ASBI Durability Survey of Concrete Segmental Bridges

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The American Segmental Bridge Institute (ASBI) recently published the fifth edition of its *Durability Survey of Concrete Segmental Bridges*.[1] This survey includes data up to 2020 and marks 47 years of concrete segmental bridge construction in the United States. With this recent survey, ASBI has also launched an online app that provides a map and database, specific to segmental bridges.[2] The ASBI Segmental Bridge App includes information on all segmental bridges from the 2020 Durability Survey. This article summarizes the performance of bridge types found in the database. Segmental bridges continue to show excellent durability performance, with only 0.7% rated as "poor" in the National Bridge Inventory (NBI) database.[3]

Background

While some bridges are readily identifiable as segmental bridges, particularly during construction, many variations exist. For this survey, segmental bridges are confined to those defined in ASBI's *Definition of Concrete Segmental Bridges*.[4] Only bridges with segmental superstructure elements are included because that is the only segmental attribute type found in the NBI database.[3]

Concrete segmental bridge construction offers several advantages: repetitive construction procedures, minimal impacts on traffic and the environment during construction, economical construction, and a durable structure.[5] Segmental construction is particularly valuable in a variety of difficult site conditions such as when piers need to be placed on small footprints, superstructures need to span natural hazards or community landmarks, or superstructures such as curved highway access ramps need to be constructed on a small or large radius.

Segmental Bridge Inventory

The purpose of the ASBI Durability Survey is to quantify and summarize the existing condition of concrete segmental bridges in the NBI database. While owners can directly identify a bridge as a segmental box girder with the NBI codes for main span or approach span design, not all segmental bridges meeting the definition from ASBI are coded in this manner in the NBI database. Some segmental bridges are coded under one of the prestressed concrete selections or, in rare cases, are coded incorrectly. Each bridge in the data presented in the ASBI survey has been verified to meet one of the concrete segmental construction types defined in the *Definition of Concrete Segmental Bridges*.[4]

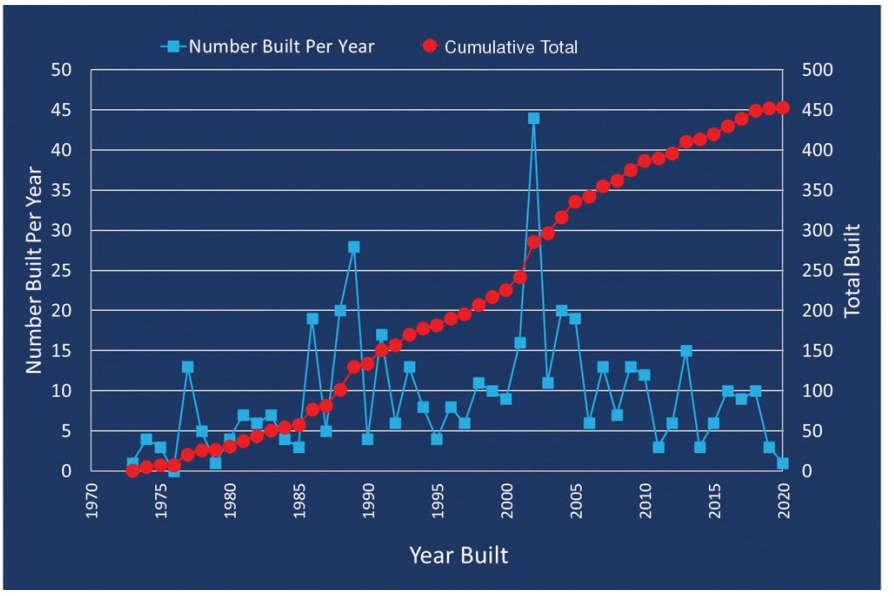
All U.S. states and territories with concrete segmental bridges in their inventories are included in the ASBI survey. In 2020, 46 states and 2 territories had at least one segmental bridge in their inventories, up from 38 in 2012. The four states without any concrete segmental bridges in their inventories are Arkansas, Kansas, South Dakota, and Wyoming. **Figure 1** shows the number of segmental bridges constructed annually along with a running cumulative total. The first recognized segmental bridge in the inventory was constructed in 1973. Each segmental bridge in the survey is assigned an ASBI number for quick reference and can be found in the ASBI online app.[2]

National Bridge Inventory Database

The NBI website includes documents describing the data, data files for direct download, and a link to the Long-Term Bridge Performance (LTBP) InfoBridge website,[6] which provides data and analytics. (See the Winter and Spring 2020 issues of *ASPIRE®* for more information about LTBP InfoBridge.)

As noted previously, the data used in the ASBI survey are NBI data through 2020. States enter data in the NBI according to directions in the Federal Highway Administration (FHWA) coding guide.[7] Since the publication of FHWA's final rule on assessing pavement and bridge condition for the National Highway Performance Program in

Figure 1. Segmental bridges inventoried by year with cumulative totals (through 2020). All Figures: Reproduced by permission from *Durability Survey of Concrete Segmental Bridges*, fifth ed. Austin, TX: American Segmental Bridge Institute, 2022.



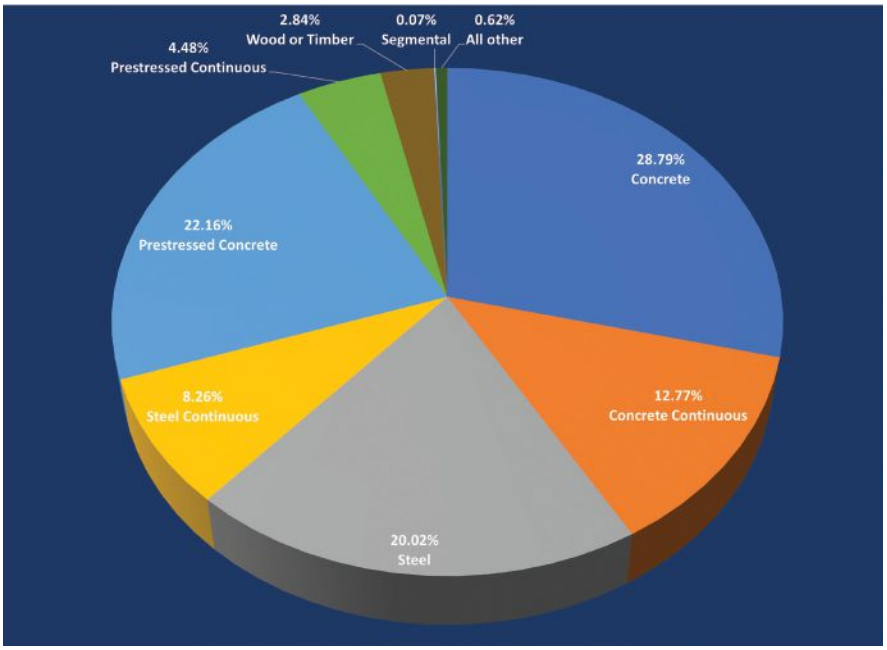


Figure 2. Types of bridges (%) in the full National Bridge Inventory database.

January 2017, overall bridge condition has been rated in the NBI as good, fair, or poor.[8]

Bridge condition ratings are based on the lowest FWHA condition rating among four items: deck, superstructure, substructure, or culvert (items 58 to 61 in the database). Because the lowest item rating controls the overall rating, a poor rating does not necessarily indicate that the segmental superstructure is in poor condition.

Data Presentation and Discussion

The 2020 NBI database includes 618,451 bridges. **Figure 2** shows the breakdown of the inventory by bridge type. Of the bridges in the NBI, 453 (0.07%) have been identified as concrete segmental bridges. Because the first segmental bridge did not appear in the database until nearly 50 years ago, a more representative comparison considers all bridges in the inventory built after 1970 (**Fig. 3**). While the overall number of segmental bridges is only 0.12% of the inventory since 1970, this is an increase of over 70% compared with the number shown in Fig. 2. Other prestressed concrete structures also increase as a percentage of the total inventory in this time frame.

For bridges built from 1970 to 2020, **Fig. 4** shows the percentages of bridges rated as "poor" by type. Considering the percentages shown for the type breakdown in the NBI database (Fig. 3), several materials are overrepresented in the "poor" category (Fig. 4): steel (combined steel, steel continuous), wood/timber, and "all other." Nonprestressed concrete (concrete, concrete continuous) and prestressed concrete (prestressed, prestressed continuous, segmental) have lower percentages of poor ratings than their percentages of the total bridge population. Specifically, segmental bridges represent 0.03% of the poor ratings of bridges constructed since 1970, compared with segmental bridges comprising 0.12% in the full data set since 1970.

Figure 3. Types of bridges constructed since 1970 (%) in the National Bridge Inventory.

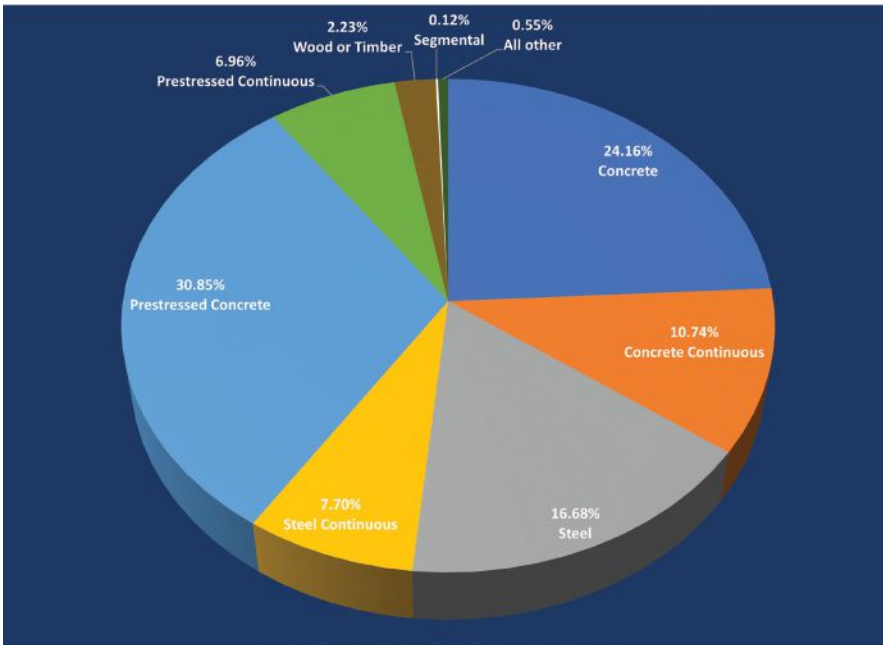


Figure 5 provides another way to visualize the condition ratings of the bridge inventory built since 1970. This figure shows the percentage of bridges in each of the three rating categories (good, fair, poor) within the total number by bridge type. The chart shows bridge types having the largest percentages of poor ratings at the top and gives the total breakdown for all bridges at the bottom. In this figure, the red bar (poor condition) percentage is the equivalent of 3 out of 453 bridges for segmental bridges, whereas concrete continuous bridges with a similar percentage of poor ratings represent 452 bridges out of 37,464 bridges.

Concrete makes up more than 70% of all bridges, and there were 4641concrete bridges in poor condition. In contrast, steel accounts for 24% of bridges built since 1970, but there were 4349 steel bridges in poor condition. These figures demonstrate the longevity and overall lack of deterioration of segmental concrete and prestressed concrete bridges in the inventory relative to other bridge types.

Performance of Older Segmental Bridges

As the first segmental bridges built in the United States are now nearly 50 years old, it is worthwhile to consider the performance of some of these first-generation structures. Significant improvements in design techniques, construction materials, and processes have occurred in the years since they were built.

The John F. Kennedy Memorial Causeway (NBI: 161780061702026; ASBI: 335) was built in 1973 on Park Road 22 over the Gulf Intracoastal Waterway in Nueces County, Texas. It was the first precast concrete balanced-cantilever segmental bridge in the United States. The 2020 NBI

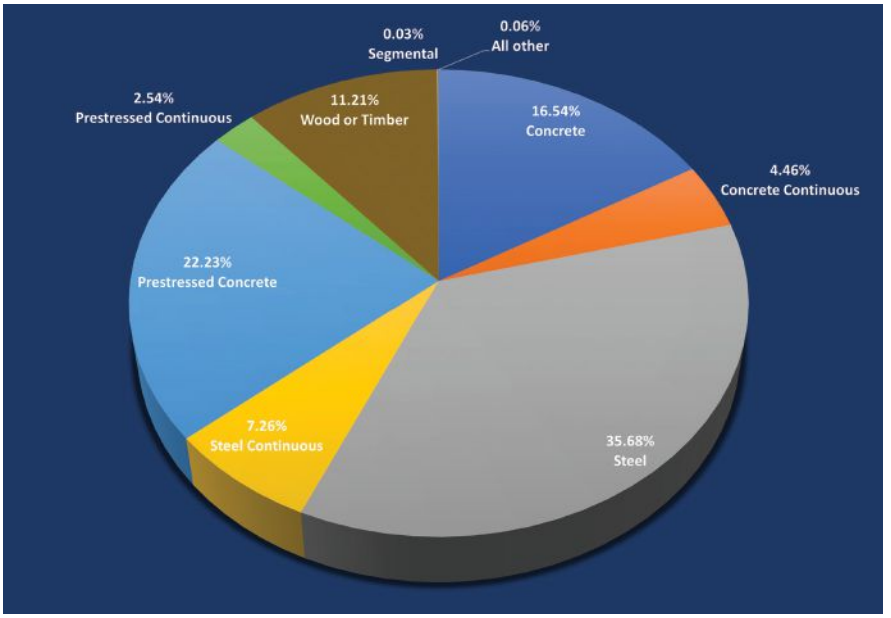


Figure 4. Types of bridges constructed since 1970 that are rated "poor" (%) in the National Bridge Inventory.

data indicate that this bridge is in "fair" condition. The deck, superstructure, and substructure were given a condition rating of 6. This is considered satisfactory. For a bridge that is approaching 50 years old in a marine environment, this is excellent performance. In addition to the routine NBI inspection, the Texas Department of Transportation commissioned an in-depth inspection and appraisal of this structure in 2019, which found very few defects. (See the Project article in the Summer 2021 issue of *ASPIRE* for more details.)

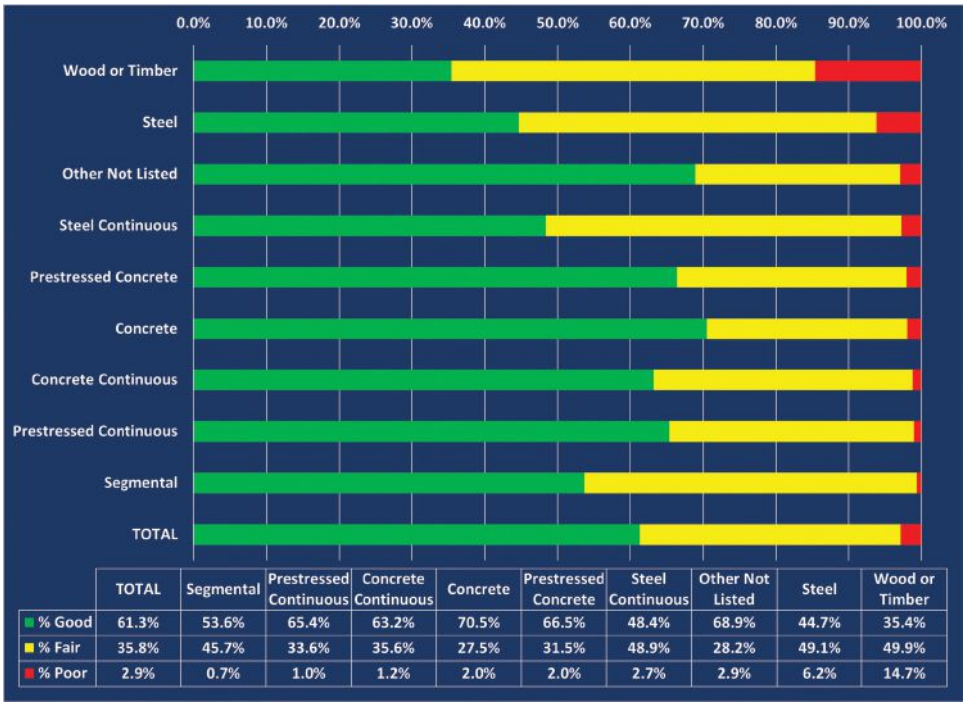
The Pine Valley Creek Bridges (respectively NBI: 57 0692L and 57 0692R; ASBI: 3 and 365) are twin structures built in 1974 in San Diego, Calif., and carry Interstate 8 over Pine Valley Creek. These were the first cast-in-place concrete, balanced-cantilever segmental bridges in the United States. The 2020 NBI data indicate that the deck, superstructure, and substructure of each bridge had a condition rating of 7. These ratings indicate overall "good" condition, which is outstanding for bridges that have been carrying interstate traffic on a daily basis for nearly 50 years.

Conclusion

The NBI data through 2020 show that concrete segmental bridges continue to perform well. Of the 453 segmental bridges in the ASBI Durability Survey, only 3 were rated as being in poor condition. Of those bridges, one is in poor condition due to the substructure (nonsegmental), and the issues with the other two have since been corrected in more recent designs by using improved design methodology, better calculation methods, and better detailing.

Bridges constructed from steel (both steel and steel continuous types) during the past 50 years have a higher percentage of structures rated as poor than concrete structures in that same period. It is reasonable to conclude that a properly maintained concrete segmental bridge can exceed a service life of 100 years, resulting in low life-cycle costs.

Figure 5. Bridges constructed since 1970 in the National Bridge Inventory categorized by type and condition.



	TOTAL	Segmental	Prestressed Continuous	Concrete Continuous	Concrete	Prestressed Concrete	Steel Continuous	Other Not Listed	Steel	Wood or Timber
% Good	61.3%	53.6%	65.4%	63.2%	70.5%	66.5%	48.4%	68.9%	44.7%	35.4%
% Fair	35.8%	45.7%	33.6%	35.6%	27.5%	31.5%	48.9%	28.2%	49.1%	49.9%
% Poor	2.9%	0.7%	1.0%	1.2%	2.0%	2.0%	2.7%	2.9%	6.2%	14.7%

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