Chapter 11

Federal Bridge Program/Status of the Nation's Bridges

Overview and Evolution of the Bridge Programs

For the last 30 years, bridges located on public roads, which are in excess of 6 meters in total length have received periodic, biennial inspections to ensure safety to the traveling public. Inspections are guided by federally defined minimum data collection requirements. Every year bridge information is submitted from the States to the Federal Highway Administration (FHWA). Information collected and maintained by FHWA forms the basis for determining the condition of the Nation's bridges and for the apportionment of bridge replacement and rehabilitation funds to the States. Since initiation of the legislation guiding the development of the National Bridge Inspection Standards (NBIS) and associated funding programs, over $55 billion in Highway Bridge Replacement and Rehabilitation Program (HBRRP) funding has been allocated and used to improve the condition of the Nation's bridges. Other sources of funding from Federal and State programs are also used for bridge activities.

Bridges are critical elements within the highway transportation network. Deterioration of structures must be periodically mitigated through proactive interventions to ensure the safety of the traveling public, ensure connectivity of the network, and retain the significant intrinsic asset value of the bridge stock. These preservative actions cost significantly more than highway pavement activity on a unit cost basis. In addition, bridges may become functionally obsolete due to changing traffic demands. Actions must be taken to avoid adverse economic impacts to the traveling public, which may result due to this functional obsolescence of the structure.

Programs have been developed and legislated to ensure bridge safety and provide funding for rehabilitation, improvement, and replacement of the structure. These programs are summarized in this section. The information collected through the bridge inspection process, which represents the most comprehensive source of bridge condition and composition data at the national level, is summarized to give a background for the in-depth examination presented in the remaining portions of the chapter.

Initiation and Evolution of the Bridge Programs:

On December 15, 1967, the Silver Bridge carrying US 35 between Point Pleasant, West Virginia and Gallipolis (Kanauga), Ohio collapsed during rush-hour traffic. Thirty-one vehicles fell into the Ohio River or onto the Ohio shore killing 46 people and injuring 9. The collapse, which was the first major failure of a structure since the wind-induced failure of the Tacoma Narrows Bridge in 1940, prompted national concern about bridge conditions and safety.

Congressional hearings on the failure resulted in mandates requiring the U.S. Secretary of Transportation to develop and implement the National Bridge Inspection Standards (NBIS). The NBIS, developed by FHWA in cooperation with the American Association of State Highway and Transportation Officials (AASHTO), was enacted as part of the Federal-Aid Highway Act of 1971. This landmark legislation was enacted on April 27, 1971 and established, for the first time in U.S. history, uniform, national standards for bridge inspection and safety evaluation. The Act also designated funding for the replacement of deficient bridges on the Federal-aid highway system. Through the legislation:

- All States are required to perform periodic inspection of bridges in excess of 6.1 meters (20 feet) located on Federal-aid highway systems.
- Bridge inspection data collection requirements were established.
- Qualifications for key bridge inspection personnel were defined.
- Training programs for bridge inspectors were developed and implemented.

- The Special Bridge Replacement Program (SBRP) was established to provide funding for the replacement of bridges located on the Federal-aid system.

Since its enactment, the NBIS has been fine-tuned, additional inspection requirements have been added, and funding programs have been updated. It quickly became evident that safety assurance was required for all structures located on public roadways. The requirement to inventory and inspect bridges on Federal-aid highways was extended to all bridges in excess of 6.1 meters (20 feet) located on public roads. Data collection requirements were enhanced, and training programs continued to be developed and expanded as more knowledge became available through research and experience. Funding programs were expanded to permit the use of Federal funds for replacement of both Federal-aid and non-Federal-aid bridges.

Despite efforts to continually enhance the process of bridge inspection, unforeseen events periodically necessitated expansion. On Interstate 95, the primary highway on the Atlantic seaboard that provides connectivity between Florida and Maine, approximately 30 miles east of New York City, near Greenwich, Connecticut. On June 28, 1983, a section of the Mianus River Bridge catastrophically failed due to instantaneous fracture of a pin and hanger detail. This failure resulted in several fatalities and disrupted commerce in the Northeastern U.S. for several months. Following this event, significant research into fatigue of steel connections was performed and tremendous insight into the behavior of steel connections was obtained. The program was enhanced to incorporate more rigorous inspection procedures for fracture critical structures. Training programs were developed putting the research results and accumulated experience and understanding of fatigue and fracture into practice.

On April 5th, 1987, disaster struck again with the collapse of a bridge carrying the New York State Thruway (Interstate 90) across the Schoharie River. With rising water levels due to localized flooding, the soil around the pier was simply washed away. This was followed by the subsequent loss of bearing capacity for the foundation of the center pier, which lead to the catastrophe. Several fatalities resulted from this failure. Other notable scour-induced failures have occurred throughout the country, including the collapse of the Hatchie River Bridge in Tennessee on April 1, 1989. These bridges indicated the potential problem, given that a more than 80 percent of the bridges on public roads cross over waterways. With approximately 475,000 structures crossing waterways, program enhancement was required. FHWA acted quickly by providing guidance for scour assessment and requiring periodic underwater inspection of all structures at risk and susceptible to scour damage.

The combination of research, experience, and technology transfer of knowledge acquired has been used to train professionals performing inspections of fatigue and scour susceptible structures. Catastrophic failures, such as the Mianus River and the Schoharie Creek bridges, due to scour and fatigue have been avoided. Additional knowledge is required on these and other extreme events, such as earthquakes and collisions, to avoid such calamities in the future. Research efforts performed by FHWA and the transfer of results to experienced engineers practicing in the field continue to proactively mitigate potential failures.

Catastrophic events highlighted the need to replace bridges before they collapse. The Special Bridge Replacement Program (SBRP), created by the Federal-Aid Highway Act of 1971, which provided funds to help States replace bridges, required expansion to permit rehabilitative activities. Again, action was taken and, in 1978, the Surface Transportation Assistance Act of 1978 replaced the SBRP with the Highway Bridge Replacement and Rehabilitation Program (HBRRP).

The program initiated through the Federal Aid Highway Act of 1971 has been incrementally enhanced so that today all structures in excess of 6.1 meters (20 feet) on public roads receive, in general, biennial safety inspections. Notable changes in legislation can be seen in Exhibit 11-1. "Best-practices" for routine, fracture critical, and underwater inspections have been defined and published. Qualifications of inspection personnel have been established, and training programs implemented to ensure completeness of engineering reviews and consistency of inspection condition assessments.

Exhibit 11-1

Summary of Major Bridge Inspection and Bridge Program Funding Legislation and Noteworthy Changes

ACT AND DATE	REQUIREMENTS
Federal-Aid Highway Act of 1970 (P.L. 91-605)	- Inventory requirement for all bridges on the Federal-aid systems - Established minimum data collection requirements - Established minimum qualifications and inspector training programs - Established Special Bridge Replacement Program
Surface Transportation Assistance Act of 1978 (P.L. 95-599)	- Established Highway Bridge Rehabilitation and Replacement Program (extending funding to rehabilitation) to replace Special Bridge Replacement Program - Extended inventory requirement to all bridges on public roads in excess of 6.1 m - Provided $4.2 billion for the HBRRP, over 4 years
Highway Improvement Act of 1982	- Provided $7.1 billion for the HBRRP over 4 years
Surface Transportation and Uniform Relocation Assistance Act of 1987	- Provided $8.2 billion for the HBRRP over 5 years. - Added requirements for underwater inspections and fracture critical inspections - Allowed increased inspection intervals for certain types of bridges
Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA - 1991)	- Provided $16.1 billion for the HBRRP over 6 years - Mandated State implementation of bridge management systems
National Highway System Designation Act of 1995	- Repealed mandate for management system implementation
Transportation Equity Act for the 21st Century (TEA-21, 1998)	- Provided $20.4 billion in HBRRP funding over 6 years

Information Collected Through the Bridge Inspection Program

As part of the National Bridge Inspection Standards (NBIS), qualifications of key personnel have been identified, training programs developed and offered to bridge owning agencies, assistance with bridge program development provided, and minimum data collection requirements defined. The information that is obtained through the process defined by the NBIS is discussed below. This information forms the basis for the subsequent examinations of the conditions and performance information presented later in the chapter.

For most structures, the NBIS requires visual inspection once every two years. For structures with safety concerns, inspections may be performed more frequently. Likewise, for structures with special favorable characteristics, the period of observation may be increased. The bridge owners (States, cities, municipalities, etc.) are responsible for these inspections with oversight by the State Department of Transportation (DOT). Information is collected on the bridge composition and conditions and reported to FHWA where the data is maintained in the National Bridge Inventory (NBI) database. This information forms the basis of the bridge safety assurance efforts and provides the mechanism for the determination of fund requirements and fund apportionments. The FHWA provides oversight of the States compliance with the requirements of the NBIS.

Q. **Are there many bridges that receive inspections more or less frequently that once every two years?**

A. Eighty-two percent of all structures are inspected on the standard NBIS 2 year cycle. Four percent of structures have received an exemption to the 2-year requirement and are inspected every 4 years. The remaining 14 percent of structures are inspected more frequently that the standard 2-year cycle. The majority of these structures are inspected once every year.

The NBI database contains the following types of information: Inventory information characterizing the structure, Condition Ratings, Appraisal Ratings, and Calculated Fields.

Inventory information includes location and description fields, geometric data (lengths, clearances, lane widths), functional descriptions (classification, NHS Designation, service carried and crossed, etc.), and design characteristics (superstructure designs and materials, deck types, design load, etc.). This information permits classification of structures according to serviceability and essentiality for public use. The composition of structures in the network can be ascertained through examination of the inventory data. The NBI database represents the most comprehensive source of information available on the National-level.

Through periodic safety inspections, data is collected on the condition of primary components of the structure. Condition ratings are collected for the following components on the bridge:

- The bridge deck, including the wearing surface.
- The superstructure, including all primary load carrying members and connections.
- The substructure, considering the abutments and all piers.
- Culverts, recorded only for culvert bridges.
- Channel/channel protective systems, for all structures crossing waterways.

The culvert condition rating describes all structural elements of culvert designs, which do not have a distinct deck, superstructure, and substructure. The channel/channel protective system rating describes the physical conditions of slopes and the channel for water flow through the bridge.

Bridge inspectors utilize a ten (10) point system, where code 9 indicates excellent, as-new condition and code 0 indicates a failed condition. Codes 7–9 indicate satisfactory to excellent conditions. Codes 5 and 6 indicate either fair or satisfactory conditions of the components. Codes 4 and less indicate poor, serious, critical conditions, conditions representing imminent failure of the component or failed conditions. The description of the condition rating codes has been illustrated in Exhibit 3-21. Inspectors assess the ratings in a visual fashion based on engineering expertise and experience. Extensive training for inspectors is provided and references are available to guide assignment of the ratings. These ratings form the basis for assessing the structural condition of the bridge.

Functional adequacy is also a concern in the bridge population. Following collection of the inventory information and condition ratings, appraisal ratings are calculated to assess the adequacy of the structure to provide the required service. Appraisal ratings are quantified for:

- Structural evaluations (load carrying capacities).
- Deck geometry (indicating constrictions which affect safety).
- Underclearances (which, if insufficient, results in detours).
- Waterway adequacy (the ability of the opening to handle the flow-rates).

A bridge may be structurally deficient and/or functionally obsolete. These determinations are assessed based on the condition and appraisal ratings. Structural deficiencies result from poor condition ratings or from low load ratings. Functional obsolescence results from low appraisal ratings or from low design-load capacities. Inadequate waterway adequacy can be a contributing factor for either structural deficiencies or functional obsolescence.

Composition and Status of Bridge System

Composition:

In describing the characteristics of the current highway system, the following information was summarized in Chapter 2:

- Number of Bridges by Owner and the changes in ownership percentages using the 1996, 1998, and 2000 NBI datasets. (Exhibit 2-4)
- Number of Bridges by Functional System for each rural and urban functional classification using the 1996, 1998, and 2000 NBI datasets. (Exhibit 2-10)
- Percentage of Deck Area by Functional Classification for each rural and urban functional classification using the 1996, 1998, and 2000 NBI datasets. (Exhibit 2-11)

This section of the chapter expands on the information presented in Chapter 2. More information is presented for specific ownership, functional classifications, superstructure materials, and designs in the last portion of the chapter.

Information is presented to highlight the details of the bridge inventory composition and to highlight conditions in greater detail. Traditionally, information is often presented by numbers of bridges and every bridge in the inventory is counted equally. Thus, large suspension bridges, such as the Golden Gate or the George Washington Bridge, are considered equivalent to small, two-lane bridges carrying low volumes of traffic. In some cases, insight into the condition or the composition may be obtained by considering the size of the structure and/or the traffic carried. Considerations of size of the structure will be incorporated through presentation of information using the deck area of the bridge. Considerations of the volume of traffic served by the structure will be incorporated through presentation of information using the Average Daily Traffic (ADT).

The NBIS contains nearly 700,000 records, which describe either the features carried by the bridge, termed as "on" records, or the features crossed by the structure, termed as "under" records. Separating the on-records from the under records reveals that there are 586,930 bridges over 6.1 meters (20 feet) in total length located on public roads in the United States. These bridges, on average, carry 3.8 billion vehicles per day and comprise a total deck area in excess of 315 million square meters.

Q. How do the bridge ownership percentages compare with road ownership percentages?

A. The majority of bridges (98 percent) and roadways (97 percent) are owned by State and local agencies. The vast majority of roadways, however, are owned by local agencies (77 percent). Bridge ownership is nearly equally divided between State (47 percent) and local agencies (51 percent).

The majority of structures are owned by State and Local agencies (47 percent and 51 percent of the bridges respectively). Comparing bridge ownership to roadway ownership (20 percent and 77 percent State and local ownership respectively) shows that there is a much higher percentage of State ownership in the bridge network. State and local agencies, when taken together, own 97 percent of the roadways and 98 percent of the bridges by numbers. Considering functional classification, as presented in Exhibits 2-10 and 2-11, the number of rural bridges has remained relatively static, while the number of urban bridges has increased slightly from 1996 to 2000.

This information is elaborated upon in Exhibit 11-2, which presents a cross-tabulation between the functional class and the ownership. It also shows percentages of bridges weighted equally (by numbers), by Average Daily Traffic (ADT) carried, and by deck area.

Exhibit 11-2

Bridges by Ownership and Functional Classification

FUNCTIONAL CLASS	FEDERAL	STATE	LOCAL	PRIVATE	UNKNOWN	TOTAL	% BY NOS	% OF ADT	% OF DECK AREA
Rural Bridges									
Interstate	30	27,417	14	42	0	27,503	4.69%	10.25%	8.38%
Other Arterials	565	71,301	2,501	149	7	74,523	12.71%	10.18%	15.70%
Collectors	1,306	68,559	73,113	249	44	143,271	24.43%	4.76%	13.75%
Local	6,856	27,534	174,973	644	117	210,124	35.83%	1.76%	10.35%
Subtotal Rural	**8,757**	**194,811**	**250,601**	**1,084**	**168**	**455,421**	**77.66%**	**26.95%**	**48.17%**
Urban Bridges									
Interstate	1	27,058	368	354	0	27,781	4.74%	36.18%	19.24%
Other Arterials	50	44,435	17,539	479	96	62,599	10.68%	32.10%	26.27%
Collectors	22	5,000	9,690	145	85	14,942	2.55%	2.38%	2.74%
Local	110	4,675	20,440	368	66	25,659	4.38%	2.39%	3.57%
Subtotal Urban	**183**	**81,168**	**48,037**	**1,346**	**247**	**130,981**	**22.34%**	**73.05%**	**51.83%**
Rural & Urban									
Interstate	31	54,475	382	396	0	55,284	9.43%	46.43%	27.62%
Other Arterials	615	115,736	20,040	628	103	137,122	23.38%	42.28%	41.97%
Collectors	1,328	73,559	82,803	394	129	158,213	26.98%	7.14%	16.49%
Local	6,966	32,209	195,413	1,012	183	235,783	40.21%	4.15%	13.92%
Total	**8,940**	**275,979**	**298,638**	**2,430**	**415**	**586,402**			

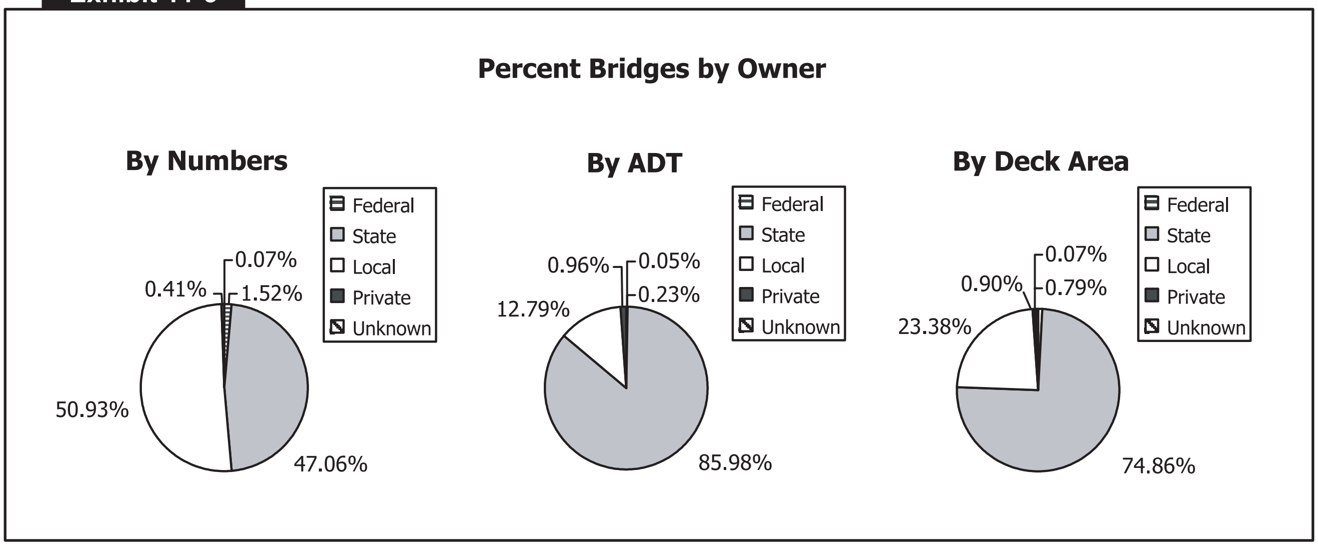
Source: National Bridge Inventory.

** Note that the table does not include structures with unknown functional classifications (528 structures).*

Exhibit 11-2 shows rural bridges make up 77.6 percent of all structures. Urban bridges comprise 22.3 percent of the inventory, carry over 73 percent of the daily traffic, and constitute 51.8 percent of all the deck area. Urban bridges tend to be larger in deck area and carry more traffic. This indicates the magnitude of the disparity between urban and rural structures in terms of traffic and size. A similar trend is found between functional classifications where Interstates and other arterials, which comprise approximately 1/3 of the inventory by numbers, but carry close to 90 percent of all the daily traffic, and have approximately 70 percent of the total deck area.

Exhibit 11-3 shows percentages by owner where the percentages are evaluated in terms of numbers, traffic carried, and deck area. By each measure, State and locally owned bridges dominate the population in terms of percentages. State bridges tend to be larger and carry higher volumes of traffic. State owned bridges are located on higher functional class roadways (Interstates and principal arterials), whereas locally owned structures tend to be located on lower functional class roadways (collectors and local roadways). The number of bridges and traffic carried are shown by functional classification for State-owned bridges in Exhibit 11-4 and for locally owned bridges in Exhibit 11-5.

Exhibit 11-3

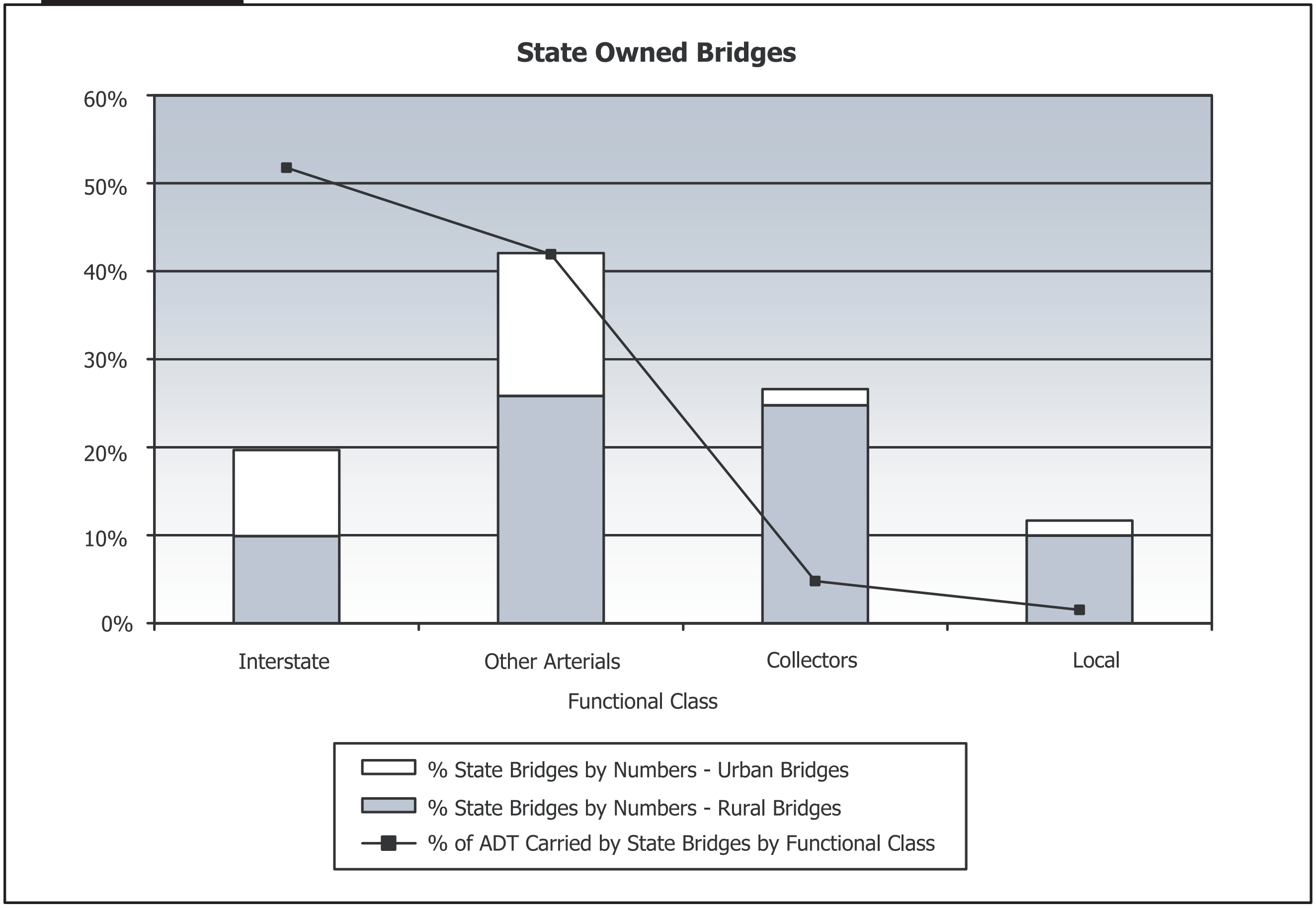


Source: National Bridge Inventory.

Bridges in the inventory are, on average, approximately 40 years old, with an average year of construction of 1963 for rural and urban structures. (See Exhibit 11-6.) The year of construction distribution and the cumulative number of structures and ADT are shown in Exhibit 11-7.

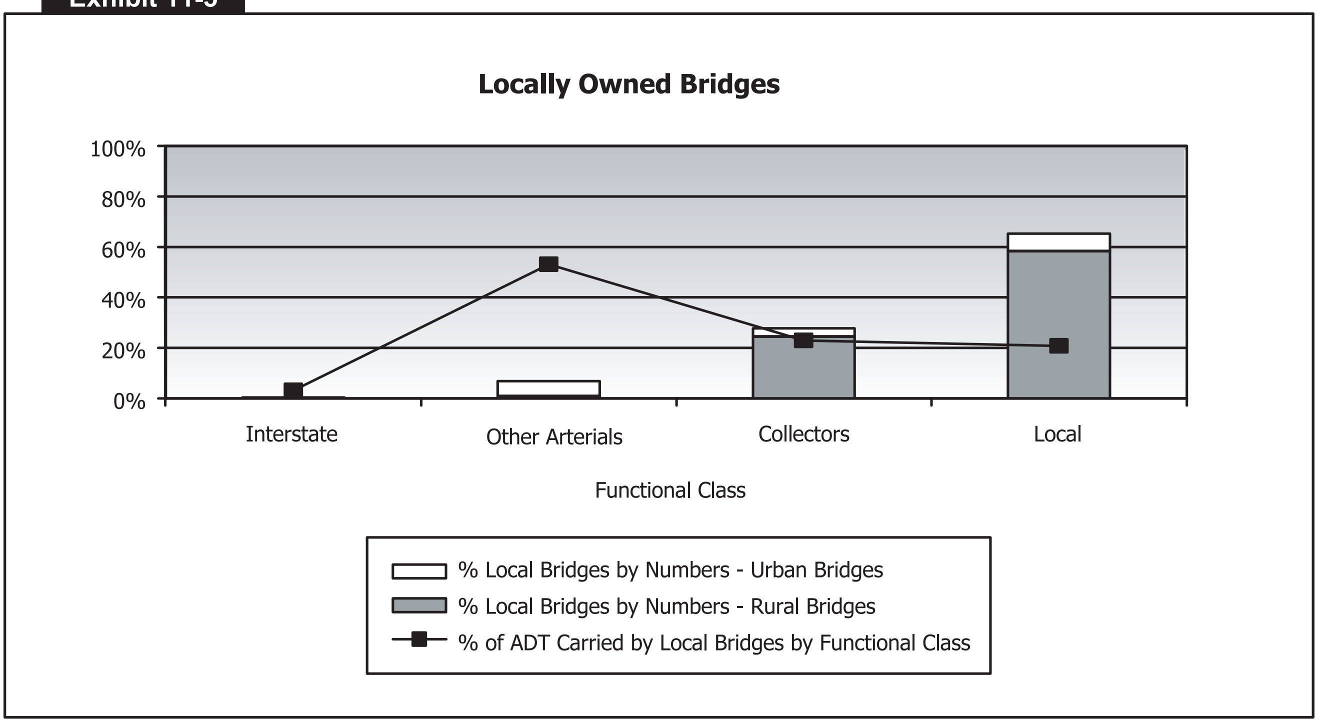
Urban structures are slightly younger than rural structures. The average age of structures does not significantly vary by ownership with the exception of private owners. The private bridge population, which includes those owned by railroads and other private owners, are on average more than 50 years old. Exhibit 11-7 shows the year of construction distribution and the cumulative percentage of bridges and ADT carried. Decreased bridge construction occurred during World War II. Following this period, there was a large increase in the number of bridges constructed. This is generally attributed to the Interstate construction "boom". The chart indicates a large increase in daily traffic on new structures. A large percentage of this traffic nevertheless utilizes older structures on a daily basis, with 50 percent of all the daily traffic in the United States using bridges that are more than 40 years old.

Exhibit 11-4



Source: National Bridge Inventory.

Exhibit 11-5



Source: National Bridge Inventory.

Exhibit 11-6

Average Year of Construction by Functional Classification and Ownership - All Structures

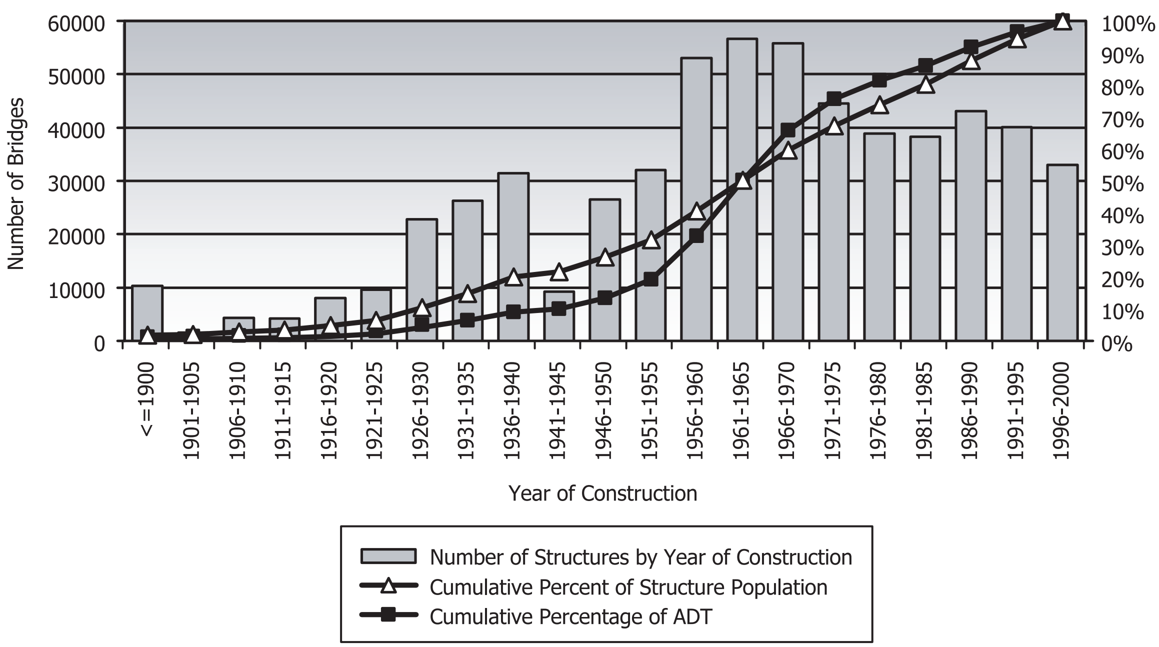
FUNCTIONAL CLASS	FEDERAL		STATE		LOCAL		PRIVATE		AVERAGE	
	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
Rural Bridges										
Interstate	1963	(6)	1967	(10)	1959	(34)	1964	(16)	1967	(10)
Other Arterials	1965	(20)	1961	(22)	1970	(28)	1955	(20)	1961	(23)
Collectors	1963	(18)	1960	(21)	1963	(23)	1946	(27)	1962	(22)
Local	1965	(19)	1965	(22)	1962	(28)	1941	(31)	1963	(27)
All Rural	**1965**	**(19)**	**1962**	**(21)**	**1962**	**(26)**	**1945**	**(29)**	**1962**	**(24)**
Urban Bridges										
Interstate	1967	(8)	1970	(12)	1963	(15)	1965	(14)	1970	(12)
Other Arterials	1959	(25)	1966	(20)	1963	(25)	1952	(27)	1965	(22)
Collectors	1956	(14)	1965	(22)	1964	(25)	1952	(32)	1964	(24)
Local	1957	(22)	1969	(20)	1965	(25)	1949	(33)	1965	(25)
All Urban	**1958**	**(22)**	**1968**	**(18)**	**1964**	**(25)**	**1955**	**(28)**	**1966**	**(21)**
All Structures	**1965**	**(19)**	**1964**	**(20)**	**1963**	**(26)**	**1951**	**(29)**	**1963**	**(23)**

Source: National Bridge Inventory.

Additional information on the composition of the bridge inventory is presented in the last portion of this chapter.

Exhibit 11-7

Year of Construction and Cumulative ADT - All Structures



Source: National Bridge Inventory.

Deficiencies:

In Chapter 3, an overview of the condition and performance of bridges was presented. The following information was included in that chapter:

- Bridge component condition rating distributions showing the number of bridges by the ratings for the deck, superstructure, and substructure.
- Percentage of deficiencies, in terms of the number of bridges, and the trend of deficiencies using the 1994, 1996, 1998, and 2000 NBI data.
- Numbers and percent structurally deficient and functionally obsolete by owner (Federal, State, local, private, unknown, and all owners).
- Ownership of structurally deficient and functionally obsolete bridges as a percentage of the deficiencies by numbers.
- Rural and urban deficiency trends using the number of deficient bridges from the 1994, 1996, 1998, and 2000 NBI databases.
- Numbers and percent deficiencies, structural and functional, by functional classification and rural/urban status.
- Deficiency trends, in terms of numbers and percentages, for rural and urban Interstates, other arterials, collectors, and local bridges.

Deficiencies in the bridge population occur as the result of structural or functional causes, as previously described. These types of deficiencies are not mutually exclusive and a bridge may be both structurally deficient and functionally obsolete. In general, when deficiency percentages are presented, however, the structures are indicated as structurally deficient, functionally obsolete, or non-deficient. As structural deficiencies may imply safety problems they are considered more critical and thus a bridge that is both structurally deficient and functionally obsolete is only identified as structurally deficient. A portion of the structurally deficient population will also have functional issues that must be addressed. Bridges that are indicated as functionally obsolete do not have structural deficiencies.

Overall, there are 167,566 deficient structures within the highway bridge network representing 28.6 percent of the total inventory of highway bridges. There are 90 million square meters of deck area on deficient bridges carrying over 1 billion vehicles daily. The number of deficient bridges by owner and functional classification are shown in Exhibit 11-8 by rural and urban designations. Percentages shown in this exhibit are the percentages of all structures for the owner/functional class combination, (i.e. - 16 percent of rural Interstate bridges owned by State agencies are deficient). In general, urban bridges have higher deficiency percentages than rural bridges. This is particularly evident when examining the Interstate and arterial structures. There are a significant number of deficient local bridges. Exhibit 11-8 shows the deficiency percentages, in general, are usually lower for the higher functional classification (Interstates and principal arterials). There are higher percentages of deficiencies for bridges on local roads, regardless of the owner.

The percentages of bridges with structural deficiencies, functionally obsolete conditions, and non-deficient designations are indicated in Exhibit 11-9. In general, the total percentage of deficiencies is approximately the same when the percentages are determined by numbers, traffic carried, and deck area; however, when traffic carried and deck area are considered, the impact of functional obsolescence becomes more pronounced.

Percent deficiencies for each functional classification are shown in Exhibit 11-10, including deficiencies with bridges weighted equally (by numbers), bridges weighted by the traffic carried (by ADT) and bridges weighted by the deck area. The data in this exhibit shows that there are no major differences between the

Exhibit 11-8

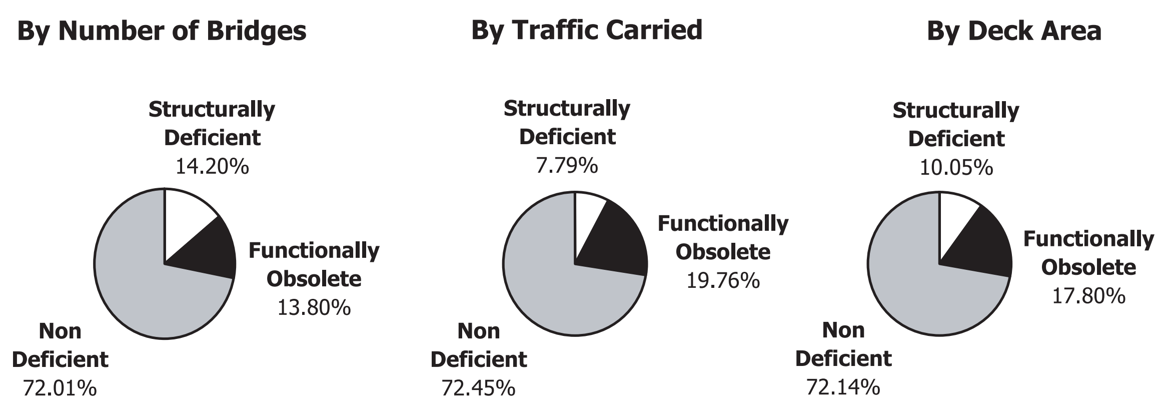
Number and Percent of Deficient Bridges by Ownership and Functional Class

FUNCTIONAL CLASS	NUMBER AND PERCENTAGE OF DEFICIENT STRUCTURES									
	FEDERAL		STATE		LOCAL		PRIVATE		TOTAL	
Rural Bridges										
Interstate	1	3%	4,380	16%	6	43%	6	14%	4,393	16%
Other Arterials	134	24%	12,881	18%	559	22%	56	38%	13,630	18%
Collectors	366	28%	17,337	25%	16,909	23%	128	51%	34,740	24%
Local	1,441	21%	8,691	32%	61,988	35%	418	65%	72,538	35%
Subtotal Rural	**1,942**	**22%**	**43,289**	**22%**	**79,462**	**32%**	**608**	**56%**	**125,301**	**28%**
Urban Bridges										
Interstate	1	100%	7,270	27%	173	47%	58	16%	7,502	27%
Other Arterials	19	38%	14,039	32%	6,343	36%	242	51%	20,643	33%
Collectors	11	50%	2,098	42%	3,363	35%	93	64%	5,565	37%
Local	62	56%	1,905	41%	5,896	29%	214	58%	8,077	31%
Subtotal Urban	**93**	**51%**	**25,373**	**31%**	**15,741**	**33%**	**607**	**45%**	**41,814**	**32%**
Rural & Urban										
Interstate	2	6%	11,650	21%	179	47%	64	16%	11,895	22%
Other Arterials	153	25%	26,920	23%	6,902	34%	298	47%	34,273	25%
Collectors	377	28%	19,435	26%	20,272	24%	221	56%	40,305	25%
Local	1,503	22%	10,596	33%	67,884	35%	632	62%	80,615	34%
All	**2,035**	**23%**	**68,662**	**25%**	**95,203**	**32%**	**1,215**	**50%**	**167,115**	**28%**

Source: National Bridge Inventory.

Exhibit 11-9

Percent Deficient - All Bridges



Source: National Bridge Inventory.

deficiency percentages whether these are based on the total number of bridges, ADT, or area. In general, there are few functionally obsolete bridges, in terms of percentages, in the rural bridge population.

Deficiencies are higher for urban bridges, which in general have a larger percentage of functionally obsolete bridges.

Exhibit 11-10

Percent Deficient Bridges by Numbers, ADT and Deck Area by Rural and Urban Designation and Functional Class

FUNCTIONAL CLASSIFICATION	BY NUMBERS Structurally Deficient	BY NUMBERS Functionally Obsolete	BY NUMBERS Total Deficient	BY ADT Structurally Deficient	BY ADT Functionally Obsolete	BY ADT Total Deficient	BY DECK AREA Structurally Deficient	BY DECK AREA Functionally Obsolete	BY DECK AREA Total Obsolete
Rural Bridges									
Interstate	3.89%	12.08%	15.97%	4.36%	11.57%	15.93%	4.50%	10.52%	15.02%
Other Arterials	7.31%	10.98%	18.30%	7.09%	13.05%	20.13%	8.00%	11.93%	19.93%
Collectors	13.22%	11.04%	24.26%	11.37%	18.61%	29.99%	11.74%	10.94%	22.68%
Local	22.88%	11.66%	34.55%	12.17%	25.97%	38.14%	16.00%	13.00%	28.99%
All Rural	**16.15%**	**11.38%**	**27.53%**	**7.14%**	**14.31%**	**21.45%**	**10.17%**	**11.63%**	**21.81%**
Urban Bridges									
Interstate	6.50%	20.51%	27.00%	7.28%	19.93%	27.21%	8.89%	22.66%	31.55%
Other Arterials	9.59%	23.45%	33.04%	9.66%	23.81%	33.47%	11.35%	22.91%	34.26%
Collectors	12.76%	24.74%	37.49%	11.73%	29.27%	41.00%	13.42%	26.52%	39.94%
Local	13.05%	18.53%	31.58%	9.20%	29.98%	39.18%	10.92%	25.35%	36.26%
All Urban	**9.97%**	**22.01%**	**31.98%**	**8.53%**	**22.27%**	**30.80%**	**10.52%**	**23.18%**	**33.69%**
All Bridges									
Interstate	5.20%	16.32%	21.52%	6.64%	18.08%	24.72%	7.56%	18.98%	26.53%
Other Arterials	8.35%	16.68%	25.03%	9.04%	21.22%	30.26%	10.10%	18.80%	28.90%
Collectors	13.18%	12.33%	25.51%	11.49%	22.17%	33.66%	12.02%	13.53%	25.55%
Local	21.81%	12.41%	34.22%	10.46%	28.28%	38.74%	14.69%	16.17%	30.86%
All Bridges	**14.77%**	**13.76%**	**28.53%**	**8.16%**	**20.12%**	**28.28%**	**10.35%**	**17.61%**	**27.97%**

Source: National Bridge Inventory.

Actions Taken to Remove Deficiencies:

Over $55 billion in HBRRP funding alone has been allocated and utilized to ensure safety and continuing functionality of the bridge network. Actions are taken on deficient bridges to mitigate the cause of the deficiency. The types of work performed were examined using summary information produced by the Federal Highway Administration. The 1998 summary of bridge construction and bridge rehabilitation activity with Federal fund participation through shows:

- Over 50 percent of all activity focuses on replacement of deficient bridges.
- Approximately 40 percent of activity is used for major or minor rehabilitation of deficient bridges.
- The remaining 10 percent of activity is used for new bridge construction.

In 1990, 17 percent of activity with federal fund participation involved new bridge construction. This percentage has decreased from 1990 to 1998. Currently, approximately 90 percent of all projects receiving Federal fund participation involve reconstruction or rehabilitation.

Exhibit 11-11 tabulates the number of deficient bridges reconstructed, as indicated in the NBI database. The information is presented by owner, functional classification, and rural/urban designation. The average number of years after construction before reconstruction was undertaken is also indicated. On average, Interstate bridges are reconstructed approximately 20 years after they are placed in service. The time to reconstruction is longer for other functional classifications. In general, urban bridges are reconstructed earlier, in terms of their age, than rural bridges. Progress has been made in reducing the deficiencies. Approximately 85,000 structures (15 percent of the inventory) have been reconstructed or rehabilitated. Reconstruction and rehabilitation efforts have contributed to the reduction in deficiencies shown and discussed in Chapter 3.

Exhibit 11-11

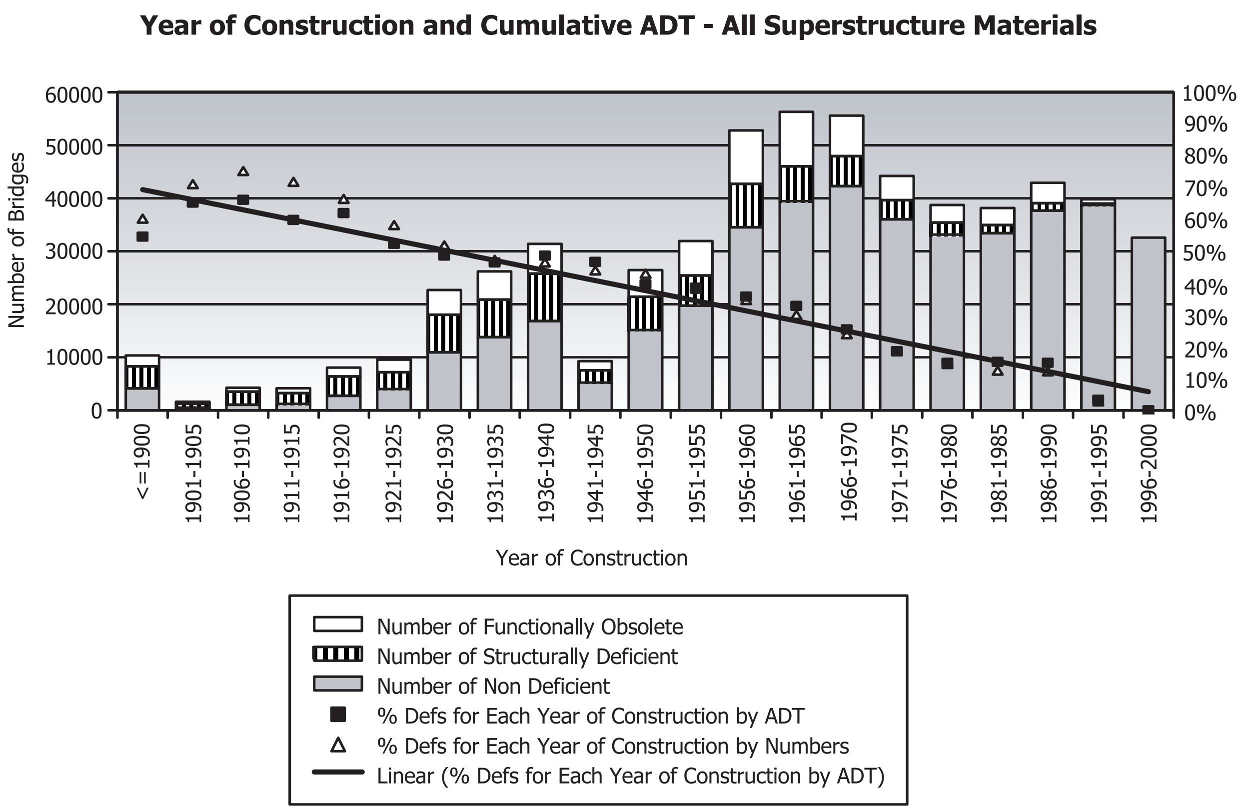
Number of Bridges Reconstructed or Rehabilitated and Average of Years Before the Action was Undertaken

FUNCTIONAL CLASS	NUMBER REHABILITATED BY OWNER (AND AVERAGE YEAR OF REHABILITATION)									
	FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS	
Rural Bridges										
Interstate	1	(25)	6,155	(20)	2	(49)	1	(5)	6,159	(20)
Other Arterials	66	(32)	15,488	(31)	323	(35)	29	(38)	15,906	(32)
Collectors	66	(36)	8,121	(28)	7,302	(41)	34	(25)	15,523	(34)
Local	1,649	(19)	2,246	(32)	18,834	(42)	70	(52)	22,799	(39)
All Rural	**1,782**		**32,010**		**26,461**		**134**		**60,387**	
Urban Bridges										
Interstate	1	(23)	6,648	(23)	57	(21)	46	(22)	6,752	(23)
Other Arterials	11	(41)	9,021	(29)	3,376	(35)	113	(25)	12,521	(31)
Collectors	5	(15)	752	(32)	1,307	(35)	24	(43)	2,088	(35)
Local	47	(29)	460	(26)	2,108	(35)	58	(26)	2,673	(33)
All Urban	**64**		**16,881**		**6,848**		**241**		**24,034**	
All Bridges										
Interstate	2	(24)	12,803	(22)	59	(22)	47	(22)	12,911	(22)
Other Arterials	77	(33)	24,509	(31)	3,699	(35)	142	(28)	28,427	(31)
Collectors	71	(34)	8,873	(29)	8,609	(40)	58	(33)	17,611	(34)
Local	1,696	(19)	2,706	(31)	20,942	(41)	128	(40)	25,472	(38)
All Bridges	**1,846**		**48,891**		**33,309**		**375**		**84,421**	

Source: National Bridge Inventory.

When a structure is placed in service, the deterioration process begins on the components of the bridge. The rate of deterioration was examined by the percentage of deficiencies by year of construction. (See Exhibit 11-12.) As bridges age, increasing numbers of structures become deficient and increasing funds are required to remove the deficiency. This is a concern with the increasing age of the large Interstate population and the relatively short period of time for the average reconstruction effort on Interstate bridges. With this ever-aging, continually deteriorating population of highway structures, increasing traffic demands, and limited budgets, a closer look at transportation system preservation strategies including preventative maintenance and improved bridge inspection and management techniques is warranted.

Exhibit 11-12



Source: National Bridge Inventory.

Specific Bridge Types

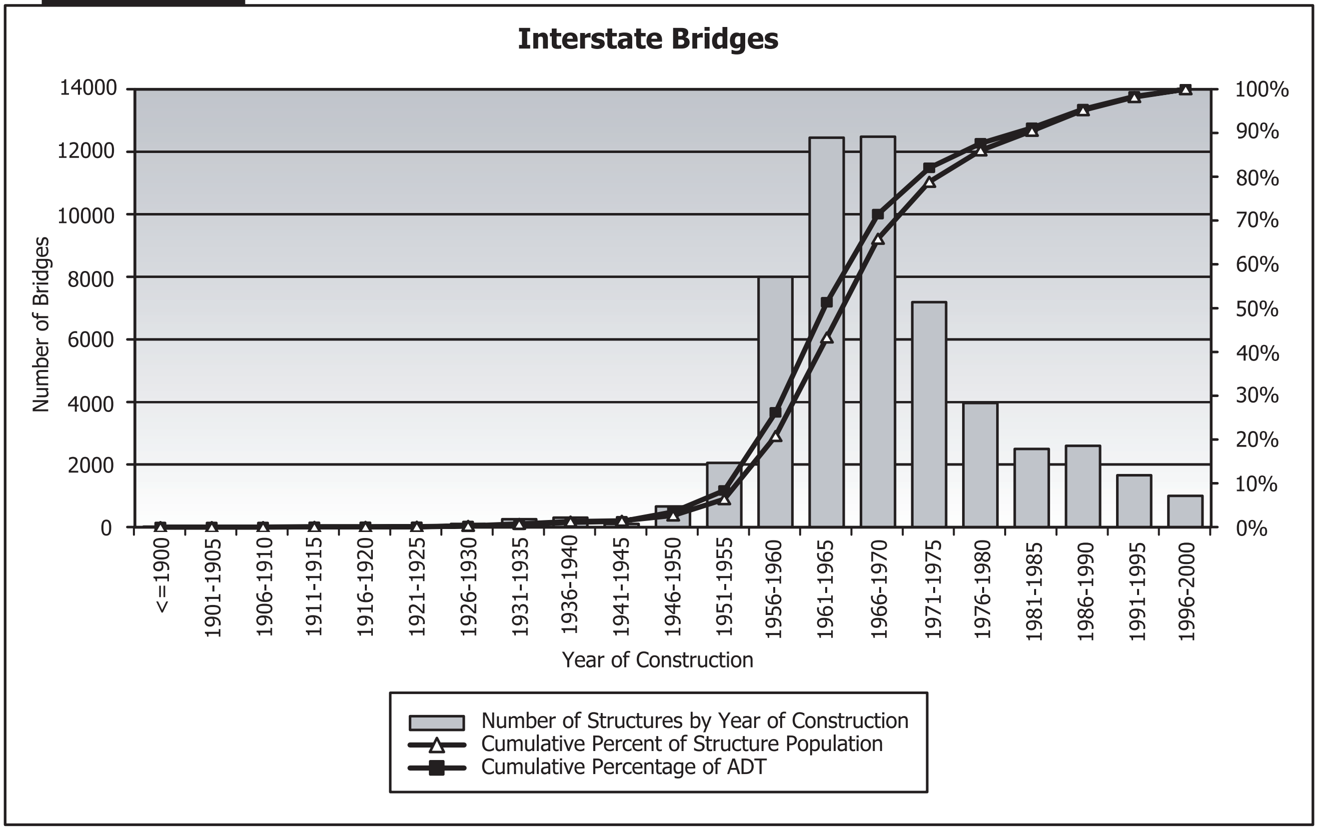
The following areas are addressed in this section of the chapter:

- Additional detail on Interstates, other arterials, collectors and local bridges.
- Characterization of the superstructure material types used in the bridge network.
- Examination of the age distribution, deficiency percentages, and deficiency trends for each superstructure material (concrete, steel, prestressed concrete, timber, and other).

Year of Construction by Functional Classification

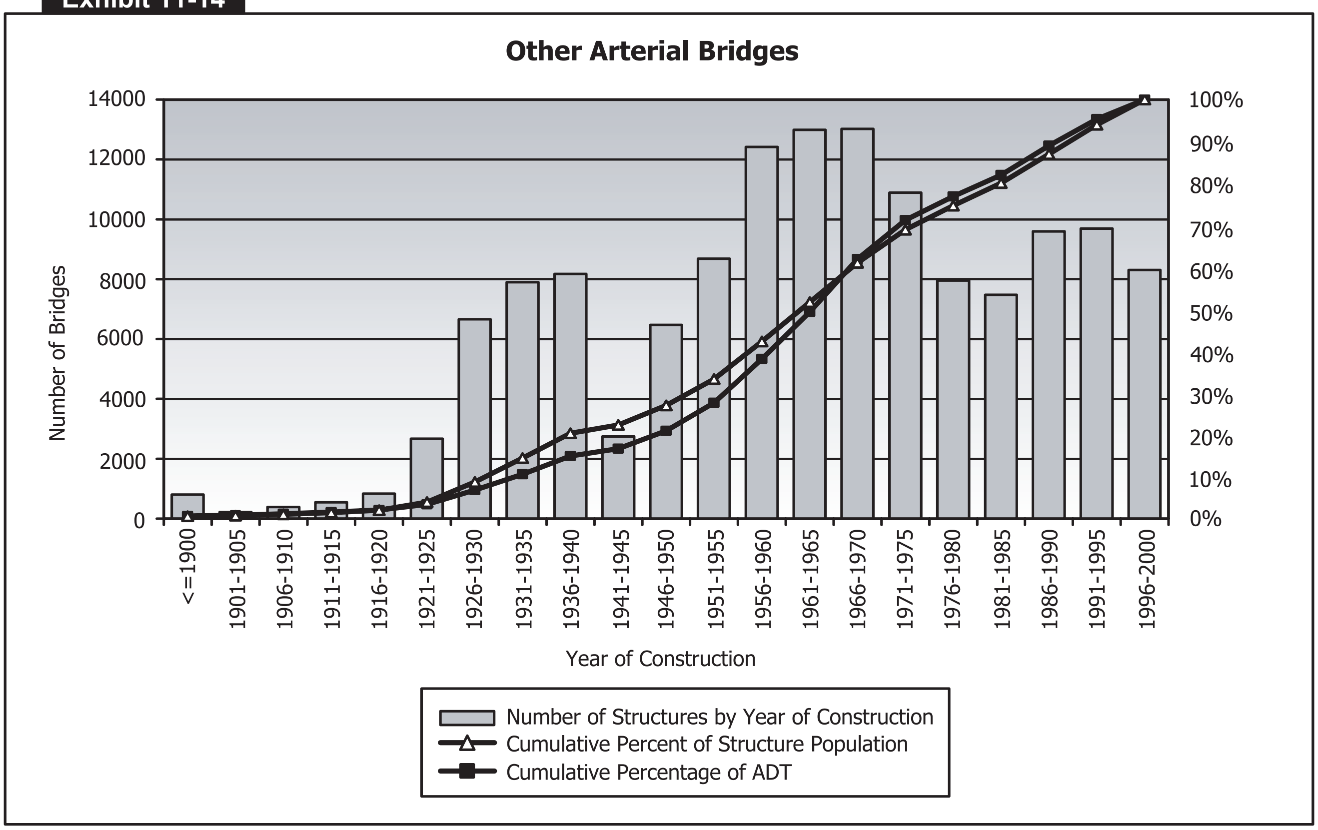
The year of construction distribution was presented for all structures in the National Bridge Inventory. Distributions were created for Interstates (see Exhibit 11-13), other arterials (see Exhibit 11-14), collectors (see Exhibit 11-15), and local (see Exhibit 11-16) bridges. There is a distinct peak in the distribution of Interstate bridges with the average year of construction in the mid 1960's. Other functional classifications have much greater dispersion in the year of construction.

Exhibit 11-13



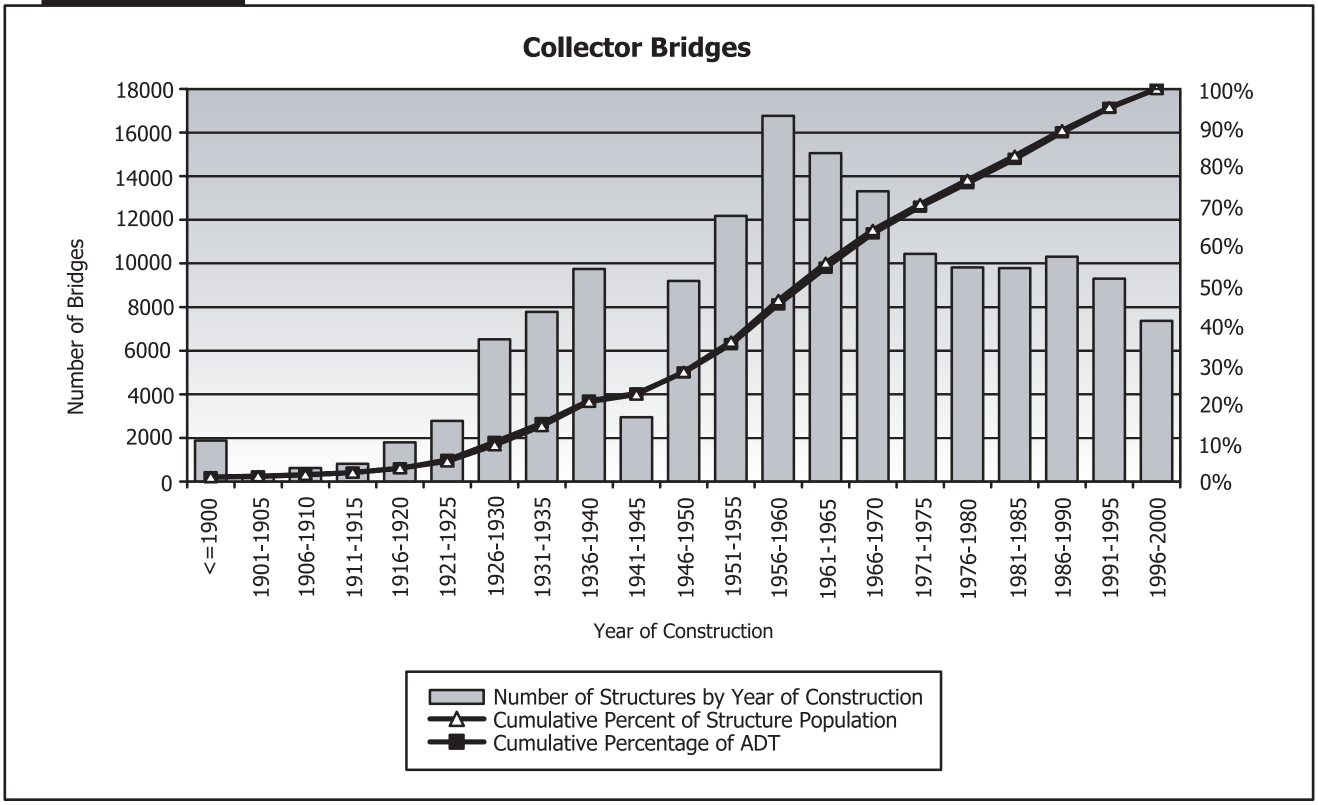
Source: National Bridge Inventory.

Exhibit 11-14



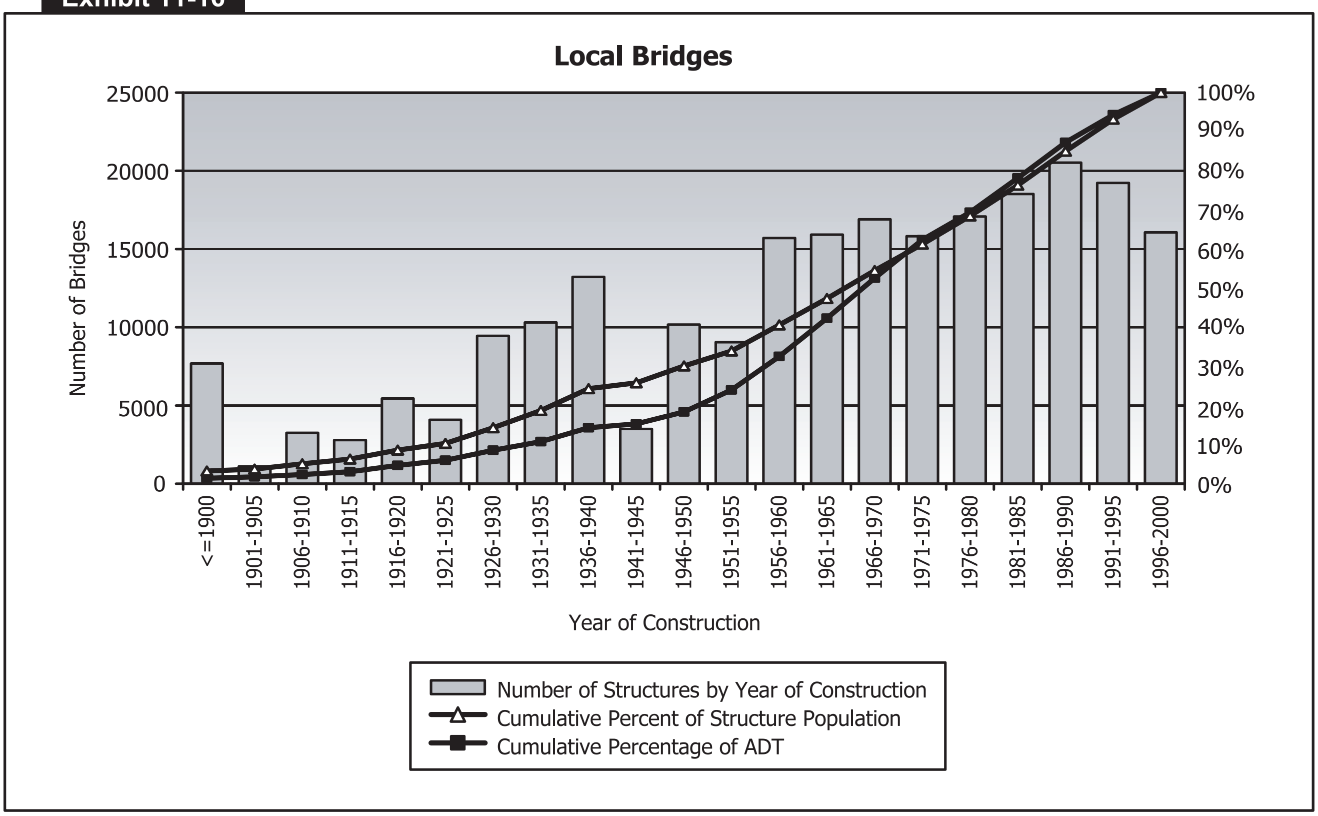
Source: National Bridge Inventory.

Exhibit 11-15



Source: National Bridge Inventory.

Exhibit 11-16

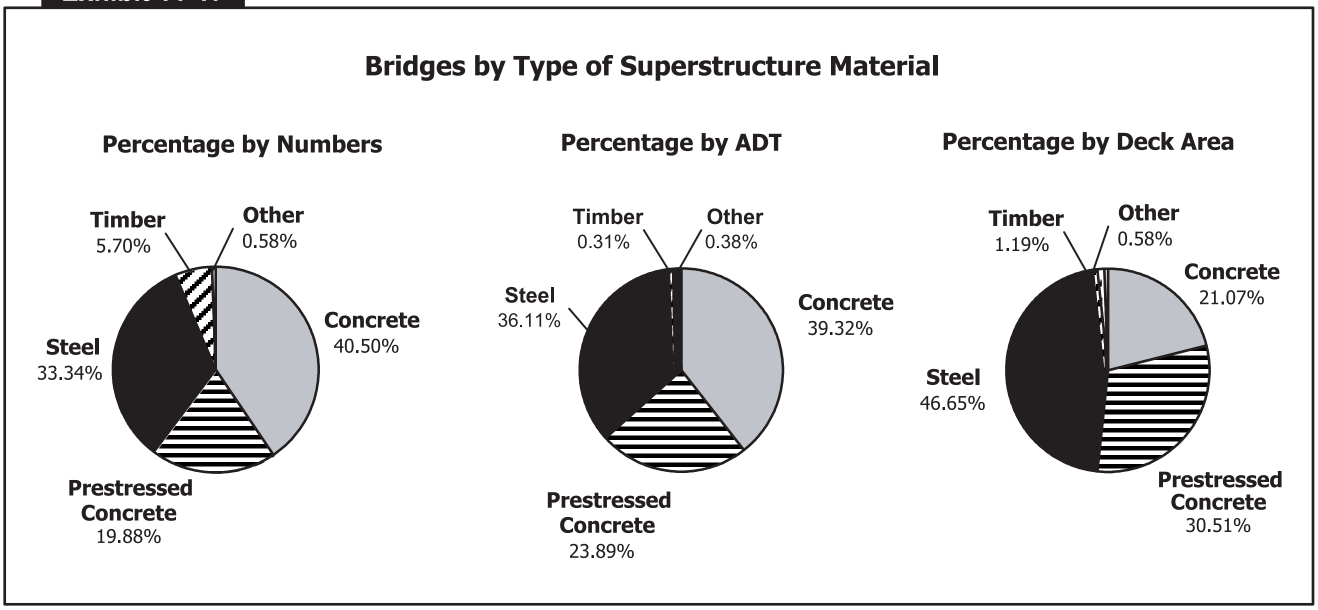


Source: National Bridge Inventory.

Superstructure Material Types

Predominant materials used for bridge superstructures are steel, concrete, prestressed concrete, and timber. Other materials, such as aluminum, iron, and composite materials, are utilized on less than 1 percent of the structures. The percentage of superstructure materials utilized is shown in Exhibit 11-17 weighting bridges equally (by numbers), weighting by the traffic carried (ADT), and weighting by the size of the structure (by deck area). Steel bridges tend to be utilized for longer than average structures carrying higher volumes of traffic than average. Timber bridges, which constitute 5.7 percent of the inventory by numbers, carry small volumes of traffic and are smaller than average in terms of deck area. Material percentages are shown for Interstates, other arterials, collectors and local functional classifications in Exhibit 11-18.

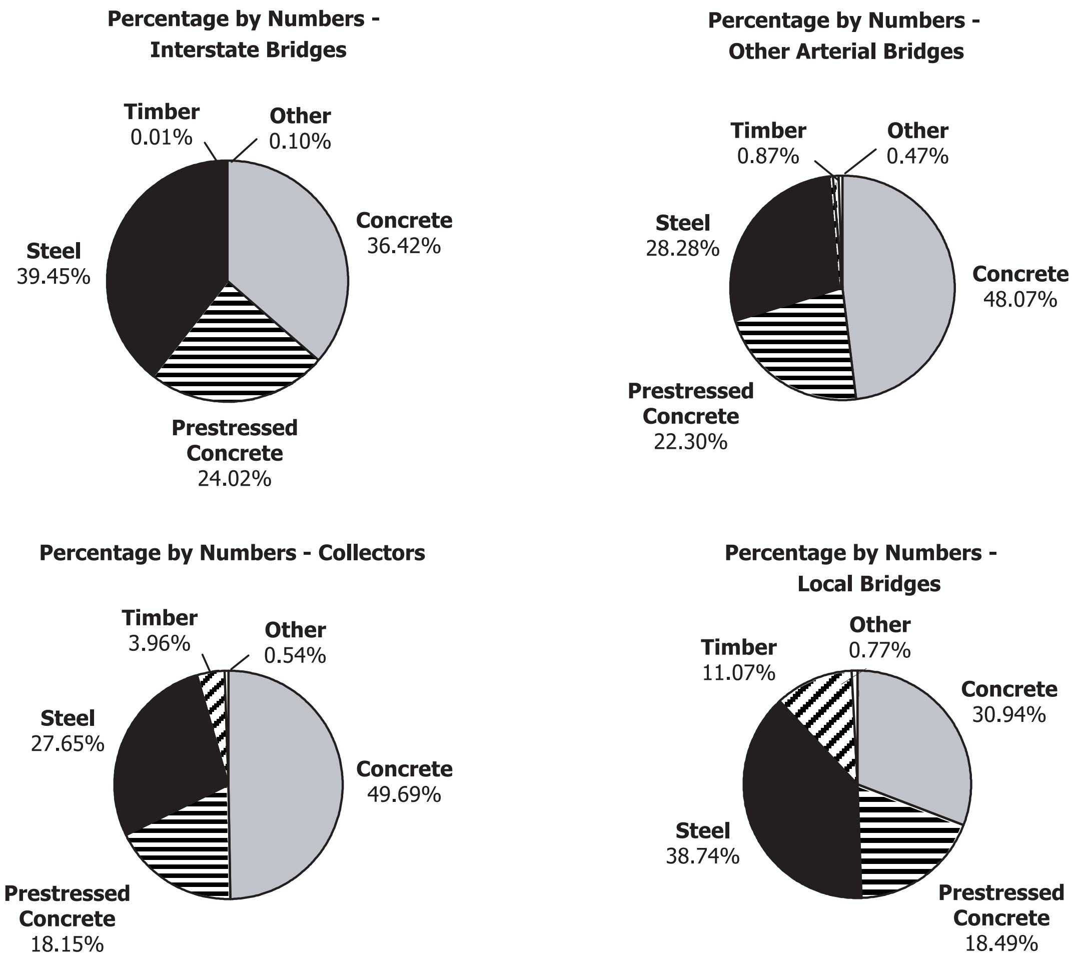
Exhibit 11-17



Source: National Bridge Inventory.

Exhibit 11-18

Bridges by Type of Superstructure Material and Functional Class



Source: National Bridge Inventory.

The number and percentage of bridges by superstructure material, owner, and functional classification are shown in Exhibit 11-19. Figures include both rural and urban designations. Exhibit 11-20 shows the percentages of material type used for the varying functional classifications and owners for rural bridges. Exhibit 11-21 shows the same information for urban bridges.

Exhibits 11-20 and 11-21 present the superstructure material percentages for rural and urban designations respectively. Notable differences can be seen in the Interstate bridge population with significantly higher percentages of urban Interstates constructed with steel. Prestressed superstructure bridges also constitute a higher percentage of the inventory in urban environments. Concrete (excluding prestressed concrete) is the dominant material for rural bridges. Timber superstructure bridges are prevalent in rural areas and not common in urban environments.

Exhibit 11-19

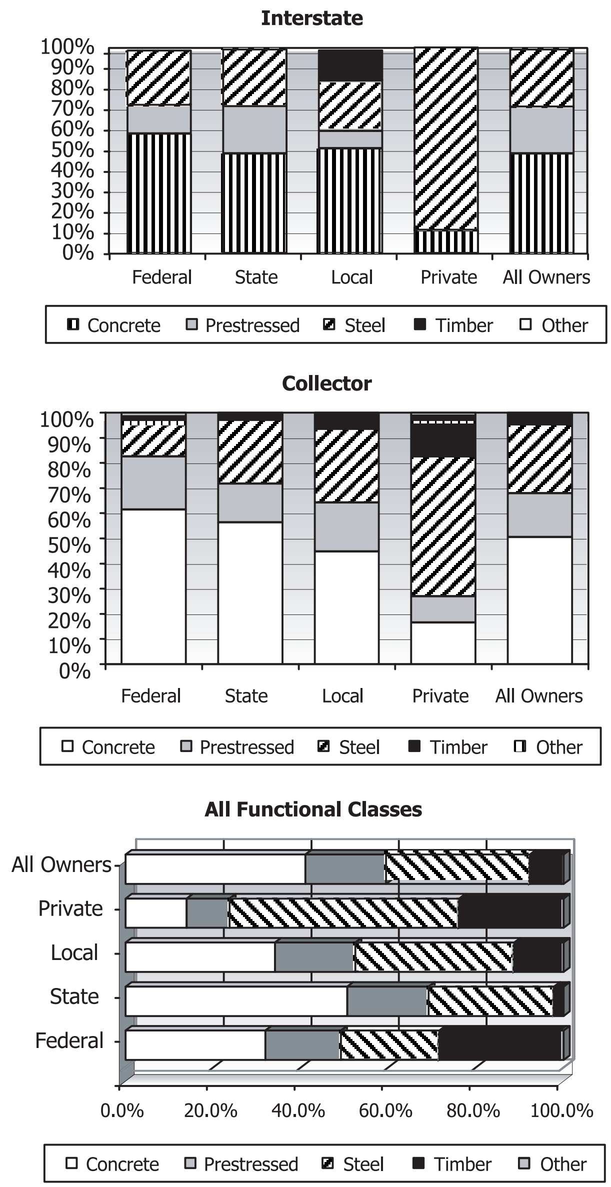
Bridges by Type of Superstructure Material, by Owner and Functional Classification

Functional Class	MATERIAL	FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS	
Interstate	Concrete	12	(52%)	20,088	(37%)	58	(20%)	40	(10%)	20,198	(36%)
	Prestressed	3	(13%)	13,288	(24%)	24	(8%)	5	(1%)	13,320	(24%)
	Steel	8	(35%)	21,295	(39%)	211	(71%)	349	(89%)	21,863	(39%)
	Timber	0	(0%)	6	(0%)	2	(1%)	0	(0%)	8	(0%)
	Other	0	(0%)	53	(0%)	1	(0%)	0	(0%)	54	(0%)
Other Arterial	Concrete	216	(37%)	56,326	(48%)	10,088	(49%)	141	(22%)	66,782	(48%)
	Prestressed	126	(22%)	25,980	(22%)	4,725	(23%)	131	(20%)	30,979	(22%)
	Steel	196	(34%)	33,556	(29%)	5,076	(25%)	352	(54%)	39,249	(28%)
	Timber	32	(5%)	825	(1%)	339	(2%)	11	(2%)	1,209	(1%)
	Other	12	(2%)	369	(0%)	264	(1%)	12	(2%)	658	(0%)
Collector	Concrete	759	(61%)	40,496	(55%)	37,686	(45%)	64	(16%)	79,014	(50%)
	Prestressed	263	(21%)	11,739	(16%)	16,735	(20%)	58	(15%)	28,836	(18%)
	Steel	170	(14%)	19,763	(27%)	23,719	(29%)	224	(57%)	43,945	(28%)
	Timber	27	(2%)	1,741	(2%)	4,508	(5%)	44	(11%)	6,324	(4%)
	Other	19	(2%)	319	(0%)	520	(1%)	6	(2%)	867	(1%)
Local	Concrete	1,957	(26%)	8,319	(26%)	62,647	(32%)	179	(18%)	73,199	(31%)
	Prestressed	1,234	(17%)	6,733	(21%)	35,537	(18%)	110	(11%)	43,651	(18%)
	Steel	1,751	(24%)	15,996	(49%)	73,284	(38%)	473	(47%)	91,592	(39%)
	Timber	2,452	(33%)	1,222	(4%)	22,423	(11%)	235	(23%)	26,350	(11%)
	Other	56	(1%)	233	(1%)	1,529	(1%)	9	(1%)	1,829	(1%)
All Urban Bridges	Concrete	2,944	(32%)	125,229	(45%)	110,479	(37%)	424	(17%)	239,193	(41%)
	Prestressed	1,626	(17%)	57,740	(21%)	57,021	(19%)	304	(12%)	116,786	(20%)
	Steel	2,125	(23%)	90,610	(33%)	102,290	(34%)	1,398	(57%)	196,649	(33%)
	Timber	2,511	(27%)	3,794	(1%)	27,272	(9%)	290	(12%)	33,891	(6%)
	Other	87	(1%)	974	(0%)	2,314	(1%)	27	(1%)	3,408	(1%)

Source: National Bridge Inventory.

Exhibit 11-20

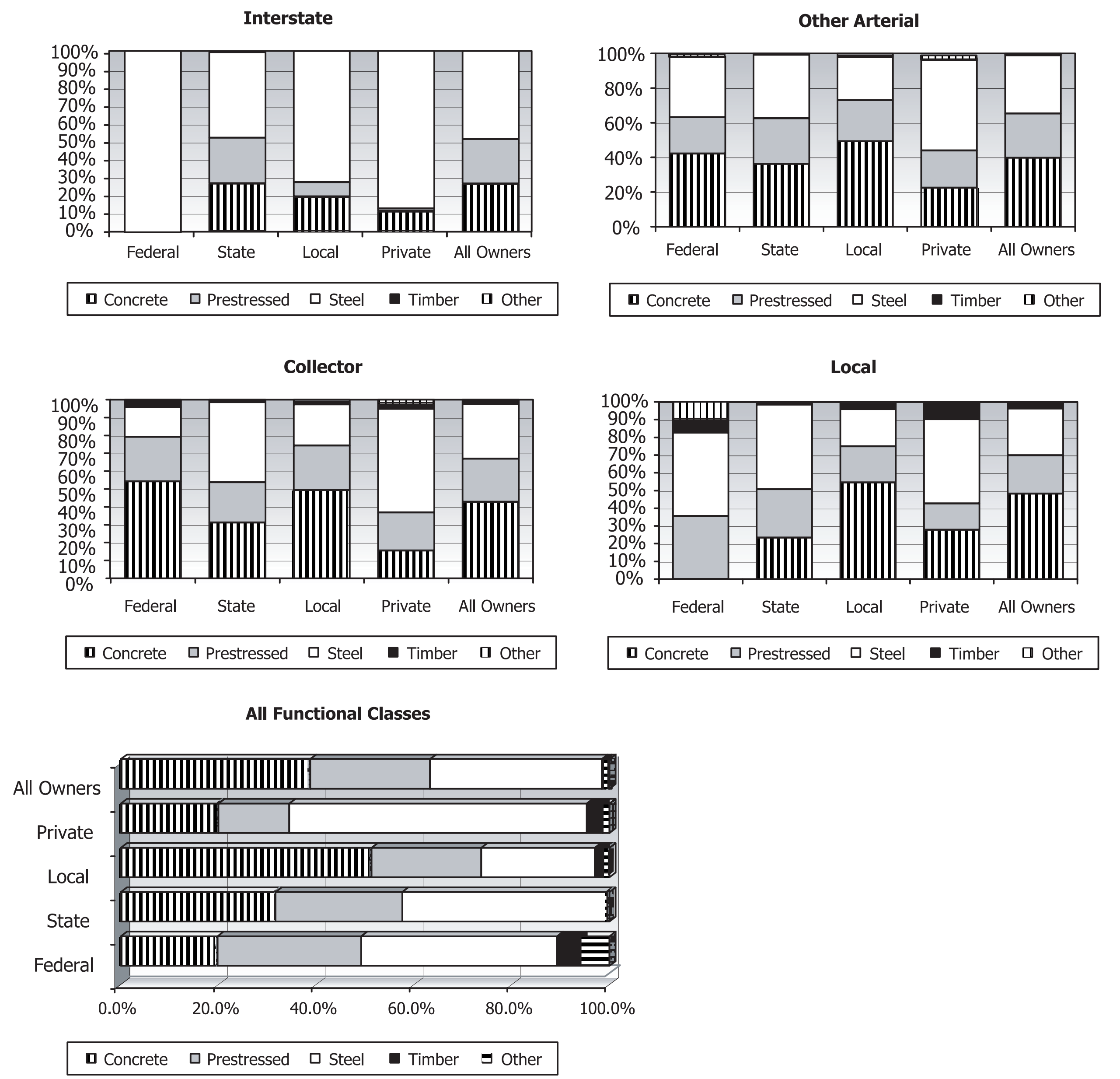
Rural Superstructure Materials by Owner and Functional Classification



Source: National Bridge Inventory.

Exhibit 11-21

Urban Superstructure Materials by Owner and Functional Classification



Source: National Bridge Inventory.

Concrete Superstructure Bridges (Excluding Prestressed Concrete)

The average age of concrete bridges in the NBI is approximately 40 years with an average year of construction of 1961. The average age of bridges for each combination of ownership and functional classification may be determined in Exhibit 11-22. The year of construction distribution and cumulative ADT are shown in Exhibit 11-23 for all concrete superstructure bridges (exclusive of prestressed concrete). Deficiencies and deficiency trends are shown in Exhibits 11-24 and 11-25 respectively for reinforced concrete superstructure bridges.

Exhibit 11-22

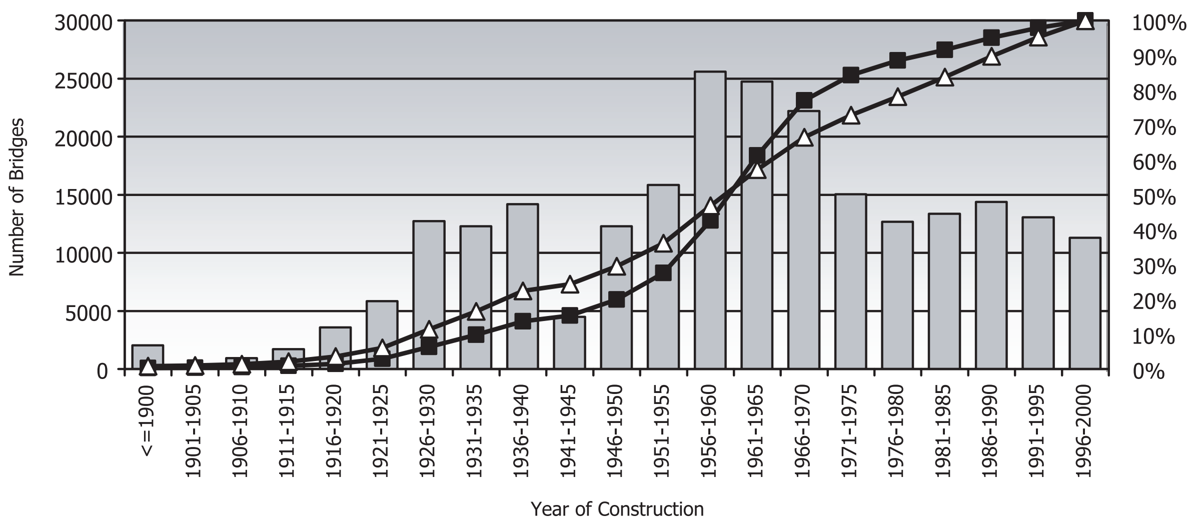
Average Year of Construction and Standard Deviation for Concrete Bridges by Functional Classification and Ownership

FUNCTIONAL CLASS	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
	FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS	
Rural Bridges										
Interstate	1964	(2)	1965	(10)	1943	(38)	1954	(9)	1965	(10)
Other Arterials	1958	(22)	1955	(21)	1971	(26)	1955	(23)	1956	(22)
Collectors	1959	(17)	1957	(20)	1962	(22)	1941	(28)	1959	(21)
Local	1960	(18)	1960	(22)	1965	(26)	1950	(36)	1964	(26)
All Rural	**1960**	**(18)**	**1958**	**(20)**	**1964**	**(25)**	**1949**	**(32)**	**1961**	**(22)**
Urban Bridges										
Interstate			1966	(10)	1968	(20)	1967	(18)	1966	(10)
Other Arterials	1962	(18)	1959	(20)	1962	(23)	1943	(24)	1960	(21)
Collectors	1950	(11)	1958	(22)	1964	(25)	1935	(25)	1962	(24)
Local	1952	(19)	1964	(21)	1965	(24)	1949	(36)	1965	(24)
All Urban	**1954**	**(18)**	**1961**	**(18)**	**1964**	**(24)**	**1948**	**(30)**	**1962**	**(21)**
All Structures	**1959**	**(18)**	**1958**	**(20)**	**1964**	**(25)**	**1948**	**(30)**	**1961**	**(22)**

Source: National Bridge Inventory.

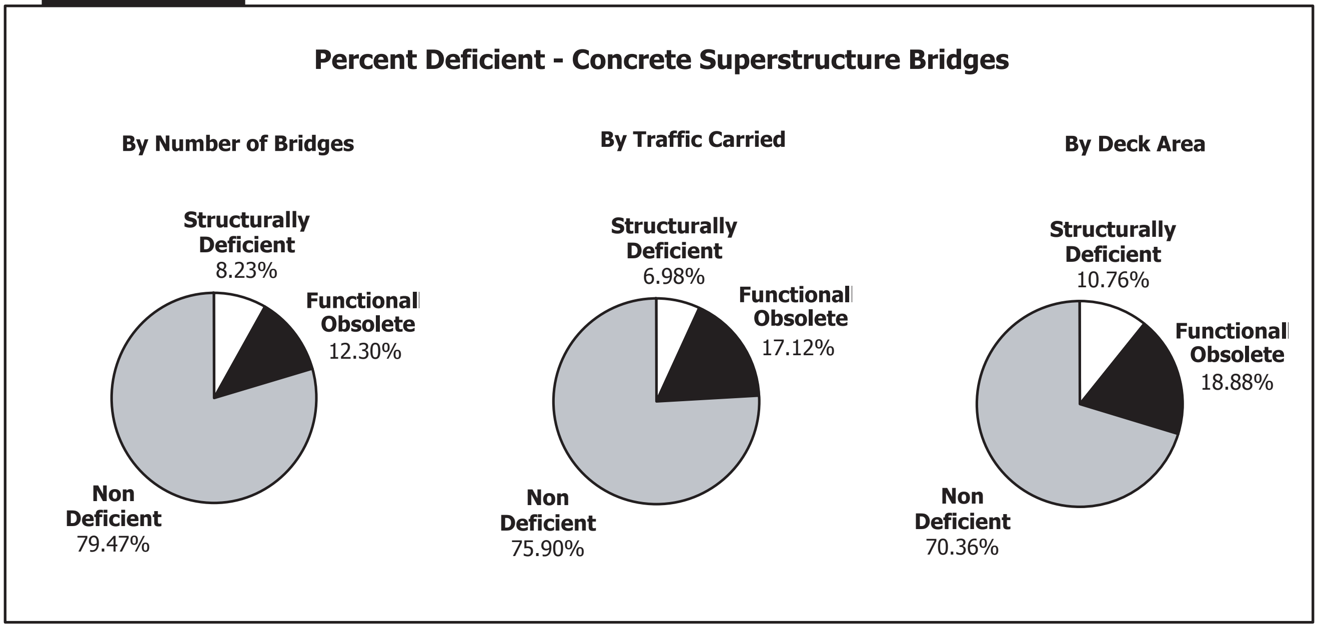
Exhibit 11-23

Year of Construction and Cumulative ADT - Concrete Superstructure Bridges (excluding prestressed concrete superstructures)



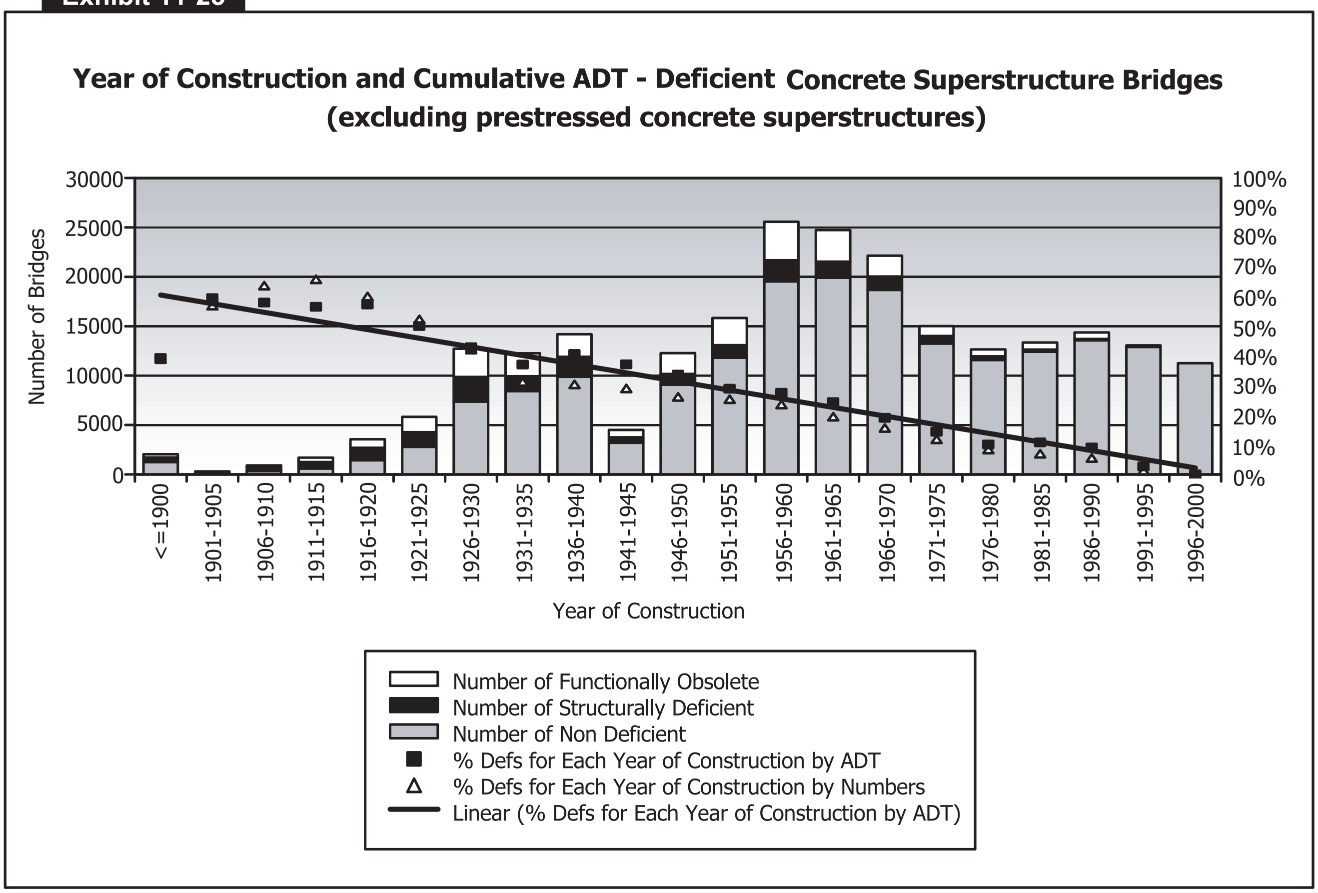
Source: National Bridge Inventory.

Exhibit 11-24



Source: National Bridge Inventory.

Exhibit 11-25



Source: National Bridge Inventory.

Steel Superstructure Bridges

The average age of steel bridges in the NBI is approximately 44 years with an average year of construction of 1958. The average age of bridges for all combinations of functional classification and ownership may be determined through examination of Exhibit 11-26. The year of construction distribution and cumulative ADT for all steel superstructure bridges are shown in Exhibit 11-27. Deficiencies and deficiency trends are shown in Exhibits 11-28 and 11-29 respectively for steel superstructure bridges.

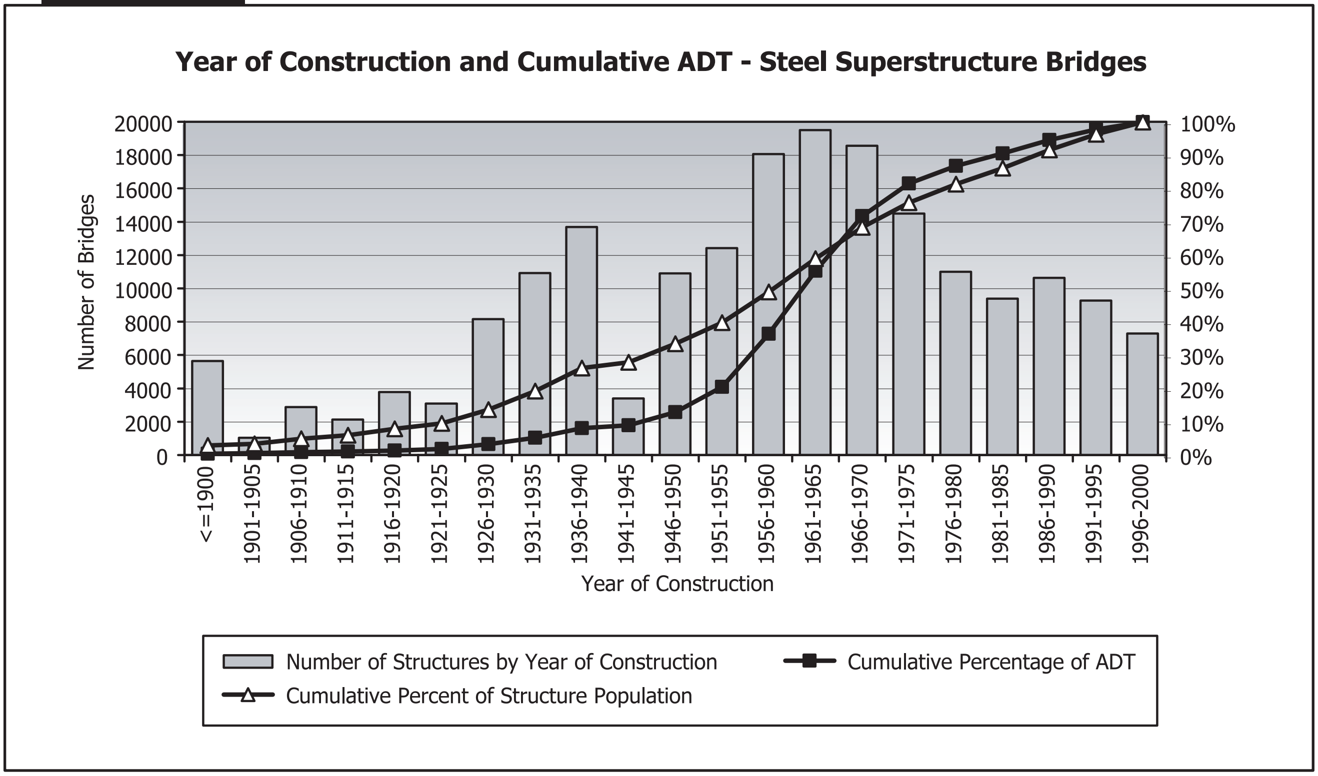
Exhibit 11-26

Average Year of Construction and Standard Deviation for Steel Bridges by Functional Classification and Owner

FUNCTIONAL CLASS	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
	FEDERAL		STATE		LOCAL		PRIVATE		AVERAGE	
Rural Bridges										
Interstate	1960	(10)	1967	(10)	1967	(28)	1965	(16)	1967	(10)
Other Arterials	1965	(19)	1960	(20)	1961	(29)	1951	(18)	1960	(20)
Collectors	1963	(20)	1958	(20)	1956	(23)	1945	(24)	1957	(22)
Local	1964	(21)	1963	(21)	1953	(29)	1936	(28)	1955	(28)
All Rural	**1964**	**(21)**	**1961**	**(19)**	**1954**	**(28)**	**1942**	**(26)**	**1957**	**(25)**
Urban Bridges										
Interstate	1967	(8)	1969	(11)	1959	(10)	1965	(13)	1969	(11)
Other Arterials	1947	(31)	1965	(18)	1956	(25)	1947	(23)	1963	(21)
Collectors	1955	(14)	1965	(19)	1955	(25)	1949	(30)	1959	(23)
Local	1955	(20)	1967	(19)	1955	(27)	1944	(33)	1958	(25)
All Urban	**1953**	**(23)**	**1967**	**(16)**	**1955**	**(26)**	**1953**	**(25)**	**1964**	**(20)**
All Structures	**1963**	**(21)**	**1963**	**(18)**	**1954**	**(27)**	**1949**	**(26)**	**1958**	**(24)**

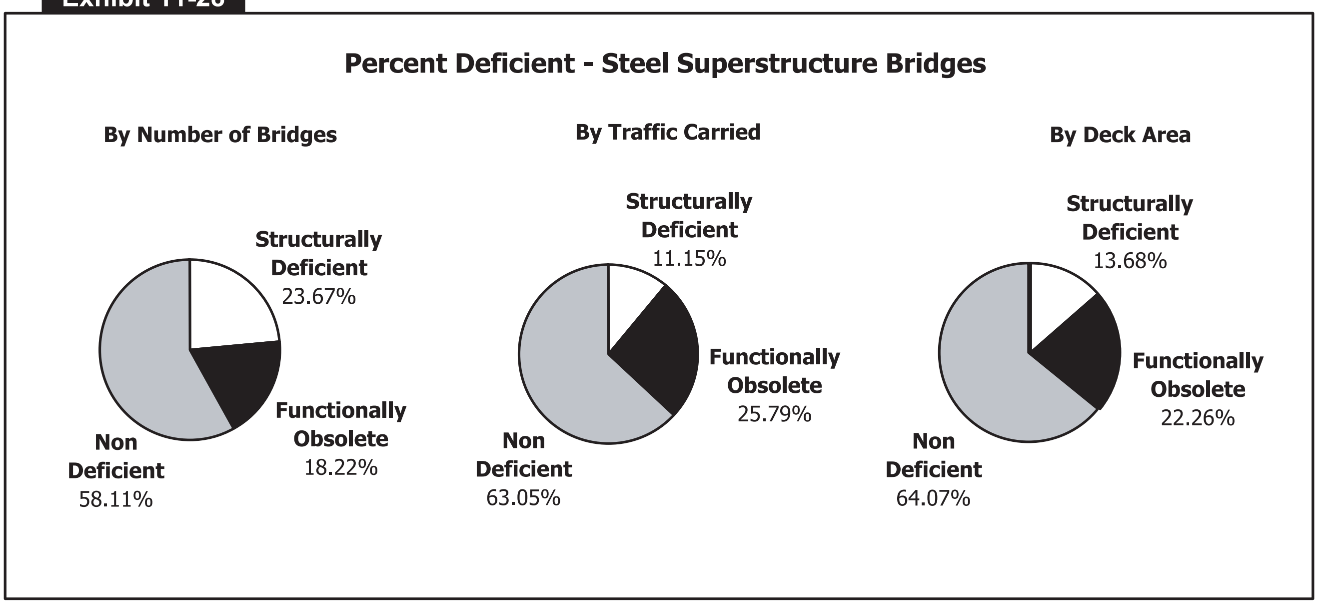
Source: National Bridge Inventory.

Exhibit 11-27



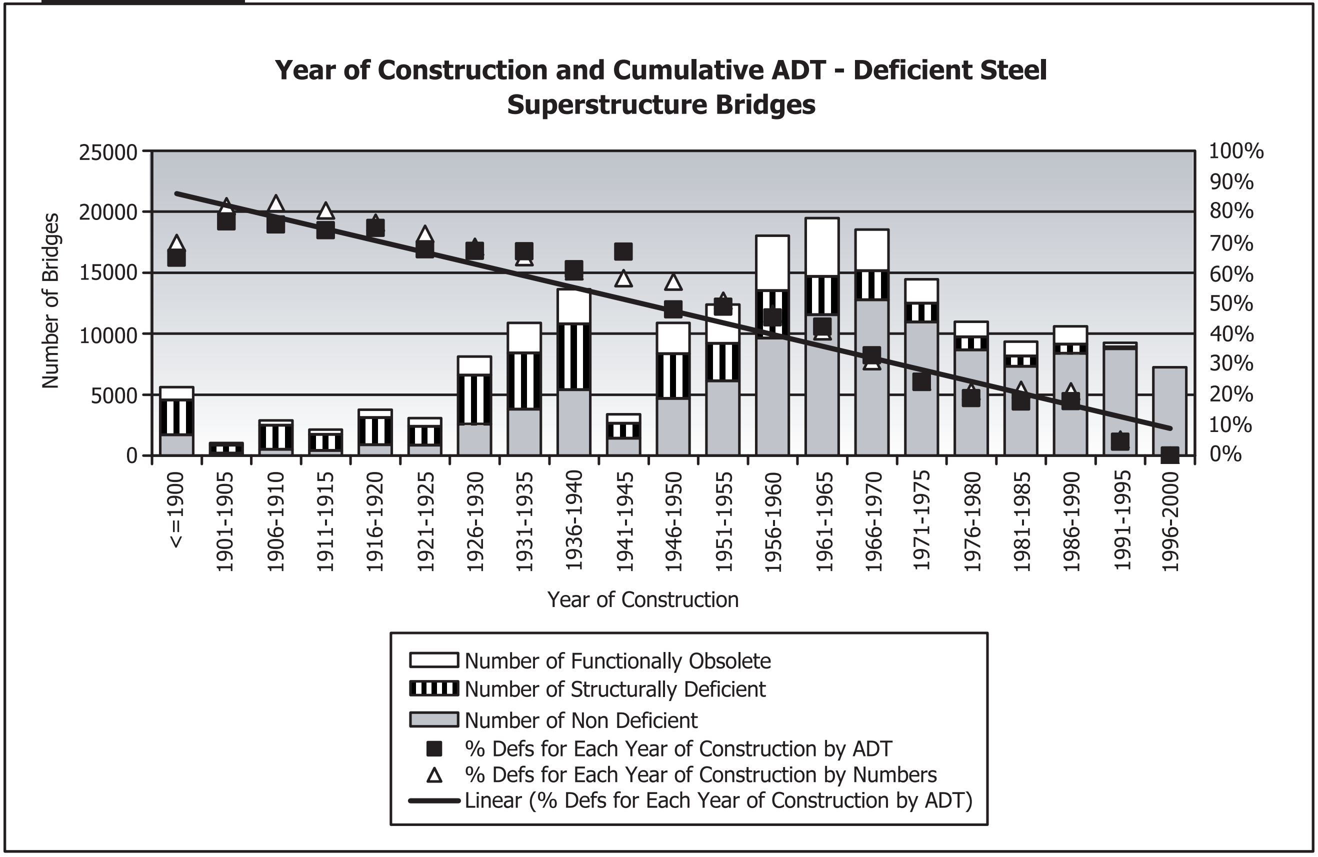
Source: National Bridge Inventory.

Exhibit 11-28



Source: National Bridge Inventory.

Exhibit 11-29



Source: National Bridge Inventory.

Prestressed Concrete

Prestressed concrete was introduced in the middle of the 20th Century, and today the majority of bridges are constructed using prestressed concrete designs. The average age of prestressed concrete bridges in the NBI is approximately 24 years with an average year of construction of 1978. There are no significant differences in the age of rural versus urban prestressed bridges. The average age of bridges for all combinations of functional classification and ownership is shown in Exhibit 11-30. The year of construction distribution and cumulative ADT are shown in Exhibit 11-31 for all prestressed concrete superstructure bridges. Deficiencies and deficiency trends are shown in Exhibits 11-32 and 11-33 respectively for concrete superstructure bridges.

Exhibit 11-30

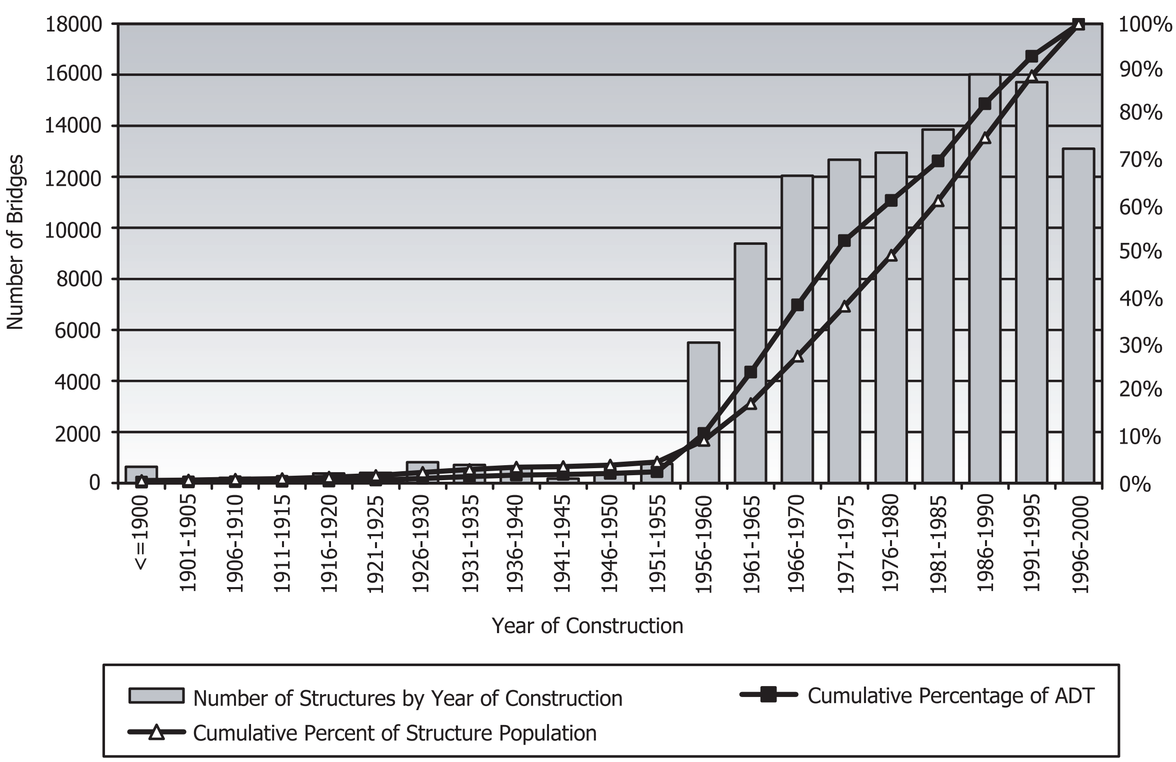
Average Year of Construction and Standard Deviation for Concrete Bridges by Functional Classification and Ownership

FUNCTIONAL CLASS	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
	FEDERAL		STATE		LOCAL		PRIVATE		AVERAGE	
Rural Bridges										
Interstate	1968	(5)	1973	(10)	1996				1973	(10)
Other Arterials	1978	(12)	1980	(16)	1981	(17)	1972	(11)	1980	(16)
Collectors	1977	(11)	1978	(16)	1978	(17)	1982	(19)	1978	(16)
Local	1977	(13)	1979	(15)	1980	(17)	1981	(20)	1980	(17)
All Rural	**1977**	**(13)**	**1978**	**(15)**	**1980**	**(17)**	**1979**	**(18)**	**1979**	**(16)**
Urban Bridges										
Interstate			1975	(12)	1993	(6)	1973	(14)	1975	(12)
Other Arterials	1977	(11)	1979	(15)	1977	(18)	1979	(20)	1978	(16)
Collectors	1971	(13)	1975	(20)	1976	(19)	1982	(22)	1975	(20)
Local	1974	(19)	1978	(14)	1976	(19)	1975	(19)	1977	(18)
All Urban	**1975**	**(17)**	**1977**	**(14)**	**1976**	**(19)**	**1978**	**(20)**	**1977**	**(16)**
All Structures	**1977**	**(13)**	**1978**	**(15)**	**1979**	**(17)**	**1978**	**(19)**	**1978**	**(16)**

Source: National Bridge Inventory.

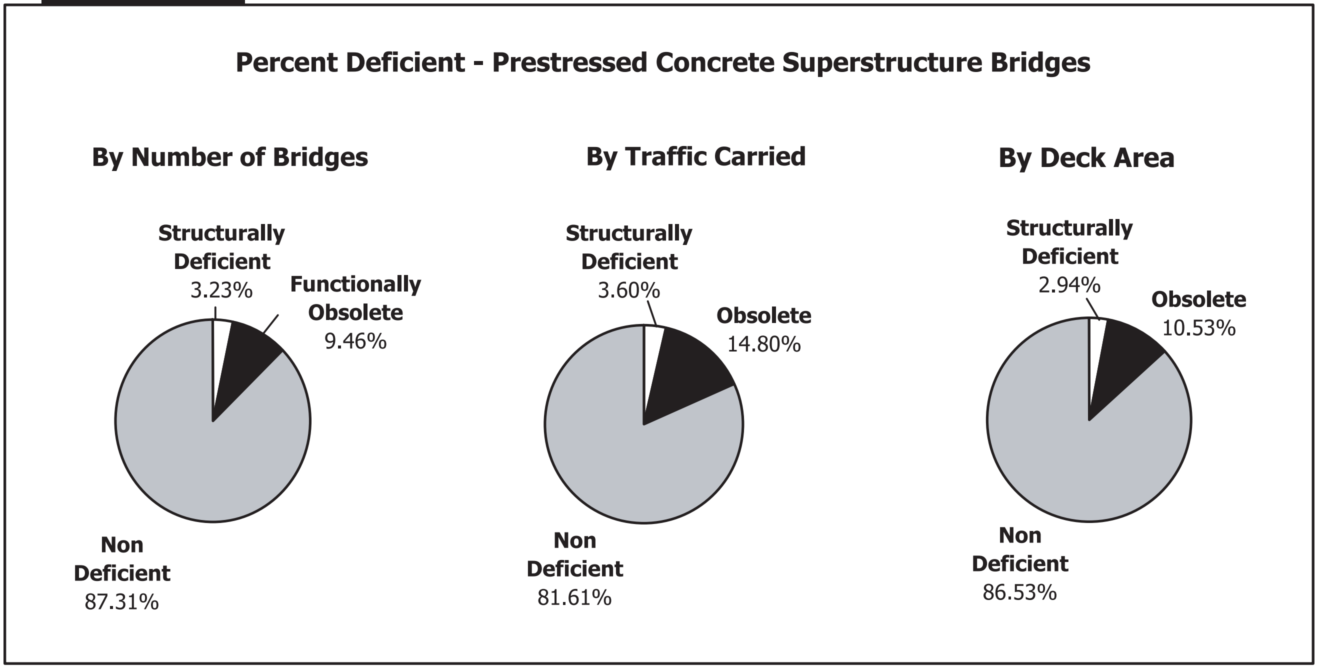
Exhibit 11-31

Year of Construction and Cumulative ADT - Prestressed Concrete Superstructure Bridges



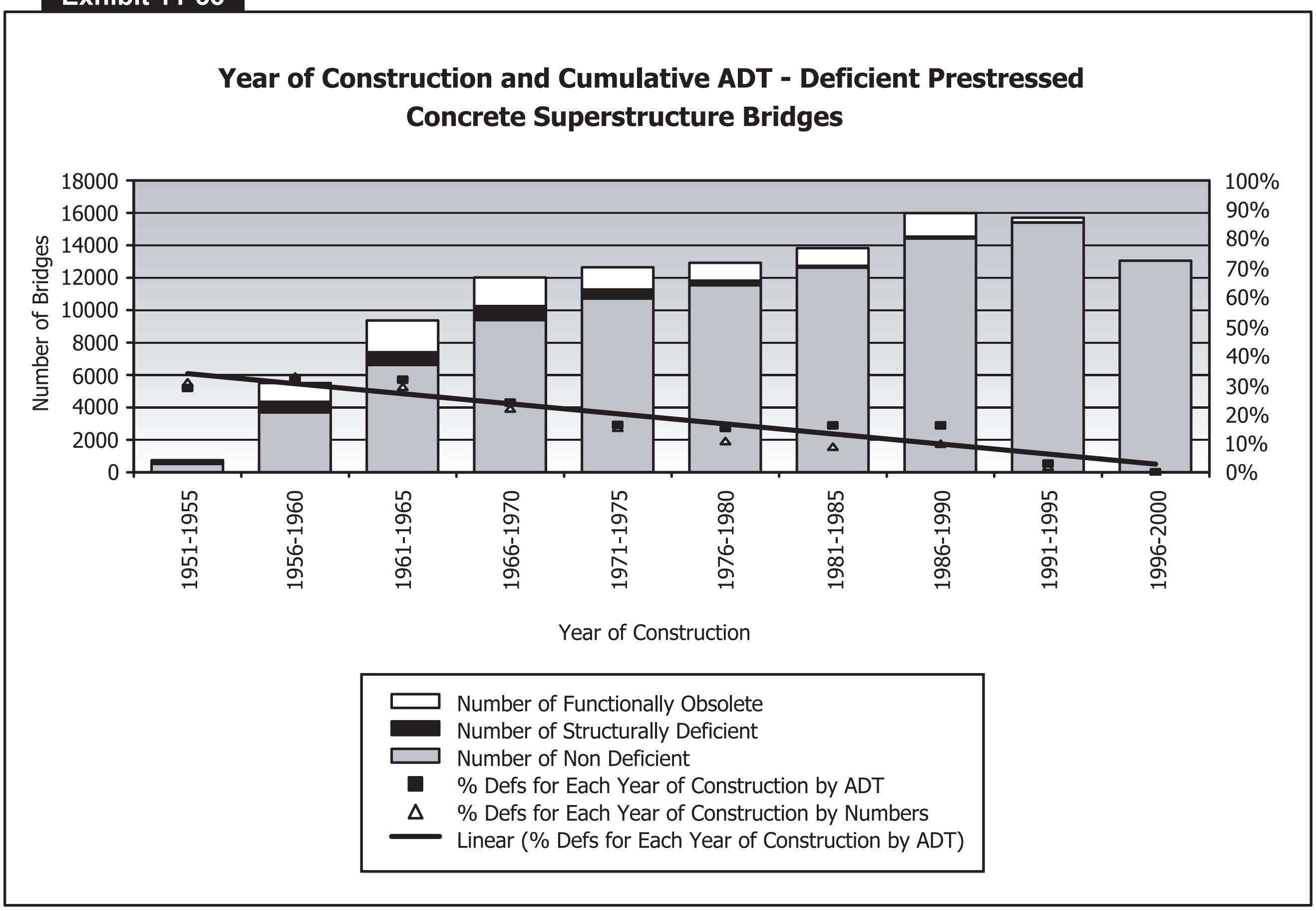
Source: National Bridge Inventory.

Exhibit 11-32



Source: National Bridge Inventory.

Exhibit 11-33



Source: National Bridge Inventory.

Timber Bridges

Timber bridges, as described previously, are primarily used in rural environments for small spans carrying small volumes of traffic. The average age of timber bridges in the NBI is 43 years with an average year of construction of 1959. There is no significant difference between the ages of the rural and the urban timber bridge populations. The average age of timber bridges for all combinations of functional classification and ownership is presented in Exhibit 11-34. The year of construction distribution and cumulative ADT are shown in Exhibit 11-35 for all timber superstructure bridges. Deficiencies and deficiency trends are shown in Exhibits 11-36 and 11-37 respectively for timber superstructure bridges.

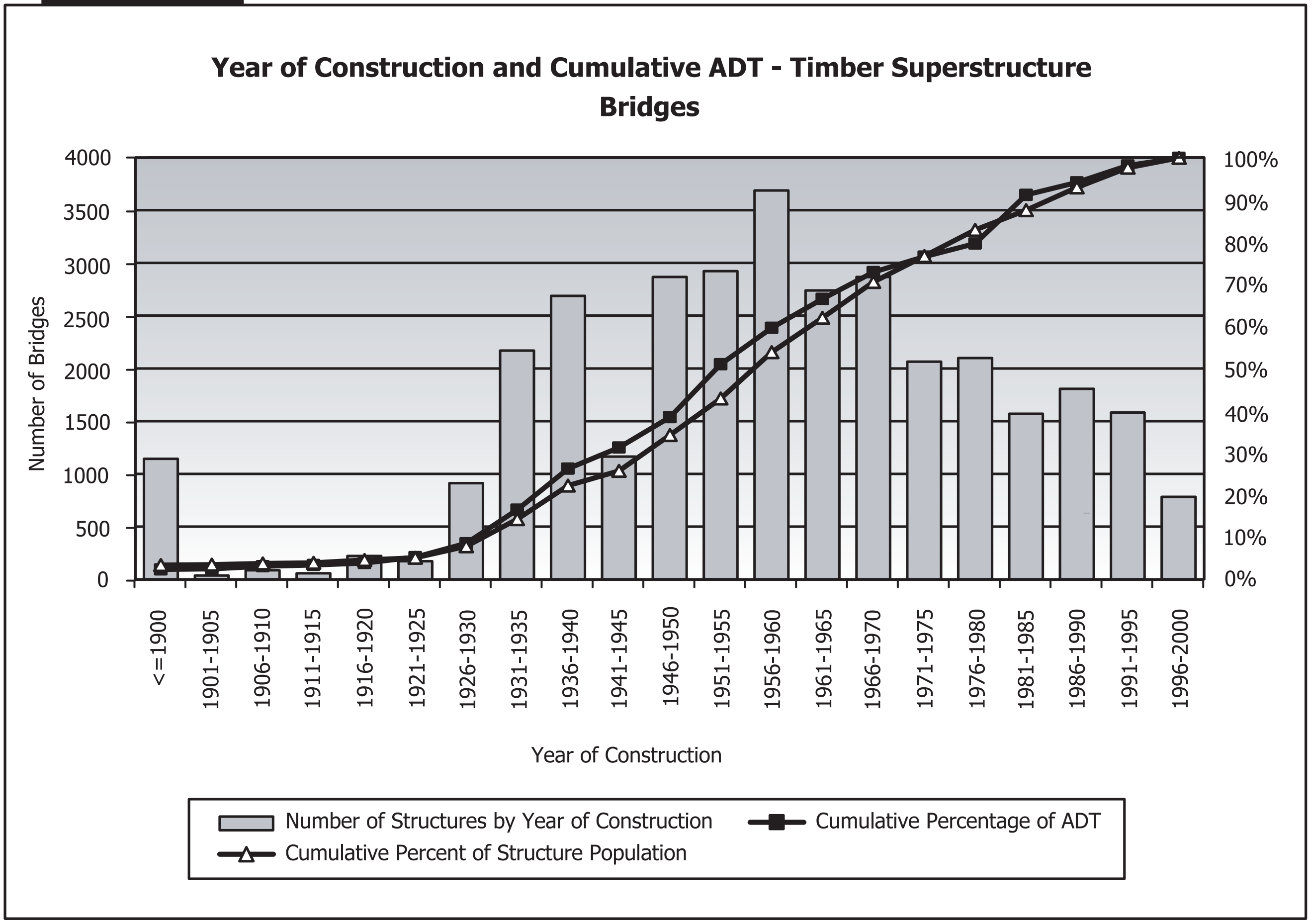
Exhibit 11-34

Average Year of Construction and Standard Deviation for Timber Bridges by Functional Classification and Ownership

FUNCTIONAL CLASS	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION) FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS
Rural Bridges									
Interstate			1960	(20)	1974	(18)			1963
Other Arterials	1956	(14)	1943	(12)	1970	(30)	1956	(33)	1949
Collectors	1955	(16)	1953	(15)	1958	(21)	1933	(21)	1956
Local	1964	(18)	1960	(22)	1959	(23)	1937	(25)	1959
All Rural	**1964**	**(18)**	**1953**	**(18)**	**1959**	**(23)**	**1936**	**(25)**	**1959**
Urban Bridges									
Interstate									
Other Arterials			1946	(22)	1956	(24)	1927	(15)	1951
Collectors	1951		1937	(34)	1959	(30)	1919	(24)	1953
Local	1955	(19)	1951	(29)	1965	(24)	1931	(22)	1962
All Urban	**1954**	**(18)**	**1945**	**(28)**	**1963**	**(25)**	**1929**	**(21)**	**1959**
All Structures	**1964**	**(18)**	**1953**	**(19)**	**1959**	**(23)**	**1935**	**(24)**	**1959**

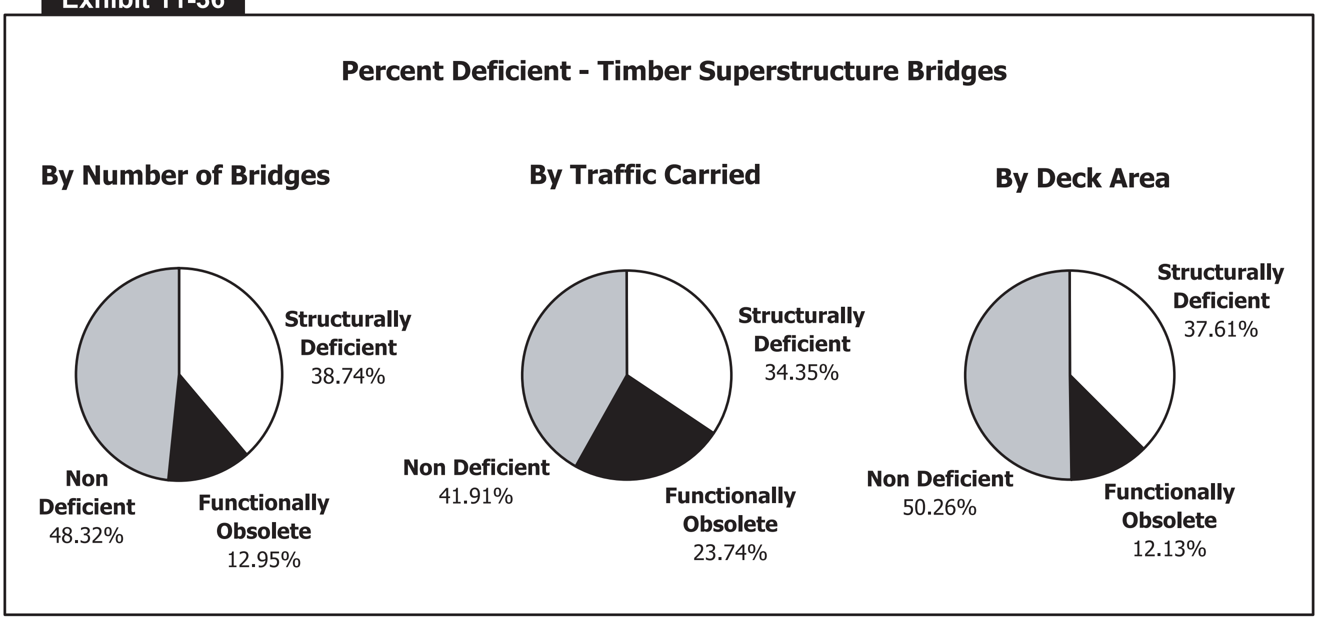
Source: National Bridge Inventory.

Exhibit 11-35



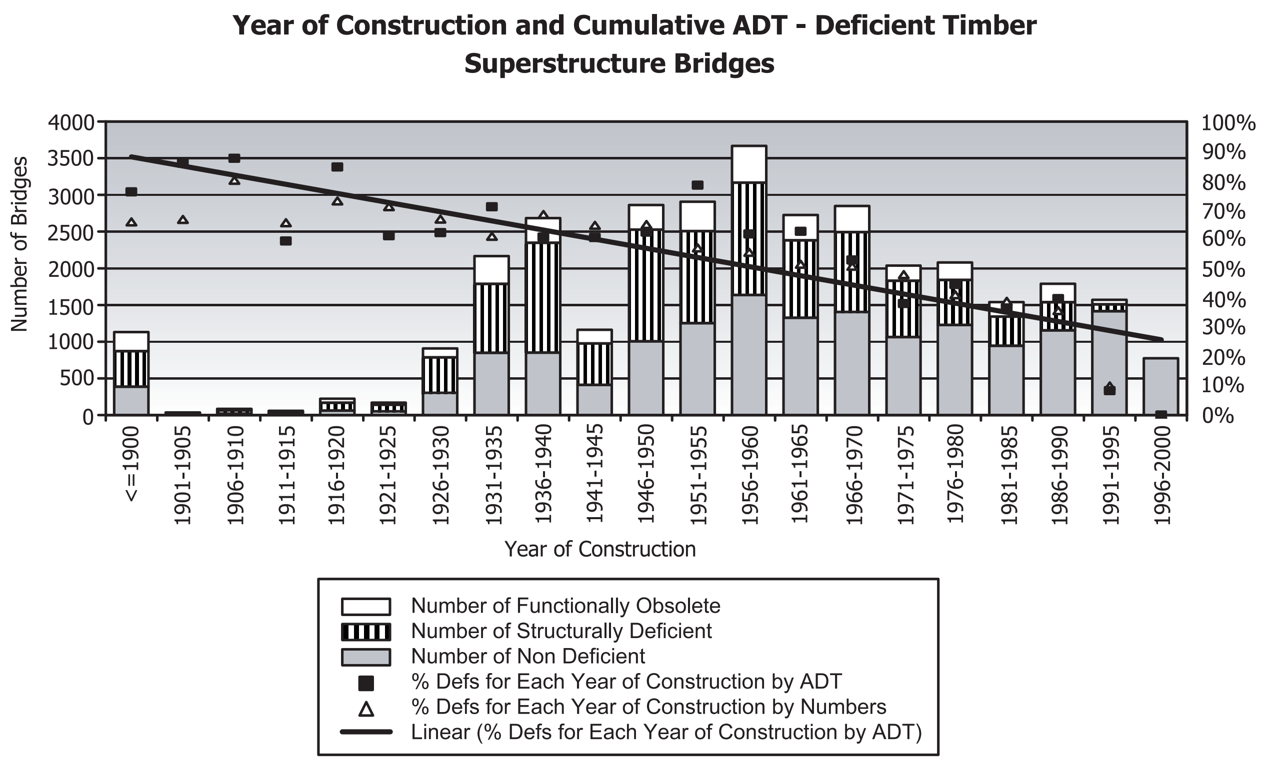
Source: National Bridge Inventory.

Exhibit 11-36



Source: National Bridge Inventory.

Exhibit 11-37



Source: National Bridge Inventory.

Other Superstructure Materials

There are a small number of bridges, in terms of percentage of the population, composed of other materials, which includes aluminum, wrought and cast iron, masonry, and other uncategorized materials. The average age of these bridges is 67 years with an average year of construction of 1935. Urban bridges are, on average, older than rural bridges constructed of these other materials. The average age of these structures is shown for all combinations of functional classification and ownership in Exhibit 11-38. The year of construction distribution and cumulative ADT are shown in Exhibit 11-39 for all structures constructed of these other materials. Deficiencies and deficiency trends are shown in Exhibits 11-40 and 11-41 respectively.

Exhibit 11-38

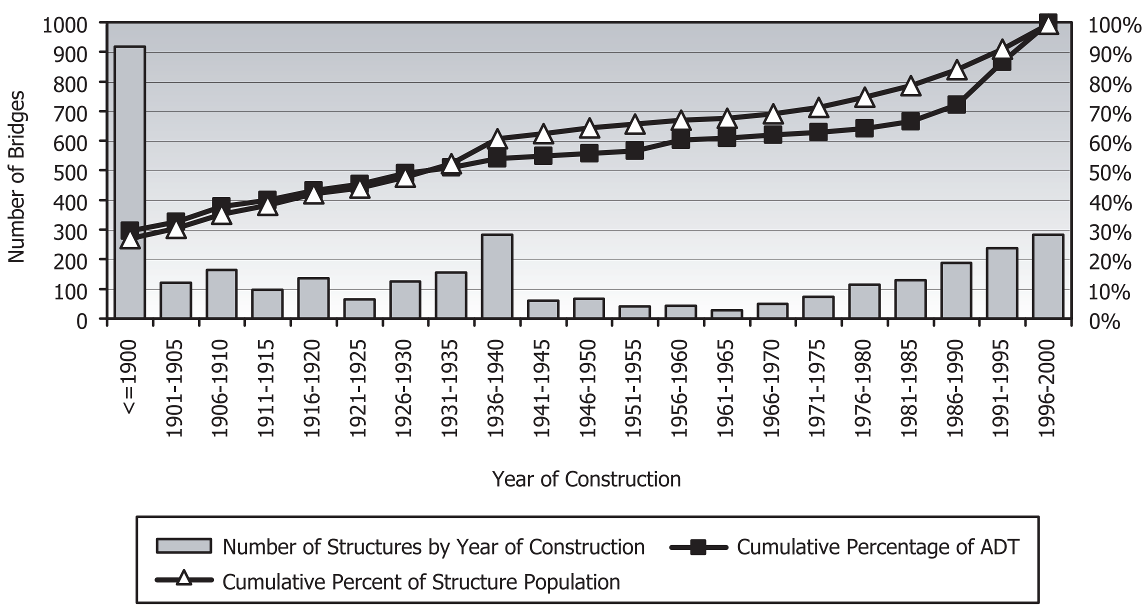
Average Year of Construction an Standard Deviation for Other Superstructure Materials Bridges by Functional Classification and Ownership

FUNCTIONAL CLASS	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
	FEDERAL		STATE		LOCAL		PRIVATE		AVERAGE	
Rural Bridges										
Interstate			1976	(9)					1976	(9)
Other Arterials	1970	(24)	1931	(37)	1912	(61)			1929	(44)
Collectors	1952	(43)	1932	(41)	1942	(39)	1927	(38)	1938	(40)
Local	1952	(34)	1952	(52)	1938	(43)	1895	(44)	1940	(44)
All Rural	**1954**	**(36)**	**1939**	**(45)**	**1938**	**(42)**	**1907**	**(42)**	**1939**	**(43)**
Urban Bridges										
Interstate			1986	(16)	1979				1986	(16)
Other Arterials	1918		1929	(57)	1907	(38)	1923	(28)	1919	(50)
Collectors			1923	(45)	1923	(39)	1926	(16)	1923	(39)
Local	1942	(29)	1928	(50)	1925	(43)	1905	(33)	1926	(43)
All Urban	**1940**	**(28)**	**1935**	**(55)**	**1918**	**(41)**	**1921**	**(27)**	**1924**	**(47)**
All Structures	**1952**	**(35)**	**1938**	**(49)**	**1933**	**(43)**	**1916**	**(32)**	**1935**	**(45)**

Source: National Bridge Inventory.

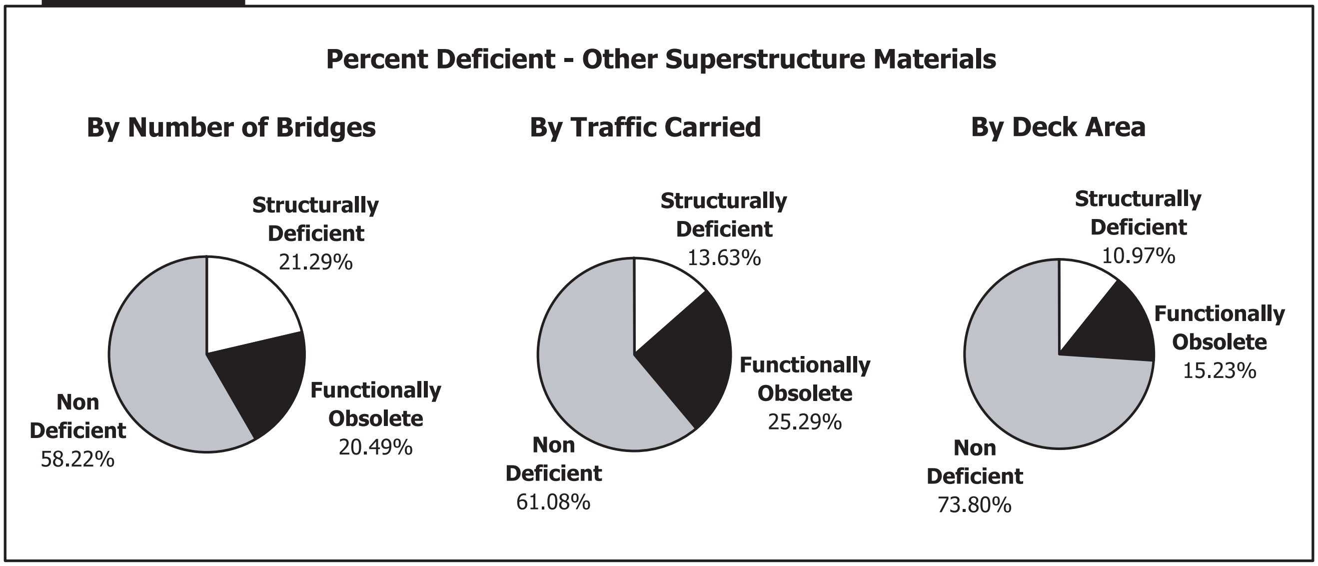
Exhibit 11-39

Year of Construction and Cumulative ADT - Other Superstructure Materials



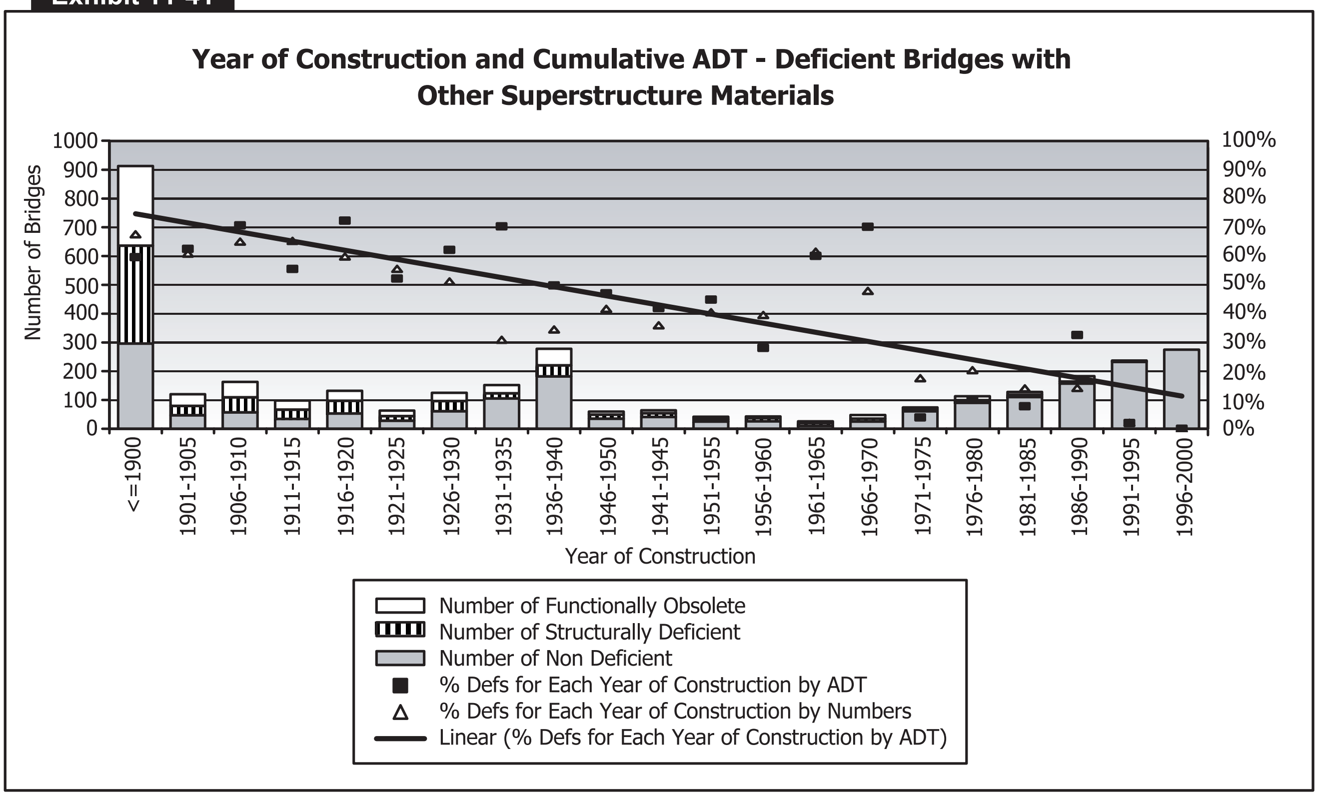
Source: National Bridge Inventory.

Exhibit 11-40



Source: National Bridge Inventory.

Exhibit 11-41



Source: National Bridge Inventory.

Culverts

In addition to examining the bridge infrastructure in terms of functional classification and ownership, it is important to examine the types of design utilized, the age of the structures, and other factors. Considering the types of design utilized, the records in the NBI describe either traditional bridge designs (80 percent—approximately 474,000 records), culverts (20 percent—approximately 117,000 records), or tunnels

(104 records). The inventory is composed almost entirely of traditional bridge and culvert designs. Both of these structures provide the same purpose of providing network connectivity. However, the design and engineering properties of bridges and culverts differ dramatically. Consider the definitions of these structures as defined in the National Bridge Inspection Standards (23 CFR 650.3):

- Bridges are defined as "supports erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet [6.1 meters] between undercopings of abutments or spring lines of arches." Traditional bridges will have distinct decks, superstructures, and substructures.
- Culverts are structures "designed hydraulically to take advantage of submergence to increase hydraulic capacity. Culverts, as distinguished from bridges, are usually covered with embankment and are composed of structural material around the entire perimeter, although some are supported on spread footings with the streambed serving as the bottom of the culvert. Culverts may qualify to be considered "bridge" length."

For safety assurance and funding purposes, culverts and bridges are equivalent; however, since the design characteristics are significantly different, it is expected that differences in deterioration patterns will occur between the populations. Thus, it is useful to examine differences between bridge and culvert designs. The number of records describing bridge, culvert, and tunnel design is tabulated together with the traffic carried (total ADT) and the percentage of total deck area in Exhibit 11-42.

Exhibit 11-42

Percentage of NBI Records by Design Type

Design	Records	Total ADT Carried	Total Deck Area
Bridges	80.20%	83.25%	97.90%
Culverts	19.78%	16.66%	2.05%
Tunnels	0.02%	0.09%	0.05%

Source: National Bridge Inventory.

Differences in bridge ownership and functional classification versus culvert ownership and functional classification are examined in the following figures. Examination reveals that there are only minor deviations from the overall percentages when examining alternative combinations of functional classification and ownership of bridges versus culverts. The design-type used for a particular situation is thus dependent on the conditions of the crossing and not the functional classification or jurisdictional issues.

The average age of structures in the National Bridge Inventory is approximately 40 years with an average year of construction of 1963. The age distribution of traditional bridge designs and culvert designs is examined and compared in Exhibit 11-43. Culverts tend to be younger than bridges with an average age of approximately 35 years, compared to an average age of approximately 40 years for traditional bridge designs. The average year of construction and standard deviation for traditional bridge designs and culvert designs are shown in Exhibit 11-44 and Exhibit 11-46 for all combinations of ownership and functional classification. Year of construction distributions and cumulative ADT percentages are shown in Exhibit 11-45 for traditional bridge designs and Exhibit 11-47 for culvert designs.

Exhibit 11-43

Bridges and Culverts by Functional Classification and Ownership

FUNCTIONAL CLASS	OWNERSHIP: FEDERAL BRIDGES	FEDERAL CULVERTS	STATE BRIDGES	STATE CULVERTS	LOCAL BRIDGES	LOCAL CULVERTS	PRIVATE BRIDGES	PRIVATE CULVERTS	ALL BRIDGES	ALL CULVERTS
Rural Bridges										
Interstate	13	8	21,619	5,891	12	-	35	4	21,679	5,903
Other Arterials	439	85	49,777	22,066	2,029	593	137	15	52,382	22,759
Collectors	997	217	49,662	19,287	57,071	16,074	223	17	107,953	35,595
Local	6,731	563	23,892	3,841	149,968	24,726	604	25	181,195	29,155
Subtotal Rural	**8,180**	**873**	**144,950**	**51,085**	**209,080**	**41,393**	**999**	**61**	**363,209**	**93,412**
Urban Bridges										
Interstate	2		24,966	2,238	263	20	342	13	25,573	2,271
Other Arterials	42	14	38,541	6,663	13,729	4,134	472	20	52,784	10,831
Collectors	18	6	4,580	529	7,326	2,696	151	3	12,075	3,234
Local	150	15	4,338	433	14,088	6,636	354	22	18,930	7,106
Subtotal Urban	**212**	**35**	**72,425**	**9,863**	**35,406**	**13,486**	**1,319**	**58**	**109,362**	**23,442**
Total Numbers	8,392	908	217,375	60,948	244,486	54,879	2,318	119	472,571	116,854
% of Bridges	90.24%	9.76%	78.10%	21.90%	81.67%	18.33%	95.12%	4.88%	80.17%	19.83%
% of Total ADT	85.64%	14.36%	83.98%	16.02%	77.69%	22.31%	93.17%	6.83%	83.28%	16.72%

Source: National Bridge Inventory.

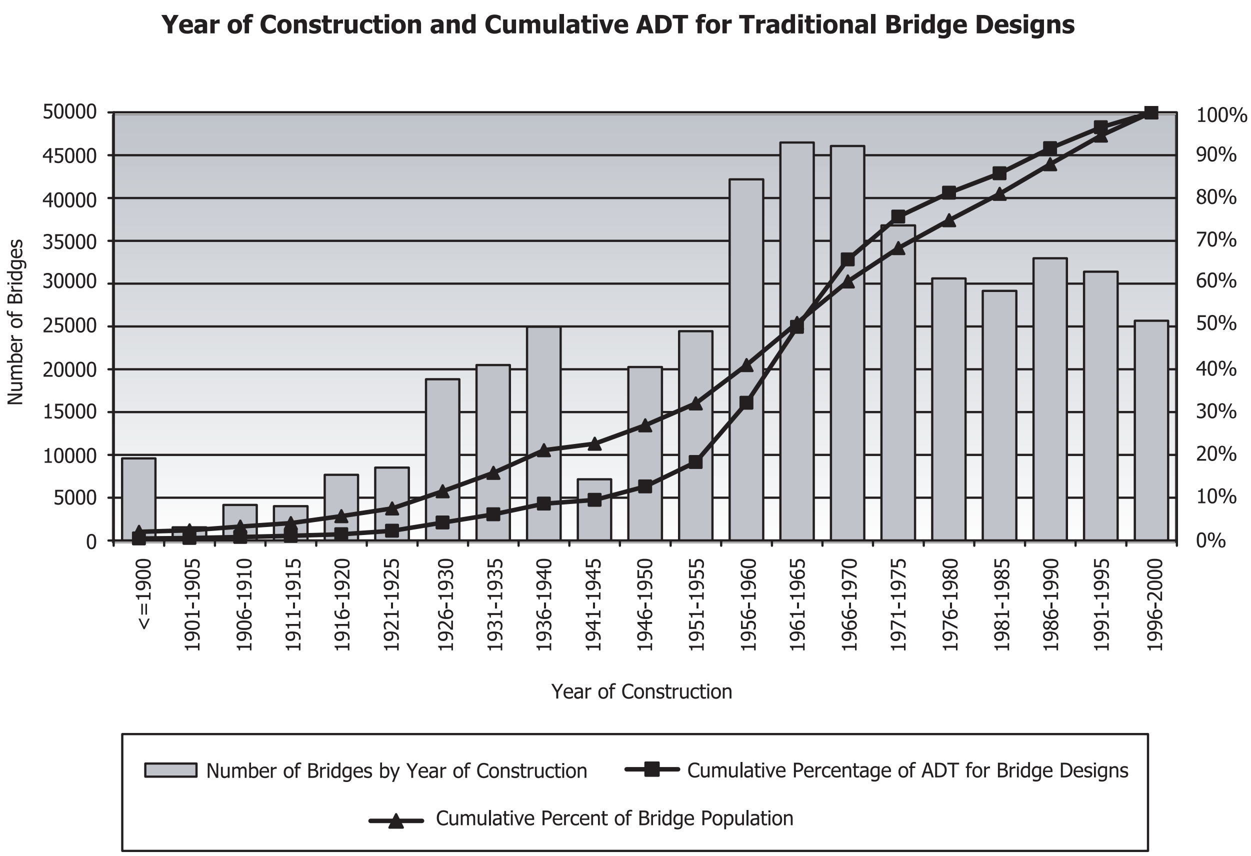
Exhibit 11-44

Average Year of Construction for Traditional Bridge Designs by Ownership and Functional Classification

FUNCTIONAL CLASS	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION): FEDERAL		STATE		LOCAL		PRIVATE		ALL OWNERS	
Rural Bridges										
Interstate	1963	-7	1968	-10	1959	-34	1964	-16	1968	-10
Other Arterials	1962	-20	1963	-22	1968	-29	1954	-19	1963	-23
Collectors	1964	-19	1961	-21	1962	-24	1945	-27	1961	-23
Local	1965	-19	1963	-21	1960	-28	1940	-30	1961	-27
All Rural	1964	-19	1963	-21	1961	-27	1944	-28	1962	-24
Urban Bridges										
Interstate	1967	-8	1970	-11	1962	-14	1966	-14	1970	-12
Other Arterials	1959	-27	1967	-20	1961	-26	1953	-27	1965	-22
Collectors	1959	-14	1964	-22	1961	-26	1952	-32	1962	-25
Local	1958	-22	1968	-20	1961	-27	1946	-33	1962	-26
All Urban	1959	-23	1968	-18	1961	-26	1954	-28	1965	-22
All Structures	1964	-19	1964	-20	1961	-27	1950	-28	1962	-24

Source: National Bridge Inventory.

Exhibit 11-45



Source: National Bridge Inventory.

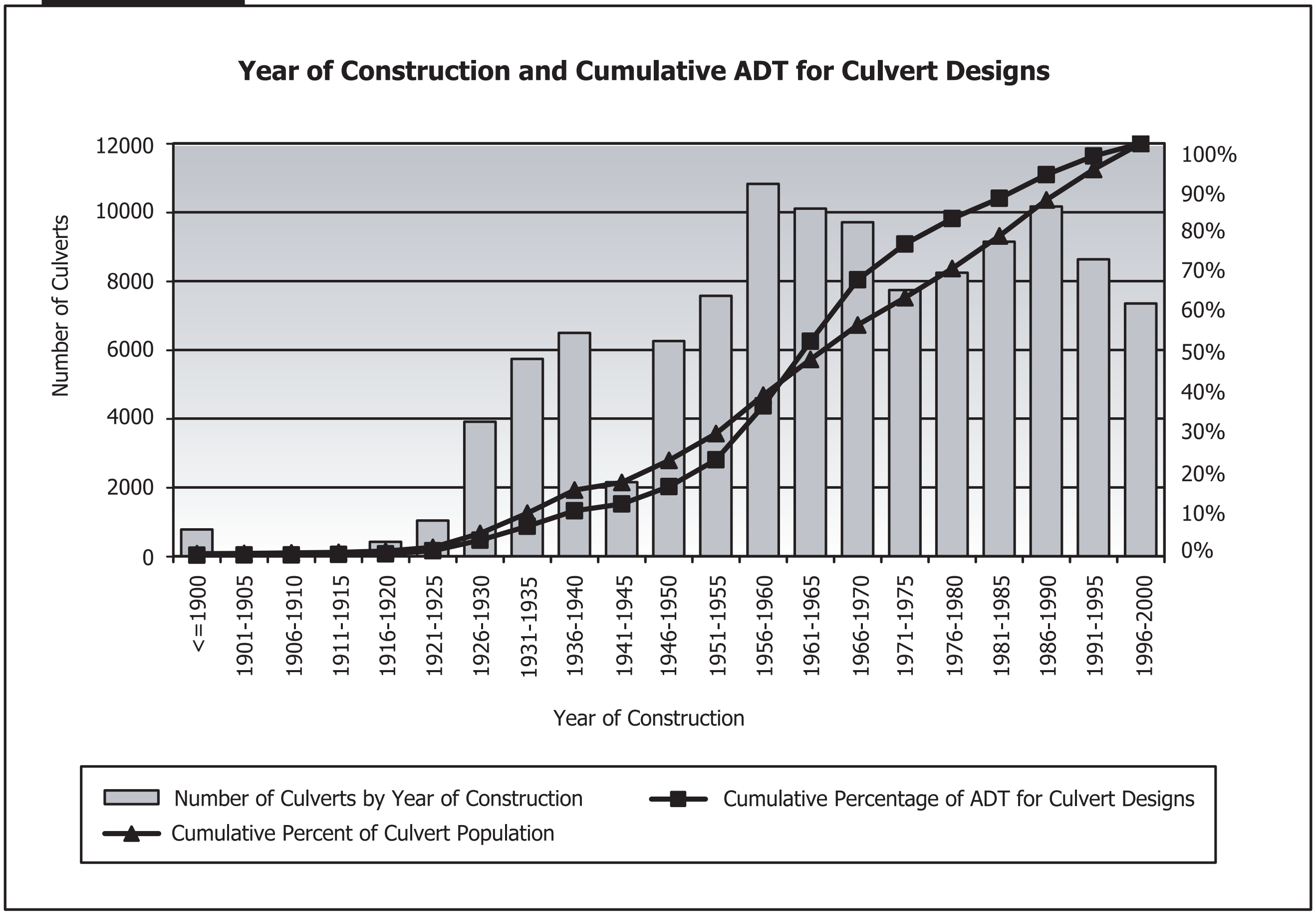
Exhibit 11-46

Average Year of Construction for Culverts by Ownership & Functional Classification

	AVERAGE YEAR OF CONSTRUCTION (AND STANDARD DEVIATION)									
FUNCTIONAL CLASS	**FEDERAL**		**STATE**		**LOCAL**		**PRIVATE**		**AVERAGE**	
Rural Bridges										
Interstate	1964	-2	1965	-11			1956	-12	1965	-11
Other Arterials	1980	-15	1957	-22	1977	-20	1972	-22	1958	-22
Collectors	1961	-17	1959	-19	1967	-20	1956	-30	1963	-20
Local	1969	-19	1977	-18	1974	-22	1975	-24	1974	-22
All Rural	1968	-19	1961	-20	1971	-22	1968	-26	1965	-21
Urban Bridges										
Interstate			1967	-11	1984	-18	1958	-9	1967	-11
Other Arterials	1962	-20	1965	-20	1970	-19	1948	-30	1967	-20
Collectors	1947	-13	1971	-20	1972	-20	1959	-45	1972	-20
Local	1949	-17	1977	-20	1973	-19	1989	-20	1973	-19
All Urban	1954	-18	1966	-19	1972	-19	1966	-29	1970	-19
All Structures	1968	-19	1961	-20	1971	-21	1967	-27	1966	-21

Source: National Bridge Inventory.

Exhibit 11-47



Source: National Bridge Inventory.

Conclusion

Bridges, as critical components of the highway system, must be maintained and preserved to ensure safety to the traveling public, support commerce and mobility within the Nation, and retain the significant accumulated asset value of the inventory. The Nation's bridges and culverts are aging and traffic demands are increasing. At the same time, funds for capital construction are becoming scarcer. Asset management principles through management systems and transportation system preservation techniques are becoming more important as the States, locals and the Federal Government struggle to maintain the safe condition of the Nation's bridges and culverts, while at the same time providing for increased demands on the highway network. Improved bridge and culvert inspection techniques, through the use of new and innovative equipment, are needed to better insure the safety of the motoring public. Longer design life structures, using the latest material and design technologies, are needed so that the Nation can maintain a functional transportation network, provide longer service life, and improve the safety of the highway network. Emphasis is needed on research so that we can continually improve the condition of the Nation's bridges and culverts.