SP-20

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation LOGH-535B

Date: September 28, 1989

In reply refer to: H-89-33

Honorable Jimmy M. Evans
Commissioner
State of Tennessee
Department of Transportation
Nashville, Tennessee 37219

About 6:45 a.m., central standard time, on November 19, 1988, a Greyhound bus with 45 occupants, traveling southbound through a construction zone on Interstate Highway 65 in Nashville, Tennessee, suddenly went out of control during a steering maneuver, rotated 190 degrees clockwise in the southbound lanes, overturned on its left side, and came to rest facing northbound on the southbound embankment. The unrestrained bus driver and 38 passengers were injured in the accident. Twelve passengers sustained serious injuries, and the bus driver and 26 passengers received minor injuries. Six passengers were not injured.[1]

It was raining at the time of the accident, and the bus was in the right travel lane. Two cars passed the bus on the left, and one of them moved in front of the bus to let the other go by. The following distance between the bus and the next vehicle in front was therefore diminished. The bus driver indicated that he was uncomfortable with this situation and chose to steer into the left lane. The bus driver was unable to complete the lane change before the bus slid into a closed lane adjacent to the left travel lane, knocking over several channelizing barrels. The bus driver was able to introduce a rightward steering maneuver, but while the front of the bus moved rightward, its rear began to track leftward. As a result, the bus began the clockwise rotation.

The segment of I-65 on which the accident took place was built in the late 1960s and consisted of two 12-foot concrete travel lanes in each direction, separated by a 40-foot grass median, with 10-foot outside shoulders, constructed of asphalt, on each side. A construction project was begun in 1987 to provide an additional travel lane in each direction. The existing lanes would remain intact, becoming the outer and middle lanes when work was completed. The new lanes would be inner lanes; with inner shoulders and a concrete barrier between them, they were to replace the grass median.

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[1] For more detailed information, read Highway Accident Report--"Greyhound Lines, Inc., Intercity Bus Loss of Control and Overturn, Interstate Highway 65 in Nashville, Tennessee, November 19, 1988" (NTSB/HAR-89/03).

While construction was in progress, southbound traffic entering the construction zone would shift to the right. The original inside lane (which would become the new middle lane) was closed to traffic. Plastic channelizing barrels were used to close off the lane. The outside lane remained open to traffic. The outer shoulder was stabilized to establish a second travel lane during the construction. Stabilization of the shoulder included application of asphalt overlays, or patches, to strengthen the pavement; the bus ran off the road approximately 50 feet past the end of a 300-foot overlay.

When the bus shifted from the asphalt lane to the concrete lane, it encountered a pavement surface with sharply reduced coefficient of friction. The bus driver may have been late with his steering input to correct the leftward movement of the bus, or the input to move the bus back to the right may not have been sufficient to develop the cornering forces to turn the front of the bus rightward before the bus moved into the closed new middle lane, given the lower coefficient of friction of the concrete lane. Thus, the lower coefficient of friction of the concrete lane adjacent to the asphalt overlay contributed to the encroachment of the bus into the closed new middle lane.

The posted regulatory speed limit in the construction zone was 45 mph. Considering calculations based on tire marks and the definable conditions under which the bus tires would hydroplane,[2] as well as witness statements, the Safety Board concluded that the speed of the bus prior to the accident was 60 to 65 mph. It was this excessive speed that led the bus to go out of control and overturn. The decreased coefficient of friction, which the bus encountered in the move to the left, contributed to the loss of control. Furthermore, high speed exacerbated the effects of the friction differential.

In this accident the bus driver did not apply brakes during the lane change. If a vehicle's brakes are applied when its left wheels are on pavement with one coefficient of friction and the right wheels are on pavement with different frictional properties, a turning moment can be introduced that can cause the vehicle to spin out of control. This occurred in 1985 when an intercity bus near Frederick, Maryland, traveling too fast for the wet highway conditions, straddled two lanes during a braking maneuver. The bus went out of control and struck a concrete bridge rail. Six of the occupants were killed, and the other 11 received injuries.

In the Nashville accident, although the friction differential was a result of the temporary use of asphalt overlays, the more general problem of low skid resistance on the existing travel lanes was not a result of the construction project. Testing of the traffic-polished surface of one lane produced a consistent skid number of 27, which indicates it is "slippery,"

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[2] Hydroplaning occurs when a vehicle traveling on wet pavement reaches a speed at which water pressure builds up under the tires. As contact diminishes between the tires and pavement, it becomes increasingly difficult for the driver to maintain directional stability. Ultimately, the ability of the tires to develop braking and turning forces can be completely eliminated.

according to widely accepted criteria developed in Kentucky.[3] Although skid testing was not performed in the adjacent lane, it is of the same composition, and the concrete was poured at the same time, so it is likely that the two had similar frictional properties.

Therefore, even before the construction project was begun, vehicles traveling on this section of highway, particularly when it was wet, would encounter potentially severe difficulties in braking and steering that would not be present on pavement with better skid resistance. These difficulties would be most severe for large vehicles and those traveling at high speed.

The construction work at the accident site is now near completion. The three concrete lanes have been opened to traffic, and the asphalt lane is no longer being used as a travel lane. Based on the reported past experience of the Tennessee DOT with concrete pavements, the newly constructed inside lane will likely have skid resistance numbers close to 60, which is "good skid resistance," according to the Kentucky criteria. But if the pavement surface of the two older lanes remains unchanged, a new instance of friction differential will exist, as one lane with high skid resistance adjoins two with substantially different properties.

Tennessee DOT has the responsibility to prevent friction differential, which may occur during and after construction projects, and also under other circumstances. The Department also has the responsibility to provide for adequate highway skid resistance overall. Testing performed in conjunction with the investigation of the bus accident indicates that both friction differential and low skid resistance conditions existed at this particular site on I-65. The Safety Board believes the Tennessee DOT should take the measures necessary to provide adequate skid resistance for all roadways within the State and to ensure that these roadways are free from significant friction differential.

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[3] Skid number is the tire-to-pavement friction coefficient X 100, for a specified set of test conditions. Although there is no consensus of opinion on appropriate skid numbers for wet pavement surface, the Commonwealth of Kentucky, a leader in skid resistance research, has developed the following criteria:

Above 39 - Good Skid Resistance
33 to 39 - Marginal
26 to 32 - Slippery
Below 26 - Very Slippery

The same study that produced those criteria also said, "Any highway section with an ADT [average daily traffic] above 1,000 should be deslicked if the SN [skid number] of the pavement is 28 or less." (Rizenbergs, Rolands L., Burchett, James L., and Warren, Larry A., "Accidents on Rural, Two-Lane Roads and Their Relation to Pavement Friction," Commonwealth of Kentucky Department of Transportation, Bureau of Highways, Division of Research, April 1976.)

FHWA has previously made findings and recommendations that would help Tennessee DOT reach those goals. The review of Tennessee's skid accident reduction program that was conducted by FHWA in 1986 indicated that ample skid data are collected, but sufficient use is not made of the data. Despite its announced intentions to do so, Tennessee DOT has yet to fully implement the recommendations FHWA made in 1986. The State was urged at that time to incorporate into highway design and construction the knowledge gained through skid testing. Another recommendation awaiting action called for establishment of criteria for acceptable skid resistance in both old and new pavements, along with a program to make sure the State's highways meet those criteria. The Safety Board urges Tennessee DOT to carry out these recommendations without further delay.

By doing so, the State would be incorporating skid accident reduction principles into its pavement management system, as called for in an FHWA policy on such systems announced in 1989. To be in compliance with the policy guidelines on this point, the Tennessee program for both highway construction and maintenance "should include a systematic process to identify, analyze, and correct hazardous skid locations."[4]

The Construction Project on I-65.--Since I-65 is a Federal-aid highway, construction projects on that highway require prior approval from FHWA. FHWA did approve the original design plans for the project on I-65. However, a decision during the construction phase of the project to eliminate the provision for "'diamond' type grinding of all concrete surfaces" was initially made without approval from, or consultation with, the appropriate FHWA division office.

Diamond grinding is one technique for raising the coefficient of friction in a pavement surface. If sufficient improvement had been accomplished in the existing concrete lanes at the site in question, there would have been little if any friction differential between the asphalt overlay and concrete travel lanes during construction or between the old and new concrete lanes after construction was completed.

According to the Tennessee DOT, the decision to eliminate the provision for diamond grinding was based on the "varying history of results" with the procedure, as well as the possibility of a future project to overlay the concrete lanes with asphalt. There are various alternatives to diamond grinding, such as tining, application of surface-roughening chemicals, and a variety of overlay methods, but Tennessee DOT did not pursue any of them when it abandoned the plans for diamond grinding.

It was only after the Safety Board made inquiries that Tennessee DOT undertook a diamond grinding test project. The results of that project have proved favorable, and Tennessee DOT has indicated diamond grinding of the existing concrete lanes within the construction zone will continue. There are no stated intentions to try other methods for improving the skid

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[4]Federal-Aid Highway Program Manual, Transmittal 428, Federal Highway Administration, March 6, 1989, p. 16.

resistance of the existing concrete surface, and there has been no timetable or other definitive word about repaving the highway with asphalt.

The Safety Board believes that friction differential is an avoidable highway hazard. The first step in preventing its development in conjunction with construction and maintenance is to evaluate each element that could bring on this condition in a project, at both the planning and implementation stages; countermeasures should then be instituted as needed. The Safety Board does not endorse one method of pavement rehabilitation over another, but it does urge Tennessee DOT to make a determination about which one is most appropriate for the highway section in question and implement the selected method as soon as possible.

Therefore, the National Transportation Safety Board recommends that the Tennessee Department of Transportation:

> Modify Tennessee's skid accident reduction program in accordance with the recommendations issued by FHWA in its 1986 review of the State's skid accident reduction activities, and with the standards and guidelines issued by the FHWA for pavement management systems. (Class II, Priority Action) (H-89-33)

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "... to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendation in this letter. Please refer to Safety Recommendation H-89-33 in your reply.

Also, as a result of its investigation, the Safety Board issued Safety Recommendations H-89-26 through -30 to Greyhound Lines, Inc. and Safety Recommendations H-89-31 and -32 to the Federal Highway Administration.

KOLSTAD, Acting Chairman, and BURNETT, LAUBER, NALL, and DICKINSON, Members, concurred in this recommendation.

By: James L. Kolstad
Acting Chairman