

BRIDGES AND NAVIGATION INTERESTS

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It is always a pleasure to come to Kentucky and particularly this part of Kentucky. It is a beautiful part of the country and there seems to be an indescribable hominess here. Those of you who live here should be thankful for it. My fondness for the State may stem, to some extent, from the fact that my paternal ancestors migrated from Kentucky to Missouri three generations ago. I'm not quite sure whether they left voluntarily or if they were asked to leave. Anyway, if it was the latter, here we are back again and this time by invitation. And, of all things, representing the U. S. Coast Guard.

Anyone attending the Structures Session of the Twenty-third Annual Kentucky Highway Conference in Lexington, Kentucky, who sees that one of the participants represents the U. S. Coast Guard is entitled to an explanation. Bear with me: I have one and I'm willing to share it with you.

The Coast Guard is fundamentally a seafaring organization. The nations' oldest, I might add. It had its beginning as an agency of the Treasury Department in 1790 and was called the Revenue Cutter Service. Its mission was to collect revenue. Collecting the revenue is a little more sophisticated today, but in those days the little Coast Guard Cutters actually patrolled off shore, under sail, of course, and hailed ships approaching our Coast; they went on board and actually collected import taxes. Time passed and in 1915, the U. S. Lifesaving Service, an organization of true coast guards whose mission was to render assistance to those in peril on the sea, merged with the Revenue Cutter Service to form the U. S. Coast Guard. In 1939, the Lighthouse Service, an agency of the Department of Commerce, merged with the Coast Guard, further broadening its scope of responsibility. In 1941, the Bureau of Marine Inspection, another agency in the Department of Commerce, merged with the Coast Guard in the Treasury Department and another marine safety function was added.

With the creation of the Department of Transportation in 1966, the Coast Guard ended its long and glorious association with the Treasury Department and became the Water Transportation Agency in the new department. Hard on the heels of this change came the transfer of certain laws from both the Bureau of Customs and the Corps of Engineers. These included certain laws pertaining to the administration of bridge functions, all of which are intended to prevent bridges over the navigable waters of the United States from unreasonably obstructing navigation.

So we are not in the bridge building business, we are in the marine safety business. In the relatively short period of 31 years that I have been with the Coast Guard, I have seen the philosophy of coast guarding change from rendering assistance to those in peril at sea to a major effort of accident prevention. This then, is our primary concern with bridges. We endeavor to prevent marine accidents involving bridges.

The Second Coast Guard District, which I represent,

is concerned with some 17,000 miles of navigable waterways throughout 21 midwestern states, 1,477 miles of which are in or bordering the State of Kentucky. The Ohio River, bordering your state from the West Virginia line to its confluence with the Mississippi, a distance of 662 miles through Kentucky, carried 120,204,227 tons of cargo in 1968; the Tennessee River, which flows 62 miles through Kentucky, carried 23,018,342 tons; the Cumberland River, which flows 75 miles through Kentucky, carried 5,086,553 tons; the Green River, entirely within the State of Kentucky, carried 16,191,483 tons; and, the Kentucky River, also entirely within the State, carried 1,040,015 tons.

Cargo is transported in barges ranging in size from 110 feet long by 26 feet wide to 290 feet long by 50 feet wide. They are lashed securely together to form a solid and rigid unit pushed by a diesel towboat which may be anywhere from 65 to 200 feet long and powered with anywhere from 300 to 9,000 horsepower. The commodities could be most anything: grain, coal, construction material, cement, petroleum products and bulk chemicals predominate.

Now, before I move on to what I'm supposed to be talking about, let me dazzle you with a few more statistics:

- (1) Since World War II, canal and river shipping has increased dramatically. Since 1960, tonnage has increased from 291 million tons to about 466 million tons in 1970.
- (2) There are 25,543 miles of inland navigation channels that are available for commercial use.
- (3) There are 1,700 companies operating barges and towing vessels.
- (4) There are 3,000 tank barges hauling liquid cargoes with a cargo capacity of 6,800,000 tons.

- (5) There are 15,000 barges hauling dry cargoes that have a total freight capacity of 17,000,000 tons.
- (6) There are 4,250 towboats and tugs which provide the propulsion power for 18,000 barges.
- (7) 15% of U. S. Domestic commerce is moved by barge.
- (8) It is estimated that barge transportation demands will increase from 350 to 500 percent in the next 50 years.

For the purpose of continuing this exposition, let's standardize on a typical 15 barge tow; five barges long, three barges wide. Approximate rectangular dimensions of this unit is 975 feet by 105 feet. Going downstream, steering a straight course, this unit will, theoretically at least, occupy a corridor 105 feet wide. Modern Ohio River locks are 1200 feet long and 110 feet wide. So, if we are to build a bridge with navigation span 110 feet wide, the same width as a lock, our tow will have five feet of clearance.

I have heard in public meetings that navigation interests are being entirely unreasonable in wanting horizontal clearance in the navigation spans of bridges greater than the width of the locks in the same river. The answer to this, of course, if that you don't build your highway overpasses the same width as your garage doors. To drive a towboat and 15 barges, approximately 25,000 tons, full speed ahead through a bridge span 110 feet wide takes more than skill. The pilot could probably make more money as a stunt man. The answer, therefore, is that the prudent navigator reduces speed. Trucks don't slow down to go under underpasses and he reasons that he shouldn't have to slow down to go under a bridge. But, the pilot slows down; two miles upriver. Remember, he's 975 feet long plus boat. He has 25,000 tons moving through the water at 14 feet per second and his problem is to have it under control before he gets to that bridge. Under control meaning that when he is finally aligned and committed to a course of action he can still stop this monster if he has to. He must avoid hitting piers at all cost. So, he slows down. Two miles per hour instead of ten. He travels at this rate through the entire zone of influence of the bridge, let's say two miles. The hourly operating cost is one hundred dollars. Usually he makes 10 miles in that hundred dollar hour. Now, he is making two miles in that hundred dollar hour.

Now, in this example, we are talking about a hypothetical bridge with extremely limited horizontal clearance in a straight stretch of the river. Let's assume this bridge is in a bend of the river or just above a bend in the river.

Let's say that a towboat and barges are again coming downriver but that in addition to getting through a narrow bridge the pilot is faced with the problem of getting around a bend immediately past the bridge. This is similar to the situation at Parkersburg, West Virginia, incidentally, the one that was damaged by an explosion ignited by a tank barge recently. It has a horizontal clearance of 326

feet in each of two spans. Well, anyway, the towboat is 975 feet long, 105 feet wide. In spite of his sweating palms, the pilot is proposing to pass under the bridge and then steer around a bend downriver. To make it interesting, let's say the river is high, as in the spring, and there is a four mph current running along with him. His speed through the water is, let's say, eight mph. Speed over the ground then is 12 mph. Shall he continue to drive? A towboat's steering capability lessens as the speed of advance is reduced. He is now three miles above the bridge and the head of his tow is a little more than 2-3/4. It takes one mile to stop. The pilot must make a decision, --NOW. He makes the right one. He slows down. Dead slow. It would have been impossible for him to steer the bend because of the proximity of the bend to the bridge.

The reason is that with forward momentum, the pilot must start turning a considerable distance above the bend; the current acting on his quarter, in addition to his momentum, pushes the tow toward the concave side of the bend. The current and momentum factors tend to force the tow straight ahead, along the initial base course. So, in order to get around the bend the pilot must steer, let's say, 20° to the right of his base course. When the turn is started, the tow assumes an inclined attitude, instead of moving through a corridor 105 feet wide, the width of the corridor is increased to between 400 and 450 feet. Continued passage under these circumstances is impossible: One. the tow cannot occupy a corridor 432 feet wide, and pass through a horizontal span of 326 feet; Two. if he waits to start steering the bend after he gets through the bridge, he will wind up sideways against the shore on the concave side of the bend. But, he was smart. He slowed down. He is going to play it safe and flank the bend. Flanking is a process of drifting slowly down the current while backing the engines occasionally to stay in alignment. The attitude of the tow in relation to the bend of the river is almost opposite that of a steering position. In flanking, the boat is kept high on the point and the barges deep in the bend. The pilot keeps backing on the engines as necessary to maintain the position of the boat while the current pushes against the side of the barges and carries them around the bend. When the pilot reaches a point where he can safely steer ahead, he puts his engines ahead and moves on out. So that is the safe way, but, it is a slow process. It could take as much as two hours as compared with perhaps 15 minutes to steer the bend without slowing down.

Another consideration occurs when boats meet in this situation. Needless to say, the upbound boat in a confined channel must wait for the downbound boat to complete a flanking maneuver so that they can safely pass. The same goes for a small downbound boat that is behind the large flanking tow. The smaller tow could probably drive on through the bridge and around the bend, but he has to wait for the large tow flanking ahead of him.

The point to all of this is that a bridge, which may be otherwise acceptable in a straight reach of the river, is often unacceptable because of its proximity to a bend. And, of course, rivers are sinuous.

This, then describes the delay aspect of the problem.

But, as I said previously, we are in the marine safety business. We are primarily concerned with the real possibility of colliding with bridges, particularly with respect to barges carrying gasoline or toxic cargoes. The danger of fire and pollution is ever present. A ruptured gasoline barge can create a holocaust. A ruptured chemical barge can play havoc with a municipal water supply.

Well, so much for horizontal clearance. Actually, horizontal clearance is simply a result of pier locations. It is the piers in the water that are of greatest concern to the navigator. It is the pier location that we are concerned with in considering whether a proposed bridge will meet the needs of navigation. So, aside from seeing that piers are far enough apart to provide for present and future navigation, we are concerned with their location in the waterway. To explain this: In considering the plans for a proposed bridge, there are three basic considerations: First, will the bridge cross a navigable waterway of the United States, if not, we do not have jurisdiction, the stream must be legally navigable; second, we must have proof that it is acceptable with authorities on both sides of the river (an application for a bridge between Kentucky and Indiana must be supported by documented approval of both States); third, will the span adequately clear the navigable portion of the river, that is, the channel, the track or the thalweg as the case may be. The new pools of the Ohio River are generally navigable from bank to bank, in order to achieve our objective of providing maximum usefulness of the waterway, we start with the premise that there should be no piers in the water. Bridge builders contend that the proposed structure cannot reasonably be constructed without piers, so we compromise. We strive to locate piers so that we not only provide maximum usefulness of the waterway, but optimum usefulness of the waterway. Maximum usefulness might be defined as least possible reduction for all types of craft that may use the waterway during the lifetime of the bridge. This means not only providing adequate navigation spans for commerce, but adequate auxiliary openings for use by recreational craft. Optimum usefulness of the waterway would include locating piers so that they are not in the line of flow. An example of this: If a barge is cast adrift and floats down the river, or if a towboat should have a power failure and drifts down the river at the mercy of the current, the bridge would be well designed from a navigation standpoint, if the barge or towboat could pass through the span without touching a pier. This, of course, is not always possible, but many existing bridges satisfy this requirement.

There are situations in which the pilot knows from experience that the current will set him across the river. What he must do to get through a span is to keep driving for one pier in order to miss colliding with one of the other piers. Pilots have respect for bridge piers and quite a few have left their mark on them. So, once again, in approaching a bridge downbound, a pilot is committed to a course of action, depending on the size of tow, horsepower and velocity of current, about a mile or more up the river. In summary, we hope there will be no piers in the water but if there must be, we hope they are not situated in vulnerable locations.

I spoke earlier about horizontal clearance. Vertical clearance is, of course, another major consideration. Generally speaking, today's modern towboats need 50 to 55 feet of vertical clearance. We have established various vertical clearance criteria for the construction of bridges. Different standards have been set for different rivers. I personally believe that more uniformity would be desirable.

The minimum set for the Ohio River is 55 feet above the water surface elevation that is not exceeded more than 2% of the time or 69 feet above the water surface elevation known as normal pool, whichever is greater. The Ohio River standard is probably one of the better and more realistic ones. It provides not only for the almost uninterrupted flow of navigation but sufficient clearance for the unusually high craft, such as pile drivers and other construction equipment, that must move on the river.

A good example of exceptionally high barges is the so called missile barges that shuttle between the NASA installation at Huntsville, Alabama and Cape Kennedy, a distance of 3,500 miles. The missiles or boosters that these barges carry cannot be reasonably transported any other way. I don't have a picture of one of these barges, but they look like a quonset hut on a barge and are about 35 to 40 feet high. This height in itself is not of great concern, the problem is that the pilot of the towboat must be able to see over it, and, of course, the lower he is the more blind area he has before him. With the extent our rivers are being used by pleasure craft, water skiers, and the like, a pilot must be constantly alert of he may run over someone without ever seeing the victim. So, in order to provide the visibility that is needed for safety, the height of boats will not decrease, we can be sure of that. I do not believe that it will increase either, I believe that the 50 - to 55-foot height is optimum.

The high point of most towboats is the top of the radar antenna but most of these are less than six feet above the top of the pilot house. There are some retractable pilot house boats where the pilot house raises and lowers on a hydraulic lift, but this is not a very practical arrangement for many reasons. It seems then that we are going to continue to design bridges with pretty much the same vertical clearances as we have in the past.

Like the retractable pilot house, there seems to be many reasons why drawbridges are not practical. Among these, of course, are cost of operation and maintenance plus the cost of delay and inconvenience to vehicular traffic whenever the span must be opened for boats to pass through. There are problems inherent in drawbridges that I would really rather not take the time to discuss. We have 190 drawbridges in our District and we administer the regulations that govern their operation. There is a trend these days toward remote semi-automated operation of drawbridges. We have six over the new Arkansas Waterway. I have had the dubious distinction of writing the regulations governing their operation. You have one such bridge here in Kentucky, over Green River at Rockport. This is a bascule owned by ICRR. The span is normally in the raised position and it automatically lowers for the passage of trains. We've had many problems with it, particularly during the first year of the automated

operation, but it seems to be operating reasonably well now.

The Coast Guard is also concerned with the lighting of bridges for the protection of navigation. Federal regulation pertaining to navigational lighting of bridges requires the owner of the bridge to provide "such lights and other signals as may be required..." In the past this has been generally limited to lights, however, I understand, that those devices considered as "other signals" are now being studied. There are many who believe that the time for taking a long look at the requirement for installing lights on bridges is long overdue. In the Second Coast Guard District, we have some 1,600 bridges. The magnitude of the task of just keeping track of and performing the annual inspection of the navigational lighting is staggering. The Coast Guard maintains a system of lighted aids to navigation along the rivers so we have a real appreciation for the problems that bridge owners face in maintaining bridge lights. Vandalism alone is becoming an expensive problem. I need not tell highway department people about that.

So, we are studying the need for lighting, and we are also studying a way to provide better radar indication of bridge piers. A bridge presents a line across the river on a radar scope, but pier locations do not show up. We are looking into the feasibility of installing radar transponders on piers so that the pier itself will give a more pronounced indication. Most commercial towboats

continue to operate on radar during foggy conditions, until they get to a bridge. If the pilot cannot see the piers, he has a problem and as I pointed out before, it isn't always easy to stop. A tow pilot cannot pull off onto the shoulder and wait it out. It could very well be that the pilot may risk running a bridge during a fog as a lesser risk than whatever alternative might be available to him.

I've tried to present candidly some of the navigation problems that relate to bridges. I think that anyone designing or building bridges today should at least be aware of the fact that these problems exist. We are all concerned in our own way with the terrible complex problem of improving our nation's transportation system. The need is critical. I am convinced that the day is not far off when the transportation of certain (bulk) commodities by water will be mandatory. Not as a matter of economics but simply to alleviate overland congestion. I drive to and from work on Interstate 55, a relatively new highway, bumper to bumper morning and night. I pass almost every week through the busy airports of the Midwest; I see the trend toward more railroad cars pulled by more powerful locomotives. I also travel up and down the rivers where you can still run for hours and never pass another boat, such as on the Tennessee and Cumberland. Surely, the increasing need to transport commodities cannot for very long ignore the rivers' potential.