16, 1998

TO: Committee of the Whole
FROM: Mervin C. Giacomini, District Engineer
SUBJECT: GOLDEN GATE BRIDGE, MOVEABLE MEDIAN BARRIER -
STATUS REPORT (INFORMATION)

I. INTRODUCTION

The various studies and tests authorized by the Board pertaining to the consideration of a moveable median barrier for possible application on the Golden Gate Bridge have now been completed. The E-TECH Crash Test Report, AutoDesk Demonstration, and Northwestern University Traffic Institute Traffic Safety Study were presented at the December 5, 1997 meeting of the Building and Operating Committee. A summary of the Northwestern University Traffic Safety Study and the AutoDesk demonstration were presented at the December 19, 1997 meeting of the Board of Directors. Consequently, the District is now in a position to start the process of reviewing and analyzing the results of these studies and tests. This report provides background information regarding the work performed to date, including the December Building and Operating Committee and Board meetings (Section II), the information requested at the December 19, 1997 meeting of the Board of Directors (Section III), issues requiring further study (Section IV), and a proposed process for the discussions regarding the moveable median barrier at future meetings of the Committee (Section V).

In addition to the staff presentation to the Committee of the Whole on January 16, Barrier Systems, Inc. (BSI), will make a presentation on their technology and address questions by District Directors.

II. BACKGROUND

Barrier Development and Testing

BSI completed the development and fabrication of approximately one hundred feet of the one-foot moveable median barrier for testing. They conducted a public demonstration of their barrier, including crash testing on January 8, 1997 at the Rio Vista airport. Some Board members and staff attended the demonstration.

Certification Testing

The Board, by Resolution No. 96-161, authorized District's participation in the cost, not to exceed \$42,500, of certification testing the moveable median barrier by Barrier Systems, Inc. pursuant to the National Cooperative Highway Research Program (NCHRP) Report No. 350. Staff negotiated a fee of \$32,450 with E-TECH Testing Services, Inc., of Lincoln, CA, to perform the NCRP 350 certification testing at their Lincoln test facility. Crash testing was conducted March 26, 1997, using a small car with a nominal weight of 1,800 lbs. at a speed of 62 mph and an approach angle of 20 degrees. On March 27, 1997, crash testing was conducted using a pickup truck with a nominal weight of 4,400 lbs., at a speed of 62 mph and an approach angle of 25 degrees. The barrier deflected approximately 18 inches in the small car crash and approximately 32 inches in the pickup truck crash. E-TECH Testing Services submitted the final test reports to the District the first of May.

The draft test report has been reviewed by the District, Northwestern University Traffic Institute (Northwestern), and Caltrans. E-TECH has responded to the review comments. Staff and Caltrans have accepted the report as complete and the Federal Highway Administration (FHWA) has approved the crash test report. District Engineer Mervin C. Giacomini briefly summarized the E-TECH Final Report of May, 1997 at the December 5, 1997 meeting of the Building and Operating Committee.

Barrier Analysis and Traffic Engineering

The Board, by Resolution No. 96-161, authorized the General Manager to expend up to \$50,000 to engage Northwestern and, if deemed necessary or appropriate, additional traffic engineering and safety consultants, to evaluate and make appropriate recommendations to the Board of Directors pertaining to BSI's proposed resolution of certain technical issues raised by the District Engineer, and to evaluate and make recommendations to the Board of Directors concerning traffic, operational, and safety tradeoffs between installation of such barrier and the operation of the Bridge without the barrier.

Northwestern was issued a Notice to Proceed effective September 12, 1996, for the first phase of the work in the amount of \$25,000. Northwestern developed criteria in March for barrier performance on the Golden Gate Bridge, analyzed the risk of a barrier system deflecting into oncoming traffic, and analyzed traffic data and prepared conclusions based on deflection characteristics determined by crash testing, with

respect to the one-foot moveable median barrier impact on traffic flow, safety, and capacity. Northwestern submitted a report to the District, "Traffic Safety Study for Moveable Median Barrier System on Golden Gate Bridge," dated October 29, 1997, which was distributed to members of the Board of Directors November 14, 1997.

Building and Operating Committee Meeting of December 5, 1997

At the December 5, 1997 meeting of the Building and Operating Committee, Mr. Robert K. Seyfried, Director of Transportation Engineering Division, Northwestern University Traffic Institute, presented a 50 minute summary review of the Northwestern University Traffic Institute Traffic Safety Study Report.

Mr. Seyfried's presentation included the following:

- A summary of the changes which have occurred since the Northwestern 1985 study.
- Accident experience in the 1991-95 period, noting, among other things, a reduction of accident rates by about one half since 1985 and a rate significantly lower than the average rate for California roadways, including freeways, and a decline of fatal and injury accidents, but an increase in the percentage of such accidents compared to total accidents.
- Review of experience at other installations of the two foot wide barrier, namely the Genvilliers Viaduct outside Paris, France (no longer in use), the Auckland Harbor Bridge in New Zealand, the San Diego/Coronado Bridge and the Tappan Zee Bridge in the state of New York.
- Barrier performance criteria, including a discussion of a mathematical model.
- A rebound and deflection analysis, noting that the narrow moveable median barrier performed significantly better than the two foot barrier in terms of deflection and rebound angle.
- A discussion of end treatment issues, particularly at the San Francisco end of the Golden Gate Bridge.
- A discussion of stopping sight distance issues and considerations.
- A discussion of lane width and barrier positioning issues and the desirable criteria therefor, noting that no

single lane configuration studied satisfied all criteria, and that the District staff would have to weigh various alternatives.

- A discussion of emergency vehicle access issues which must be considered.
- A discussion of a cost-benefit analysis he conducted.

Mr. Seyfried briefly referred to some of the potential positive and negative impacts which could result from installation of a moveable median barrier. Mr. Seyfried concluded that, in view of the various factors which must be weighed, he could not come up with a final recommendation, that the final decision was up to the Board, and that he viewed the decision as a virtual toss-up. He stated that the Board could reasonably make a decision either to install or not install a moveable median barrier.

Mr. Seyfried stated that if the decision was to install the moveable median barrier, a number of issues had to be resolved, including:

- Lateral positioning of the barrier.
- Development of an anchorage system for the terminal end of the barrier at the toll plaza.
- Development of a guidance system compatible with the Bridge and Bridge deck.
- Development of operating procedures for emergency vehicles.
- Design of transfer vehicles and the location and design of storage facilities.

Mr. Seyfried also said that, if the decision was to install a moveable median barrier, he recommended a two to three year trial period, if feasible, and, in any event, a monitoring program covering accident frequency and severity, barrier impact frequency and the magnitude of barrier displacement, secondary impacts, emergency vehicle response, and operating and maintenance costs.

After Mr. Seyfried's presentation, there were a number of questions from the Board members.

1. Director Boro asked if installation of a moveable median barrier might constitute a permanent presence which might change driver behavior. Mr. Seyfried stated that was a

possibility and added that it was hard to say why total accident frequency declined in other installations.

2. Director Harberson questioned the comparability of the San Diego/Coronado Bridge as it is wider and carries less traffic. He also noted that the District buses ranged from 9 feet 8 inches, to 10 feet 2 inches in width.
3. Director Simms asked if Northwestern was able to evaluate 9 foot lanes. Mr. Seyfried noted that the Auckland Harbor Bridge must have 9 foot lanes as it is 40 feet wide and a two foot barrier is used there.
4. Chair McDonnell inquired as to whether sight distances are mandated by FHWA. Mr. Seyfried said that there are standards for new construction. Chair McDonnell asked what the design immunity implications were. Attorney David J. Miller stated that the Board would have to balance all relevant factors and that no one factor would deprive the District of design immunity. Mr. Seyfried commented that design exceptions are not unusual and the question was whether the benefits outweigh the costs.
5. Director Eddie asked if Northwestern had analyzed the matter of the length of trucks going around curves on the Bridge. Mr. Seyfried stated that in general the longer the truck the more "off track" it would be, but that Northwestern did not analyze that particular issue; however it did analyze the issue with reference to buses and determined that their width on curves would be about one foot wider than their actual width.
6. Chair McDonnell noted that if the percentage probabilities of rebound and second deflection accidents were added, there would be a 45 percent probability of some additional accident.
7. Chair McDonnell also said he felt the typical driver reaction on impact with the barrier would be to veer away from it. Mr. Seyfried said that, because of possible damage to the vehicle upon an impact and the physical displacement of the driver's position, he felt driver control was less likely to be a factor.

Board Meeting of December 19, 1997

At the December 19, 1997 meeting of the Board of Directors, the District Engineer presented a 30 minute review of the Northwestern University Traffic Institute Report, "Traffic Safety Study for a Moveable Median Barrier System on the Golden Gate Bridge," dated October 29, 1997. He responded to

a number of questions from the Board members regarding lane width and barrier positioning issues, accident rates, and enforcement of the speed limit. President Fraser concluded the Board review and advised that further consideration of this project would be scheduled for the meeting of the Committee of the Whole on Friday, January 16, 1998.

Caltrans Participation

Caltrans and the District signed a Letter of Intent, December 31, 1996 for Caltrans' assistance in the evaluation and development of a moveable median barrier for the Golden Gate Bridge. Caltrans reviewed and concurred with the E-TECH NCHRP crash testing report and is currently reviewing the Northwestern Traffic Safety Study. It is anticipated that the Caltrans review comments and recommendation will be received prior to the January 16, 1998 meeting of the Committee of the Whole.

AutoDesk Project

Several of the traffic lane configurations using the one-foot wide moveable median barrier result in lane widths under ten feet wide. There is little historic data available to analyze the behavior of motorists driving in narrow lanes adjacent to a barrier with no space between the edge of the lane line and the barrier. The District Engineer discussed this problem with AutoDesk who agreed, as a public service in order to assist the District in analyzing this complex situation, to develop 3-D visualization of a car driving across the Golden Gate Bridge in the lane adjacent to the barrier and passing the moveable barrier transfer vehicle. At the December 5, 1997 Building and Operating Committee meeting and the December 19, 1997 meeting of the Board, the District Engineer presented the AutoDesk video depicting a computerized visualization of a car driving the Golden Gate Bridge with the moveable median barrier in place.

III. INFORMATION REQUESTED AT DECEMBER 19, 1997 BOARD OF DIRECTORS MEETING

1. Director Kaufman requested information on the comparison of the moveable median barrier installed on the Genvilliers Viaduct near Paris to the application of a moveable median barrier on the Golden Gate Bridge.

Staff Response: The five-lane Genvilliers Viaduct near Paris, France, prior to installation of the moveable barrier system in 1986, had a fixed median barrier with two 11.5 feet lanes in each direction and 8.2 feet outside shoulders. After the moveable barrier

installation, there were four 9.8 feet lanes plus a 12.8 feet center reversible lane with 3.3 feet outside shoulders. The roadway carried 115,000 vehicles per day.

The facility was evaluated in a Northwestern University Traffic Institute report in 1987 (available in the District Engineer's office) which concluded that in the four months following installation of the moveable median barrier system the accident rate increased from 1.26 accidents per million vehicle miles to 1.52 accidents per million vehicle miles. Injury accidents increased from 19% to 33% of the total accidents. Barrier system displacements up to 3.9 feet were observed on the Genvilliers Viaduct barrier. No secondary impacts due to barrier displacement were identified. The use of the moveable median barrier system was later discontinued due to an improvement project which widened the viaduct.

The Genvilliers Viaduct utilizing a moveable median barrier in the center lane functioned in a 2-3 configuration with minimum lane widths of 9.8 feet. The minimum lane proposed for the Golden Gate Bridge is 9.0 feet. The Genvilliers viaduct operated at an average daily traffic volume of 115,000 vehicles per day, roughly equivalent to the Golden Gate Bridge average daily traffic volume in 1997 of 116,000 vehicles per day. The accident rate of 1.52 accidents per million vehicle miles for the Genvilliers Viaduct with a moveable median barrier exceeds the present accident rate of 0.64 accidents per million vehicle miles on the Golden Gate Bridge without a moveable median barrier.

2. Director Kaufman requested information on a determination of the proposed lane configuration for the Golden Gate Bridge with a moveable median barrier.

Staff Response: The Northwestern Traffic Safety Study analyzed eight different lane configurations with a moveable median barrier in the 3-3 configuration and in the 2-4 configuration. The criteria for evaluating the eight configurations was as follows:

- All lanes should be at least ten feet wide and in no case should any lane be less than nine feet wide.
- The outside lanes (curb lanes) should remain eleven feet wide.
- The lanes adjacent to a moveable median barrier system should be as wide as possible.

- When the roadway is in the 2-4 configuration, the two lane section should be more than twenty feet wide.

None of the analyzed alternatives completely satisfied all the lane width criteria. Although Alternate "E" best satisfies the criteria, the alternates will be reviewed by staff based on the relevant importance of the various lane width criteria to determine the scheme which best meets the needs of the District. The following describes Alternate "E" in various configurations: a) The 3-3 configuration: the number one lane, adjacent to the barrier, is 10 feet; the number two lane is 9.5 feet; and, the number three lane, the curb lane, is 11 feet. b) The 2-4 configuration: in the two lane section the number one lane, adjacent to the barrier, is 10 feet and the number two lane, adjacent to the curb, is 11 feet. For the four lane section, the number one lane, adjacent to the barrier, is 9 feet, the number two lane is 10.5 feet, the number three lane is 9.5 feet, and the number four lane, adjacent to the curb, is 11 feet. The raised ceramic lane markers along the lane lines interfere with the placement of the moveable median barrier in all eight alternatives. In addition, when the barrier is deflected by a crash, the ceramic lane markers will be disengaged from the roadway. The feasibility of replacing ceramic lane markers along the lane lines will be evaluated as part of the evaluation of alternate barrier configurations.

3. Director Kress requested information regarding the correlation between speed control on the Golden Gate Bridge and the prevention of accidents.

Staff Response: Recent accident statistics set forth below suggest a direct correlation between speed and number of accidents. For instance, in 1995 there were a total of 54 accidents. In 1997, the first full year after implementation of the double fine zone, vans noting the 45 mile per hour speed limit and double fine zone patrolling the Bridge, and the use of LIDAR by the CHP, there were 22 total accidents, a 59% reduction in the number of accidents. Likewise, a primary comparison of statistics for the same two years does not suggest that speed control might have a correlation of a lower number of cross-over accidents. However, to confirm these apparent correlations, studies over a longer period would probably be helpful and the raw statistics may need to be refined.

4. Director Middlebrook requested information concerning the current accident rate.

Staff Response: The Northwestern University Traffic Safety Study used accident statistics on the Bridge for the years 1991 through 1995. The inclusion of statistics for 1996 and 1997 results in a slight reduction in the total accident rate from 0.64 accidents per million vehicle miles to 0.61 accidents per million vehicle miles.

YEAR	TOTAL ACCIDENTS	INJURY ACCIDENTS	FATAL ACCIDENTS	PROPERTY DAMAGE ACCIDENTS	CROSS-OVER ACCIDENTS
1991	35	18	0	17	3
1992	53	22	0	31	5
1993	46	17	0	29	6
1994	42	17	3	22	6
1995	54	28	0	26	4
1996	46	39	1	7	7
1997	22	15	0	7	5
TOTAL	298	156	4	139	36
PERCENT	100%	52%	1%	47	12%
RATE (/MVM)	0.61	0.3	0.01	0.28	0.07

The double fine zone was implemented in September, 1996 with signs at either end of the Bridge. Two vans with signs noting the 45 mph speed limit and double fine zone were placed in operation late October 1996. The California Highway Patrol started using LIDAR in July 1997. The accident rates for 1997 are for the one year period in which all three of the traffic controls were in effect.

YEAR	TOTAL ACCIDENTS	INJURY ACCIDENTS	FATAL ACCIDENTS	PROPERTY DAMAGE ACCIDENTS	CROSS-OVER ACCIDENTS
1997	22	15	0	7	5
PERCENT	100%	68%	0	32%	23%
RATE (/MVM)	0.31	0.22	0.00	0.10	0.07

IV. ISSUES REQUIRING FURTHER STUDY

1. Lateral Positioning of the Barrier System. Several alternative barrier positioning schemes were evaluated in the Northwestern study. None is fully satisfactory in terms of desired lane widths. Staff will review these alternatives based on the relative importance of the various lane width criteria to determine what scheme on balance might best meet the needs of the District if a moveable median barrier were installed. The feasibility and advisability of replacing raised ceramic lane markers along the lane lines with flush or recessed markings will be evaluated in the evaluation of alternative barrier configurations.
2. Anchorage for the San Francisco End of the Barrier System. Satisfactory functioning of the barrier system and crash cushion at the San Francisco end requires the development of an anchorage system. Although such an anchorage appears at least at this point to be technically feasible, it must be designed and tested before a moveable median barrier system can be installed.
3. Guidance System for the Barrier Transfer Vehicle. Because of the relatively narrow lanes and the possible need to locate a barrier system with its base adjacent to or straddling the raised pavement markers on the Bridge, precise placement of the barrier system is important. A guidance system which assures consistent, accurate placement of the barrier system as it is moved from one position to another must be designed and tested.
4. Procedures for Emergency Vehicle Response. In conjunction with emergency vehicle operating agencies, strategies must be developed for responding quickly and effectively to accidents on the Bridge, depending on lane configurations. Of particular concern is the development strategies for accessing the accident site, removing stalled or damaged vehicles, and relocating the barrier system if it has been displaced by the accident. Specialized equipment such as double-ended tow trucks may need to be acquired.
5. Moveable Median Barrier Transfer Vehicle Storage and Maintenance Facilities. The location and requirements for moveable median barrier transfer vehicle storage and maintenance facilities must be defined.

Previously received cost figures from BSI may not be current and did not include all items of cost to the

District should it decide to install a moveable median barrier.

6. Project Costs. Costs for the barrier; transfer vehicles, including lease or buy-back, and associated components; cost of possible special equipment, such as double-ended tow trucks (if required); lane line reconfiguration; end anchorage; guidance system; emergency response equipment; annual maintenance, operation and repair costs; and, transfer vehicle storage and maintenance facilities must be developed. Staff has scheduled a meeting on January 9, 1997 with BSI to develop preliminary costs for these items.

V. RECOMMENDED PROCESS

A press release was issued noticing the December 5, 1997 meeting, and advising that the Traffic Safety Study report is available at the District Secretary's Office and specified public libraries.

The magnitude and complexity of the application of a moveable median barrier on the Golden Gate Bridge necessitate that the process be one that is clear and concise, and provide ample opportunity for input from the consultants, the public, and Board members. The Crash Test Report by E-TECH Testing Services, Inc., and the Traffic Safety Study by Northwestern were presented for information only at the December 5, 1997 Building and Operating Committee meeting and the December 19, 1997 Board meeting so that the Board members and the public would have the opportunity to ask questions. Staff will present the information requested by Board members at the December Board meetings at the January 16, 1998 meeting of the Committee of the Whole. After the January 16, 1998 meeting, staff will analyze the comments and input from Caltrans (if and when received) as well as the comments and input from the Board and from the public, and develop more definitive and complete costs for the project. It is anticipated that this phase of the process will be completed by March, and the results presented to the Board. Thereafter, the matter will be presented to the Board with an analysis of the pros and cons of installation of a moveable median barrier for an efficiently focused discussion.

The decision-making process will involve a weighing and balancing of the various tradeoffs involved in either installing or not installing the one foot moveable median barrier. To facilitate that process, it may be helpful to further define and focus the issues involved.

The central question is, given the current safety and operational status of the Golden Gate Bridge, whether or not the projected benefits of installation of the moveable median barrier outweigh the potential risks and adverse impacts that such installation might involve.

The issues encompassed within the central question can be broken down into two types: 1) those which must be determined in order to reach a conceptual decision of whether or not to install the moveable median barrier, and 2) those which must still be resolved even if a determination were made, conceptually, in favor of such installation. It would appear that resolution of the latter category of issues can be deferred until a conceptual decision is reached so that unnecessary costs can be avoided if the conceptual decision is against installation of the moveable median barrier.

Opinions may vary as to the relative weight of various issues and as to which category they belong. Following is a proposed breakdown, offered as an analytical tool to aid the Board in reaching a decision.

- A. Issues to be resolved in order to reach a conceptual decision of whether or not to install the moveable median barrier.
 1. Issues relating to reduced width of traffic lanes:
 - Lateral positioning of moveable median barrier - width of curb lanes and lanes adjacent to barrier.
 - Possible elimination of raised lane markers and possible alternatives.
 - Potential effects of above on safety: overall accident frequency and severity/crossover accident frequency and severity.
 - Potential effects of above on traffic operations.
 - effects on traffic flow generally.
 - effects on bus and truck operations.
 2. Issues relating to presence of a moveable median barrier on the Bridge.
 - Lateral deflection and effect of opposing traffic: likelihood, frequency, effect.

- Rebound off barrier and effect on traffic in same direction.
 - Presumed elimination of crossover accidents.
3. Issues relating to loss of sight distance.
- Effect of higher brake warning lights on vehicles since 1985.
- B. Issues which still must be resolved even if a conceptual decision to install the moveable median barrier is made.
1. Development of an acceptable end treatment and anchorage system for the San Francisco end of the barrier.
 2. Development of an acceptable guidance system for the transfer vehicles.
 3. Design of transfer vehicles.
 4. Provision for, and design and location of facilities for storage and maintenance of transfer vehicles.
 5. Development of procedures for emergency vehicle response.

Of course, as indicated above, in order to make an informed decision, the Board will need more complete and definitive estimates of costs which staff will attempt to develop in the interim.

We will be guided by the Committee regarding its schedule for further discussion and action. The proposed process is the joint recommendation of staff and Directors Boro, Read, and Smith, who were appointed to serve as an advisory committee on this project.

MCG/jd