CHARACTERISTICS AND COMMON VULNERABILITIES INFRASTRUCTURE CATEGORY: RAILROAD BRIDGES

Protective Security Division
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Preventing terrorism and reducing the nation's vulnerability to terrorist acts requires understanding the common vulnerabilities of critical infrastructures, identifying site-specific vulnerabilities, understanding the types of terrorist activities that likely would be successful in exploiting those vulnerabilities, and taking preemptive and protective actions to mitigate vulnerabilities so that terrorists are no longer able to exploit them. This report characterizes and discusses the common vulnerabilities of railroad bridges.

RAILROAD BRIDGE CHARACTERISTICS

Common Characteristics

Thousands of railroad bridges exist in the United States (U.S.). Some date back to the 19th Century and were designed to withstand the weight of heavy locomotives. Today, computer technology is applied to the design and construction of bridges. Although the bridges vary in type, they all have a common goal: to safely cross over an obstacle, whether it is a body of water or a crack in the earth's crust.

The national economy is based on timely rail deliveries, especially in light of industry's current practice of just-in-time stocking arrangements. Railroad bridges can be critical chokepoints for high-volume rail lines moving freight from geographic areas of supply to other areas of demand. Furthermore, critical rail bridges are vital assets of the Strategic Rail Corridor Network (STRACNET), a 38,800-mile interconnected network of rail corridors. The STRACNET supports the deployment of military forces across the U.S. to strategically located ports of embarkation.

Railroad bridges must be strong enough to support their own weight (dead load) and the weight of a crossing train (live load). The dynamic characteristics of live load and the load caused by wind blowing across the structural members (parts) of the bridge require that bridges be stiff enough so as to not vibrate uncontrollably.

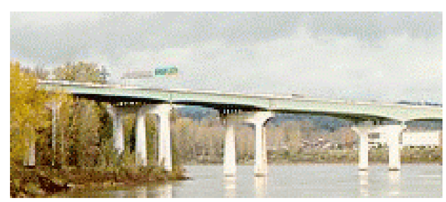
The distance that a bridge extends between supports is called the "span." There are two types: the simple span and continuous span. The middle supports for a span are known as piers, while the end supports of a bridge are called abutments. The forces that act on a bridge result in stresses to its members. There are several types of stresses: tension stress – stretching or pulling apart; compression stress – squeezing or pushing together; bending stress; shear stress; and torsional stress. Every member in a bridge must be designed to handle the different types of stresses to which it is subjected. The Fracture Critical Member is the key point of a railroad bridge that, if destroyed, would severely reduce the design load capacity of the bridge or cause the entire railroad bridge to collapse.

Common Bridge Types

All bridges, including railroad bridges, consist of four, basic structural designs, with many variations within the design categories:

- Truss,
- Beam,
- Cantilever, and
- Arch.

Truss Bridge. The truss bridge is a very widely used bridge for today's transportation needs; it is strong and relatively inexpensive. It can be made of various materials, but (like the beam bridge) steel and pre-stressed concrete are the most commonly used materials. The guiding principle behind the truss design is the use of triangles, which are very strong if used correctly. The greater amount of triangles in a truss bridge, the greater the load the bridge can support. The structure of a truss is usually combined with other structures to increase the strength.



Beam Bridges. The beam bridge has a very basic structure with a beam resting on two or more piers. The weight of the load pushes down on the beam and is transferred to the piers, which determines its loading capacity. When a load pushes down on the beam, the beam's top edge is pushed together (compression), while the bottom edge is stretched (tension). Reinforced concrete is the ideal material for beam bridge construction, because the concrete efficiently withstands compressive forces and the steel rods, embedded within, resist the forces of tension.

The length of a beam bridge is limited, and for long spans, such bridges may require multiple piers. Therefore, the capacity of a beam bridge decreases with increasing span unless other reinforcing measures are included in the design. This does not mean beam bridges are not used to cross great distances; it only means that they must be daisy-chained together, creating a "continuous span." Most beam bridges, however, are extremely simple and span short distances.

***Cantilever Bridge*.** In a cantilever bridge, the beams are either supported at only one end and carry a load at the other end or distribute the load toward the center of the bridge. Long cantilevers are used in structures where clear space is required below, such as over a shipping channel or harbor.

***Arch Bridge*.** Arch bridges are one of the oldest types of bridges and have great natural strength. They rely on the concept that the arch displaces the weight from going straight down on the supports to having a portion of the force going straight down, with the other portion being displaced diagonally to either side.

Since most railroad bridges are privately owned by various rail companies, there appears to be no complete and publicly available inventory of them. The *World Almanac and Book of Facts*, however, lists what it calls “notable” bridges, including railroad bridges, in North America.

CONSEQUENCE OF EVENT

Failure of a railroad bridge that supports the shipment of rail cars containing hazardous materials could result in a severe chemical release. A hazardous materials release in or around a railroad bridge will cause environmental damage, particularly for releases into the underlying water body. It could also cause injury or death to nearby residents or railroad employees. Some victims may experience persistent or long-term health effects or illnesses. The water supply may be contaminated, depending on the amount of chemical release into the waterway and/or the proximity of the receiving water treatment system. The physical circumstances of a railroad bridge failure would hamper response, rescue, and cleanup efforts. Specialized equipment would be necessary to effect any response (e.g., fire boats, dredging equipment). Failure of a railroad bridge that supports passenger transportation could result in injury or death to passengers and railroad employees. Failure of a railroad bridge due to a large explosion could impact neighboring residents and businesses due to the resulting explosive forces (e.g., fire and pressure).

The worst-case scenario, as defined by the railroads, would be the interruption of service for any extended time. High-traffic corridors are especially critical. Railroad logistics are directly affected by the loss or damage of bridge assets for indefinite amounts of time. It is clear that many minor incidents created on a railroad system could interrupt traffic. The railroads haul sensitive military shipments on the STRACNET, 20% of chemicals, 40% of grain harvest, 64% of coal used for electric power, and 42% of intercity ton-miles essential to the viability of the nation’s day-to-day operations. Despite the availability of alternate transportation through added barge and truck travel, many industries would be forced to close if they could not receive the required materials for operation. Additionally, they would not be able to ship their products to market. This would cause a doubling effect of the disruption of rail traffic, along with a cascading effect on the federal, state, and local economy. Depending on how logistics are affected in a terrorist attack on major railroad bridge structures, the following impacts could potentially be realized:

- The automotive industry could not operate for more than a week without rail services.
- Paper industry segments would be shut down within a week of rail service cessation.
- The coal mining industry would be halted in approximately two weeks.
- Although power generation is less dependent on coal, most utility shipments occur via specialized unit coal trains from specific coal mines or areas directly to the generation plant. Depending on stockpiles, the ability to generate electricity could be affected at these plants.
- Many lumber producers would shut down within weeks.
- The plastics industry would shut down in three to four days with major rail stoppage.
- Industrial inorganic chemicals and agricultural would be crippled by the loss of rail transportation.
- There would be a significant impact on the food and agricultural industries if there were a loss of rail transportation.
- Glass manufacturing would be seriously affected by an interruption of rail movements of raw materials.
- A large fraction of aggregate shipment is by rail. While trucks can also move the products, there is not enough capacity in the trucking industry to pick up the additional logistical burden caused by a railroad shutdown.
- Just-in-time intermodal services, including those bringing foreign goods to plants or to market, would be very difficult to maintain if there were no double-stack container services.

In addition, rail bridges are commonly linked to highway bridges or traverse highways such that failure of the bridge will impact both rail and highway traffic. See Figures 1 and 2.

Figure 1 Railroad Bridge over Highway

Figure 2 Bridge with Overhead Highway

Standards for Railroad Bridges

The Federal Railroad Administration (FRA) maintains current information on the bridge management practices of the nation's railroads. The FRA was established in 1967 to assure that the newly created Department of Transportation would include agencies addressing all modes of transportation. Until that time, railroad issues of concern to the federal government were addressed by the U.S. Department of Commerce. In addition, the Interstate Commerce Commission (ICC) continued its responsibilities for regulation of the railroad industry. All rate changes had to be submitted for approval to the ICC with suitable and extensive justification.

The FRA does not directly regulate the safety of railroad bridges. In its Statement of Agency Policy on the Safety of Railroad Bridges (49 CFR 213, Appendix C, adopted in August 2000), the FRA established nonregulatory, nonenforceable guidelines regarding the inspection and upkeep of railroad bridges.

The FRA licenses state track inspectors and regularly evaluates railroad companies' bridge inspection programs (see FRA Track Compliance Manual, Chapter 7, available at http://www.fra.dot.gov/pdf/safety/track_compliance_manual/TCM%207.PDF). The FRA deploys its own track inspectors, who encounter rail bridges in their normal course of inspections and during investigation of complaints or incidents. The primary responsibility for the FRA Bridge Safety Assurance Program rests with the Bridge Engineer in the Office of Safety Assurance and Compliance. The Track Specialist in each region administers the program in that region. Field work is conducted primarily by the federal and state Track Safety Inspectors in each region who have received training in the fundamentals of railroad bridge inspection. The FRA also has the power under the Transportation Act to close any railroad bridges that it may deem unsafe.

The FRA Statement of Agency Policy on the Safety of Railroad Bridges (49 CFR 213, Appendix C) is attached as Appendix A.

COMMON VULNERABILITIES

Critical infrastructures and key assets vary in many characteristics and practices relevant to specifying vulnerabilities. There is no universal list of vulnerabilities that applies to all assets of a particular type within an infrastructure category. Instead, a list of common vulnerabilities has been prepared, based on experience and observation. These vulnerabilities should be interpreted as possible vulnerabilities and not as applying to each and every individual facility or asset.

Following is a list of common vulnerabilities found at railroad bridges:

Exhibit 1 Economic and Institutional Vulnerabilities	
Economic and institutional vulnerabilities are those that would have extensive national, regional, industry-wide consequences if exploited by a terrorist attack.	
1	Loss of critical crossings could delay or disrupt the flow of goods to industrial and commercial establishments, and passengers to desired destinations.
2	A large fraction of aggregate shipment is by rail. While trucks can also move the products, there is probably not enough capacity in the trucking industry to pick up the additional logistical burden caused by a significant disturbance to railroad transportation.
3	Just-in-time inter-modal services, including those bringing foreign goods to plants or to market, could be difficult to maintain if there were no double-stack container services.
4	Rail bridges are vital assets of the Strategic Rail Corridor Network (STRACNET), a 38,800-mile interconnected network of rail corridors. Without such bridges, the deployment of military forces across the U.S. to strategically located ports of embarkation may be impacted.

Exhibit 2 Site-Related Vulnerabilities	
Site-related vulnerabilities are conditions or situations existing at a particular site or facility that could be exploited by a terrorist or terrorist group to do economic, physical, or bodily harm, or to disable or disrupt facility operations or other critical infrastructures.	
Access and Access Control	
1	Public and private roads may be in close proximity to railroad bridge structures or access points.
2	Public roads may pass over railroad bridges (e.g., a dual use bridge with both highway and rail structures).
3	Railroad bridges may not have perimeter fencing to limit access. Industry and population centers may have grown around the areas containing railroad bridges, thus complicating access/control issues.
4	Trains carrying hazardous materials pass over railroad bridges.
5	A railroad bridge structure is a long linear feature; therefore, it may be difficult to define and protect.
6	There is no procedure or requirement in place to ensure 100% of all rail cars/trains that will eventually travel over a railroad bridge will be inspected.
7	Waterways may provide access to areas underneath railroad bridges.
8	Approach structures (piers) may be accessible to water, foot, and vehicular traffic.
9	Railroad bridges may not have full-time security guard forces at the lower alert levels.
10	Signs may not be posted to deter vehicles, boats, or pedestrians from entering the structure or accessing critical components of a railroad bridge.
11	Video surveillance may not be in place on railroad bridge structures.
12	Lighting of critical railroad bridge components may not be adequate.
13	Vegetation may provide cover for surveillance of a railroad bridge by potential adversaries.
14	Bridges may be vulnerable to attack from the air.
15	Due to the size and operation of railroad bridges, countermeasures (e.g., shielding) may not be practical to install.
Operational Security	
16	Technical, operational, and architectural specifications may be publicly available.
17	Timetables, train movements, and train contents are readily available, and passenger trains generally keep regular, repetitive schedules.
18	Local operating procedures, train operations, and maintenance activities, which by necessity are conducted in the open, may be learned through surveillance.
	Continued on next page.

19	Railroad communications may be unencrypted and, frequencies may be able to be scanned by adversaries to determine operating conditions, location of employees, on-going activities, etc.
20	Websites may provide detailed information on live train operations/train cams, critical assets, maps, and other operational data.
21	Access to private industry security information may be shared by various agencies (CIP Act of 2002).
22	Locomotive engineers are required to be certified by the FRA, however, limited background checks may be conducted on other railroad employees and contractor personnel. Some states or union contracts may limit the use of background investigations.
Bridge Control (Swing and Vertical Lift)	
23	Movement mechanisms (gears, hydraulics, moving parts) on railroad bridges may be vulnerable to attack.
24	Control mechanisms on railroad bridges may be vulnerable to attack.
25	There may not be a back-up control center for train operations, including those that pass over railroad bridges.
26	Loss of a critical bridge component (e.g., tension member) could result in the loss of an entire bridge span, rendering the bridge unusable for an indeterminate time period.
Hazardous Materials and Toxic Chemicals	
27	Railroads transport millions of tons of hazardous materials and toxic chemicals across railroad bridges every year.
28	HAZMAT and chemical rail cars crossing railroad bridges are easily identified from the required hazard diamond markings.
Emergency Planning and Preparedness	
29	Coordination with local, state, and federal agencies on roles/responsibilities for incidents occurring on a railroad bridge may not be exercised on a routine basis. Railroad bridges may span several jurisdictions (e.g., emergency response jurisdictions and even states).
30	Interoperability of communications systems (LEA, EMT, NGB, FEMA, HAZMAT Response) may be limited.
31	Nontraditional fires/explosions at railroad bridges may cause additional challenges to first responders.
32	Railroads have had much experience with bridge repair and construction, however, contingency plans to reroute trains around a disabled railroad bridge may vary depending on the specific location and condition of the bridge.
33	Bridge repair time may depend on the waterway involved, in that critical water traffic may impact the timely reconstruction of the bridge.
34	Specialized equipment needed to remove locomotives, rail cars, and bridge debris from the waterway may not be immediately available and railroad bridge repair time may be extended.

Exhibit 3 Interdependent Vulnerabilities	
Interdependency is the relationship between two or more infrastructures by which the condition or functionality of each infrastructure is affected by the condition or functionality of each other. Interdependencies can be physical, geographic, logical, or information-based.	
General	
1	Rail lines crossing a railroad bridge may carry traffic of railroads other than that of the owner/operator of the bridge.
2	Railroad bridges may be co-located with or intersect public highways (see Figures 1 and 2).
3	Mixed train traffic may use the same bridge, with freight traffic traveling on the same or adjacent tracks with passenger traffic.
4	Railroad bridges may be owned by a non-railroad company.
5	Industrial product and raw material transportation relies on railroad bridges.
6	Strategic Rail Corridor Network (STRACNET) [Sensitive Military Shipments] relies on railroad bridges.
Natural Gas	
7	Railroad bridges may be co-located with natural gas pipelines.
Water	
8	Railroad bridges may be co-located water pipelines.
9	Bridges may traverse waterways that are drinking water sources or environmentally protected.
Electric Power	
10	Bridges may be co-located with electric power lines.
11	Electric power is necessary to operate bridge functions (e.g., monitoring and movement).
Telecommunication	
12	Railroad bridges may be co-located with fiber-optics or telephone landlines.
13	Telecommunications (e.g., telephone, radio, dispatch center signals) to ensure coordinated bridge operation (e.g., opening and closing or control lights for train traffic) may be based on remote train routing/timetables.
14	Telecommunication systems are necessary for emergency response to a railroad bridge incident.

OTHER INFORMATION

Recent History of the U.S. Railroad System

Until the end of World War II, the majority of inter-city passenger and freight transportation was provided by railroads. Freight service was offered on a competitive basis under Interstate Commerce Commission (ICC) regulation of rates and conditions. While there were many individual railroads, they were interconnected and, through extensive inter-company activities, their equipment was interoperable. More than half of all shipments moved on more than one railroad. This interchange created a national system with much competition between the companies to originate loads. In addition, each railroad was franchised to provide specific passenger service over that railroad. However, interchange was not practiced with respect to passenger service. Therefore, rail passengers had to move from one railroad to another for longer trips that could not be completed on the tracks owned by one company.

The completion of the interstate highway system increased the trucking industry's ability to provide effective long-distance service. Simultaneously, the railroads lost increasing amounts of passenger service to air travel. As a result, the railroad industry faced very serious economic challenges. To respond to these problems, two Congressional actions were taken. One transferred all inter-city rail passenger service to the National Railroad Passenger Corporation (AMTRAK); the other provided freight railroads with partial freedom from economic regulation. At about the same time, an enhanced research program sponsored by the industry began to provide a comprehensive scientific basis for the technical decisions made by the industry. The combination of these three circumstances made it possible for the railroads to adjust rates, reduce costs, and improve the effectiveness of their service. At the present time, the railroad system in the U.S. is financially healthy. It earns profits and pays taxes. Its track structure is in the best condition ever. It is competing effectively for many commodities and services.

While there is a national network of passenger services operated by AMTRAK over the freight railroad lines and in the Northeast Corridor, AMTRAK only moves about one percent of inter-city passengers. In the Northeast Corridor, however, AMTRAK does provide about 40 percent of business passenger travel in the corridor between Washington, D.C., and Boston. Interruption of that service and its replacement by air travel could present problems, because the air corridor is already overcrowded. Commuter passenger service is provided on freight railroad lines in many cities, particularly New York, Chicago, the metropolitan area of Washington, D.C., and Boston. Interruption of rail commuter service would require transfer of those passengers to other rail services and the highways, which are already congested. Light and heavy rail services are provided in metropolitan areas served by subways or other rail services operated by mass transit operators. Interference with these rail services would require moving their passengers to the congested highway networks and would create local transportation problems.

The freight rail transportation system consists of private corporations that own, build, and maintain the rail infrastructure (including bridges); the related supply and support industries; the government agencies that regulate rail transportation; and the public and quasi-private institutions that operate passenger service on the rail network that is now operated primarily for freight movement.

In the U.S., 9 Class I railroads have an annual revenue of more than $260 million each and operate over an interconnected network of about 123,000 miles of track. In total, they operate about 18,000 locomotives and pull about 1,200,000 freight cars of various characteristics. They transport about 40 percent of the ton-miles of freight moved in the U.S. – primarily bulk commodities, trailers, and containers. In addition, 32 Class II (regional) railroads each have an annual revenue of between $20 million and $260 million and operate over a minimum 350 miles of track. There are 487 short-line railroads as well. Each one has an annual revenue of less than $20 million and operates less than 350 miles of track. Each railroad originates or delivers some traffic, and therefore, is not just a switching railroad.

All track owned and operated by the three railroad classes is built and maintained to a standard gauge and to dimensional standards of gauge and cross-level in accordance with FRA regulations. Cars operated in interchange in the railroad system must be manufactured to Association of American Railroads (AAR) specifications. They must have an assigned car number, which is stored by the AAR along with the characteristics of the car.

To facilitate the aspects of the railroad industry dependent on very close working relationships, industry companies established a number of joint bodies. In the 1930s, these bodies were consolidated into the AAR. The AAR board consists of the CEOs of Class I railroads. Its committees address those elements of the industry that require joint oversight such as interchange agreements; other agreements essential to smooth operation of the interconnected transportation service; equipment specifications for the industry; pre-competitive research supporting the industry’s safety and efficiency objectives; joint legal and economic concerns; and activities where the joint processing of data offers mutual advantage without compromising the independent competitive posture of each company.

The rail system is unique in that every train movement on the system is tightly controlled. No train can enter the system from a switching yard or a siding without an “authority.” This authority can be granted by a written or radioed train order, a telephone, or by turning the red signal that blocks the train from entering the system to green. The locomotive engineer acknowledges the “authority” by voice radio.

The largest railroads have established centralized centers that assure all trains in the system operate efficiently. The dispatching center and the related customer service center receive orders for transportation, assign cars, establish the basis for assembling them into trains, allocate sufficient locomotive power to each train to assure its operation at scheduled speeds, assign crews to the train, and authorize the train to enter the railroad system.

When the train enters the system, it moves along the track in accordance with written instructions and under the control of signs and signals along the track. If there is maintenance work or a problem that has weakened the track, a “slow order” may be issued. Most of the traffic now moves in sections of track divided into blocks. These blocks are spaced according to the stopping distance of the longest and heaviest train. If the train has a green signal, it can operate at the maximum speed authorized for that equipment on that track section. If the train enters a block with a yellow signal, the next block is open, but the succeeding block is occupied. If the signal is green, the next two blocks are open.

The signals are also affected by a break in the rail. The signals in a block constitute a circuit with a low-voltage current in the rail that is shorted at the beginning and end of a block. If the block is shorted by a train, the signal is red. If there is a break in the rail, the signal is also red. If there is a failure of current, the signal system is fail-safe and turns to red through action vital relays. This system provides the railroad engineers with solid knowledge about the railroad conditions and has led to very safe operations.

A new system – Positive Train Separation (PTS) – is currently being studied to increase the efficiency of railroad operations. Since the block operating system is based on the train that is hardest to stop, and most trains can stop in a shorter distance, there is some loss of track capacity. It would be advantageous to have trains spaced only by the stopping distance of the following train. That requires the following train to have a positive indication of the leading train's actions. With the PTS, onboard computers calculate a train's stopping distance, based on the characteristics of the train's cars. Onboard communication systems establish the position of both the preceding and following trains. The engineer is advised, or an automatic system comes into play, when the distance between the trains is at the stopping distance of the following train.

As stated before, the trains are dispatched and kept on the right track by a dispatcher's action. The dispatching center and the crew-calling center assure that crews with permitted hours of service are available to operate trains when the trains must operate. In modern dispatching centers, every train's position is known. One can imagine the center's size for a railroad that has 15,000 miles of track with hundreds of trains on the line or in switchyards or sidings!

In summary, the dispatching center sends commands to operate signals to authorize a train to enter the system. The train then comes under the control of the automatic block system. The dispatching center aligns switches remotely to move the train on the correct route. It allows for efficient use of a single-track line with trains moving in opposite directions by putting trains in sidings in a timely fashion to allow for opposing traffic movement on the main line. Then, by turning a red signal to green, it allows the train in the siding to re-enter the main line when it is safe to do so.

The cargo is loaded into cars, and the cars are made up into trains going generally in the same direction but not to the same destination. As a result, the railroads must stop and disassemble trains, and then assign cars to a new train going either in the direction of their final destination or to that destination itself. Switching is often done in a "hump yard." The train is pushed to the "hump," the cars are disconnected at the hump, and roll by gravity to switching points. There they are directed to the track on which a train is being assembled that is going either in their direction or to their final destination. It is essential to keep accurate records on the destination of the cars and on the location of the car in the train to facilitate this "humping" activity. Since interchange began, each car was required to have a number that could be recorded. The cars in the train and their numbers in sequence made up the "consist." Now, the car also has a machine-readable "label." As the car passes a scanner, the scanner automatically prints out a consist list that is accurate, provided that the label is on the car and readable. If it is absent, a photograph can be taken of the car to record the number. The number can then be read on a video screen and used to establish the true consist.

Physical security of U.S. railroads is provided through in-house police forces. These forces include about 2,800 officers. They are commissioned in the state of their primary employment and are trained and licensed in the same manner as the other state-certified peace officers. The FRA published a final rule in February 1994, authorizing a railroad employee who is commissioned as a railroad police officer by any state to enforce the laws of all states in which the officer's employer owns property. The railroad police maintain a working relationship with other law enforcement agencies, including the Federal Bureau of Investigation, Drug Enforcement Administration, and INTERPOL**.**

USEFUL REFERENCE MATERIALS

1. How Stuff Works (http://www.howstuffworks.com/).

2. *Basic Characteristics of Freight Rail Transportation in the United States, 1997*, Report of the President's Commission on Critical Infrastructure Protection.

3. Association of American Railroads, *Terrorism Risk Analysis and Security Management Plan, Limited Version*, Feb. 1, 2002.

4. Association of American Railroads, *Railroad Facts*, 2002 Edition.

5. Structurae (http://www.structurae.de/).

6. *FRA Track Compliance Manual*, Chapter 7 (http://www.fra.dot.gov/pdf/safety/track_compliance_manual/TCM%207.PDF).

APPENDIX A

The FRA Statement of Agency Policy on the Safety of Railroad Bridges (49 CFR 213, Appendix C)

Guidelines

1. Responsibility for Safety of Railroad Bridges

(a) Track owner. The owner of the track on a bridge, or another person assuming responsibility for the compliance of that track with this Part under provisions of Sec. 213.5, is responsible for ensuring that the bridge is capable of safely carrying all railroad traffic operated on that track, and for specifying the maximum loads that may be operated over the bridge.

(b) Divided ownership. Where the owner of the track on a bridge does not own the bridge, the track owner should ensure that the bridge owner is following a program that will maintain the integrity of the bridge. The track owner either should participate in the inspection of the bridge, or should obtain and review reports of inspections performed by the bridge owner. The track owner should maintain current information regarding loads that may be operated over the bridge, either from its own engineering evaluations or as provided by a competent engineer representing the bridge owner. Information on permissible loads may be communicated by the bridge owner either in terms of specific car and locomotive configurations and weights, or as values representing a standard railroad bridge rating reference system. The most common standard bridge rating reference system incorporated in the “Manual for Railway Engineering” of the American Railway Engineering and Maintenance-of-Way Association is the dimensional and proportional load configuration devised by Theodore Cooper. Other reference systems may be used where convenient provided their effects could be defined in terms of shear, bending, and pier reactions as necessary for a comprehensive evaluation and statement of the capacity of a bridge.

(c) Other railroads. The owner of the track on a bridge should advise other railroads operating on that track of the maximum loads permitted on the bridge stated in terms of car and locomotive configurations and weights. No railroad should operate a load that exceeds those limits without specific authority from, and in accordance with restrictions placed by, the track owner.

2. Capacity of Railroad Bridges

(a) Determination. The safe capacity of bridges should be determined by competent engineers using accepted principles of structural design and analysis.

(b) Analysis. Proper analysis of a bridge means knowledge of the actual dimensions, materials, and properties of the structural members of the bridge, their condition, and the stresses imposed in those members by the service loads.

(c) Rating. The factors that were used for the design of a bridge can generally be used to determine and rate the load capacity of a bridge provided:

(i) The condition of the bridge has not changed significantly, and

(ii) The stresses resulting from the service loads can be correlated to the stresses for which the bridge was designed or rated.

3. Railroad Bridge Loads

(a) Control of loads. The operating instructions for each railroad operating over bridges should include provisions to restrict the movement of cars and locomotives whose weight or configuration exceed the nominal capacity of the bridges.

(b) Authority for exceptions. Equipment exceeding the nominal weight restriction on a bridge should be operated only under conditions determined by a competent engineer who has properly analyzed the stresses resulting from the proposed loads.

(c) Operating conditions. Operating conditions for exceptional loads may include speed restrictions, restriction of traffic from adjacent multiple tracks, and weight limitations on adjacent cars in the same train.

4. Railroad Bridge Records

(a) The organization responsible for the safety of a bridge should keep design, construction, maintenance, and repair records readily accessible to permit the determination of safe loads. Having design or rating drawings and calculations that conform to the actual structure greatly simplifies the process of making accurate determinations of safe bridge loads.

(b) Organizations acquiring railroad property should obtain original or usable copies of all bridge records and drawings, and protect or maintain knowledge of the location of the original records.

5. Specifications for Design and Rating of Railroad Bridges

(a) The recommended specifications for the design and rating of bridges are those found in the "Manual for Railway Engineering" published by the American Railway Engineering and Maintenance-of-Way Association. These specifications incorporate recognized principles of structural design and analysis to provide for the safe and economic utilization of railroad bridges during their expected useful lives. These specifications are continually reviewed and revised by committees of competent engineers. Other specifications for design and rating, however, have been successfully used by some railroads and may continue to be suitable.

(b) A bridge can be rated for capacity according to current specifications, regardless of the specification to which it was originally designed.

6. Periodic Inspections of Railroad Bridges

(a) Periodic bridge inspections by competent inspectors are necessary to determine whether a structure conforms to its design or rating condition and, if not, the degree of nonconformity.

(b) The prevailing practice throughout the railroad industry is to inspect railroad bridges at least annually. Inspections at more frequent intervals may be indicated by the nature or condition of a structure or intensive traffic levels.

7. Underwater Inspections of Railroad Bridges

(a) Inspections of bridges should include measuring and recording the condition of substructure support at locations subject to erosion from moving water.

(b) Stream beds often are not visible to the inspector. Indirect measurements by sounding, probing, or any other appropriate means are necessary in those cases. A series of records of those readings will provide the best information in the event unexpected changes suddenly occur. Where such indirect measurements do not provide the necessary assurance of foundation integrity, diving inspections should be performed as prescribed by a competent engineer.

8. Seismic Considerations

(a) Owners of bridges should be aware of the risks posed by earthquakes in the areas in which their bridges are located. Precautions should be taken to protect the safety of trains and the public following an earthquake.

(b) Contingency plans for seismic events should be prepared in advance, taking into account the potential for seismic activity in an area.

(c) The predicted attenuation of ground motion varies considerably within the United States. Local ground motion attenuation values and the magnitude of an earthquake both influence the extent of the area affected by an earthquake. Regions with low frequency of seismic events produce less data from which to predict attenuation factors. That uncertainty should be considered when designating the area in which precautions should be taken following the first notice of an earthquake. In fact, earthquakes in such regions might propagate their effects over much wider areas than earthquakes of the same magnitude occurring in regions with frequent seismic activity.

9. Special Inspections of Railroad Bridges

(a) A special bridge inspection should be performed after an occurrence that might have reduced the capacity of the bridge, such as a flood, an earthquake, a derailment, or an unusual impact.

(b) When a railroad's managers learn that a bridge might have suffered damage through an unusual occurrence, they should restrict train operations over the bridge until the bridge is inspected and evaluated.

10. Railroad Bridge Inspection Records

(a) Bridge inspections should be recorded. Records should identify the structure inspected, the date of the inspection, the name of the inspector, the components inspected, and their condition.

(b) Information from bridge inspection reports should be incorporated into a bridge management program to ensure that exceptions on the reports are corrected or accounted for. A series of inspection reports prepared over time should be maintained so as to provide a valuable record of trends and rates of degradation of bridge components. The reports should be structured to promote comprehensive inspections and effective communication between an inspector and an engineer who performs an analysis of a bridge.

(c) An inspection report should be comprehensible to a competent person without interpretation by the reporting inspector.

11. Railroad Bridge Inspectors and Engineers

(a) Bridge inspections should be performed by technicians whose training and experience enable them to detect and record indications of distress on a bridge. Inspectors should provide accurate measurements and other information about the condition of the bridge in enough detail so that an engineer can make a proper evaluation of the safety of the bridge.

(b) Accurate information about the condition of a bridge should be evaluated by an engineer who is competent to determine the capacity of the bridge. The inspector and the evaluator often are not the same individual. The quality of the bridge evaluation depends on the quality of the communication between them.

12. Scheduling Inspections

(a) A bridge management program should include a means to ensure that each bridge under the program is inspected at the frequency prescribed for that bridge by a competent engineer.

(b) Bridge inspections should be scheduled from an accurate bridge inventory list that includes the due date of the next inspection.

13. Special Considerations for Railroad Bridges

Railroad bridges differ from other types of bridges in the types of loads they carry, in their modes of failure and indications of distress, and in their construction details and components. Proper inspection and analysis of railroad bridges require familiarity with the loads, details, and indications of distress that are unique to this class of structure. Particular care should be taken that modifications to railroad bridges, including retrofits for protection against the effects of earthquakes, are suitable for the structure to which they are to be applied. Modifications should not adversely affect the serviceability of the bridge or its accessibility for periodic or special inspection.