PERSPECTIVE

Concrete Bridges: Market Share and Performance

by Angela Tremblay

Over the years, organizations such as the Portland Cement Association, the Precast/Prestressed Concrete Institute, and the American Segmental Bridge Institute (ASBI) have used data from the National Bridge Inventory (NBI) to determine trends in construction materials and bridge conditions.[1–4] The NBI database is maintained by the Federal Highway Administration, with data supplied annually by state departments of transportation, federal agencies, and tribal governments in accordance with the National Bridge Inspection Standards (*Code of Federal Regulations* Title 23, Part 650, Subpart C). The NBI data can be organized and analyzed to give us a snapshot of market share and durability for concrete bridges as compared with bridges of other materials. By evaluating these trends, we can gain insight into growth opportunities within the concrete bridge industry. Specifically, we can use the information to highlight the advantages of concrete bridges in terms of durability and sustainability, and we can identify potential areas for improvement.

Keith Ramsey, senior structural engineer and senior vice president at Strinteg, has analyzed the 2022 NBI data recorded through June 2023 on behalf of the National Concrete Bridge Council (NCBC). As a consultant working with PCI and NCBC, I used the data analysis provided by Ramsey to develop a report on the market share and advantages of concrete bridges. The goals of the data analysis and report are to inform the bridge community about the status of concrete bridges; to inspire us to build on our successes and seek areas for improvement; and to help us innovate, armed with the knowledge we have gained. This article provides a preview of the data and observations on the trends. The full 2023 report is available on the NCBC website (nationalconcretebridge.org).

NBI Data

The 2022 NBI included 474,844 bridges. For the purposes of the inventory, a bridge is defined as a structure that supports a public roadway with vehicular traffic and has a total structure length greater than 20 ft. Buried structures classified as culverts are excluded from the analysis in this article. The relevant data used in this summary article are coded according to the *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges*.[5] The data coding categories used in the data analysis include:

- State code (Item 1): The state code indicates the location of the structure.
- Year built (Item 27): The year built indicates the year that the original construction was completed. It is not affected by any rehabilitation projects, superstructure replacements, or bridge preservation activities. For example, if a new superstructure was placed in 2003 on existing substructure units that were built in 1953, the year built would be coded as 1953.
- Material and structure type of the main span (Item 43): This code represents the predominant material type (for example, concrete, concrete continuous, steel, steel continuous, prestressed concrete-pretensioned or post-tensioned) and the design or construction type (for example, slab, stringer/multibeam or girder, girder and floor-beam system, box beam, arch, segmental box girder). This item only indicates the predominant material and design of the main span, and it does not account for special cases in which multiple materials or designs are found within the same structure.
- Condition rating of the bridge deck, superstructure, and substructure (Items 58 to 60): A condition rating of the deck, superstructure, and substructure is assigned at each bridge inspection. The condition

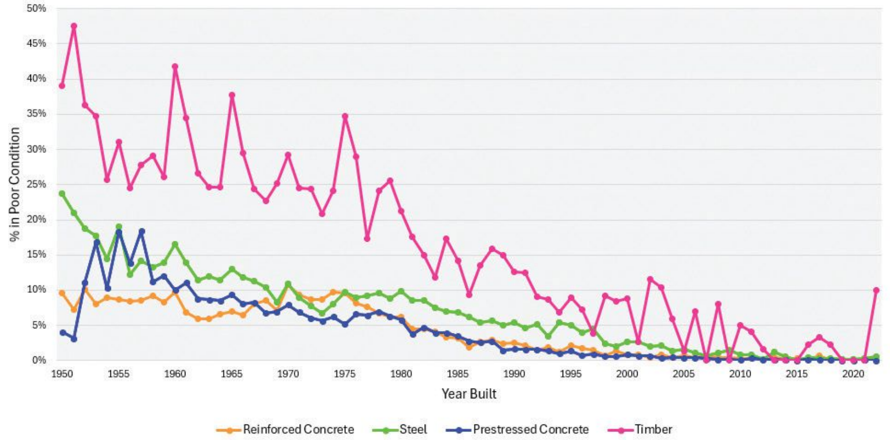

Figure 1. Comparison of the percentage of poor-condition bridges according to year built and construction material. All Figures: National Concrete Bridge Council.

ratings range from 0 (bridge closed) to 9 (excellent condition). In this data analysis, the overall condition of the bridge is taken as the lowest condition rating among these elements. A bridge that rates 4 or less on one or more of the bridge deck, superstructure, and substructure condition ratings is considered to be a "poor-condition" bridge.

There are some nuances and limitations to the NBI data. However, considering that special circumstances make up a relatively small portion of the data set, the trends based on the total number of bridges are still applicable.

Durability

The percentage of poor-condition bridges of a given structure type and material gives an indication of that structure type's durability and performance in safely carrying the design loads. **Figure 1** shows the percentage of bridges built in a given year (from 1950 to 2022) that are still in service and are in poor condition according to NBI data. For example, of the 3299 prestressed concrete bridges built in 1990 that are still in service in 2022, 55 bridges (1.7%) were in poor condition.

For bridges built in the past 30 years, the percentage of poor-condition reinforced or prestressed concrete bridges built in a given year remains consistently lower than the percentage of poor-condition steel or timber bridges. This trend speaks to the durability and longevity of concrete bridges. Concrete segmental bridges fall under the general concrete or prestressed concrete material codes and are therefore included in the overall trends. Specific analysis of the trends for concrete segmental construction are presented in ASBI's *Durability Survey of Concrete Segmental Bridges*[4] and in a summary article in the Winter 2023 issue of *ASPIRE*®.

For bridges older than 30 years, the results show greater variability from year to year. It is more difficult to draw conclusions from the trends in older bridges because after 30 years of service life, maintenance and preservation activities begin to have a greater impact on all bridge types.

Table 1, **Fig. 2**, and **Fig. 3** offer other insights into the data. For example, prestressed concrete bridges make up 40.6% of the total bridges in the NBI built from 1950 to 2022 that are still in service. However, of all the poor-condition bridges built within that time range, only 20.1% are prestressed concrete. Therefore, prestressed concrete bridges make up a smaller proportion of poor-condition bridges considering the percentage of such bridges that are in service. This comparison is interesting, but it does not account for the relative

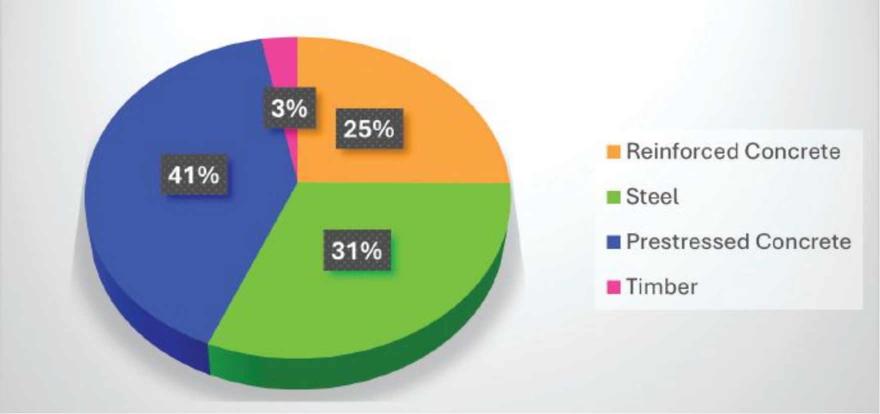

Figure 2. Percentage of in-service bridges built from 1950-2002 by material type.

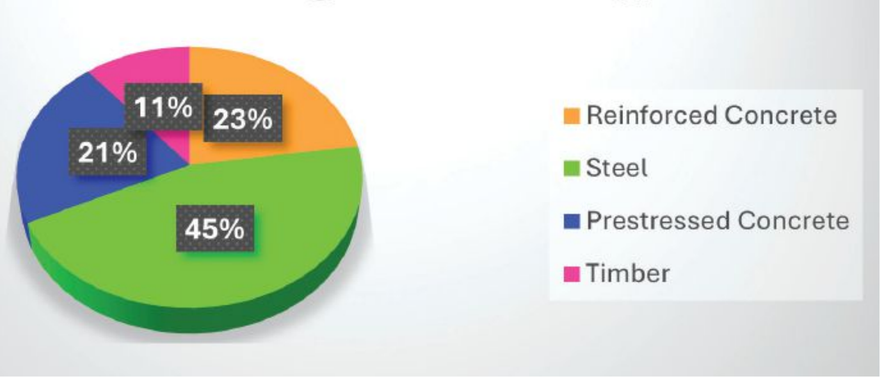

Figure 3. Percentage of poor-condition bridges built from 1950-2022 by material type.

Table 1. Material type comparison for all in-service bridges with a year-built date from 1950 to 2022

	Reinforced concrete	Steel	Prestressed concrete	Timber	All other	Total
Total bridges in service	102,349	127,298	165,880	12,331	273	408,131*
Percentage of bridges in service	25.08%	31.19%	40.64%	3.02%	0.07%	100.00%
Total bridges in poor condition	5396	10,762	5036	2603	22	23,819
Percentage of poor-condition bridges that are of the given material type	22.65%	45.18%	21.14%	10.93%	0.09%	100.00%
Percentage of bridges within the given material type that are in poor condition	5.27%	8.45%	3.04%	21.11%	8.06%	5.84%

* The total number of bridges in this data set represents those bridges with original construction dates from 1950 through 2022. The difference between this total (408,131) and the total number of bridges in the National Bridge Inventory (474,844) is the number of bridges coded with a year-built date before 1950.

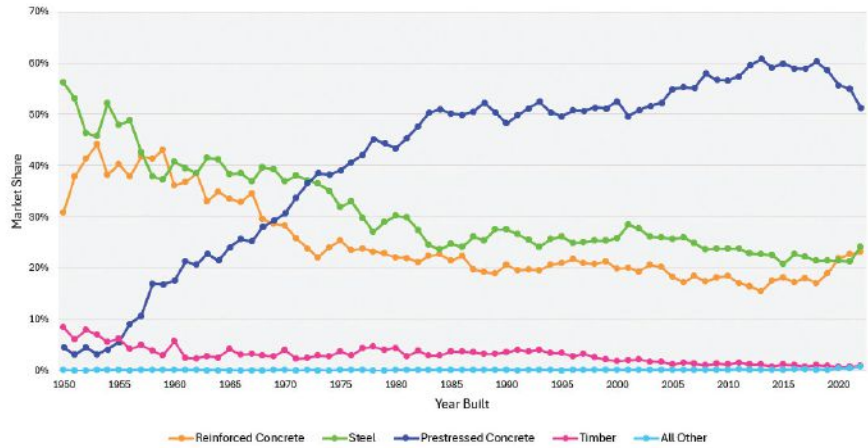

Figure 4. Comparison of the percentage of bridges built per year for different material types.

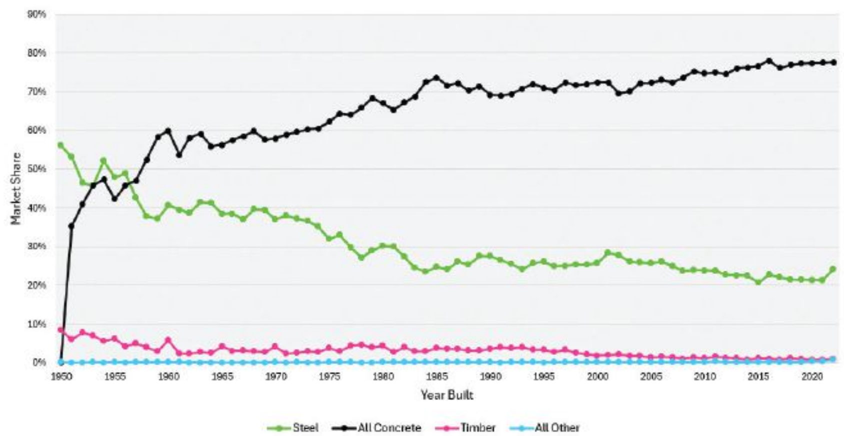

Figure 5. Comparison of the percentage of bridges built per year for different material types with reinforced concrete and prestressed concrete combined into one category.

age of the bridges, which can be seen more clearly in Fig. 1.

Market Share

"The Long Gray Line: Reflections on Concrete Bridge Progress,"[3] which appeared in the Winter 2019 issue of *ASPIRE*, considered how many states (including the District of Columbia and Puerto Rico) built at least 65% of their new bridges from 2007 through 2016 using concrete (either reinforced or prestressed) superstructure types. For that 10-year period, 31 states met the 65% threshold. When we extend this analysis to the most recent decade, we find that for the period from 2012 to 2022, 34 states met the 65% threshold. We can make a similar comparison for prestressed concrete superstructures. Between 2007 and 2016, 23 states built at least 65% of new bridges using prestressed concrete, whereas in the more recent 10-year period between 2012 and 2022, the number of states meeting the 65% threshold increased to 29. These comparisons show an increase in market share for concrete bridge construction across the United States.

Figures 4 and **5** illustrate this increase. Figure 4 shows significant growth in the prestressed concrete market share between 1950 and 1985, then a slower growth rate from 1985 to 2018. The slight decline in market share for prestressed concrete from 2018 to 2022 was accompanied by an increase in the market share for reinforced concrete bridges. The trends in market share considering all concrete bridges combined (Fig. 5) show a slowing of the growth rate and potential plateau in market share over the past 10 years.

Looking Forward

A deeper dive into the NBI data, analysis, and trends may deliver more opportunities to improve our concrete bridge industry and our infrastructure. Some states and owners historically prefer concrete superstructures. What drives that preference? How do material cost and availability affect the choices that owners make?

The most significant growth in the concrete bridge industry between 1950 and 1965 can be attributed to the introduction, acceptance, and widespread use of prestressed concrete beams and the initial construction of the interstate system. Aside from delivering what owners need in terms of cost-efficient and durable solutions, the best way to increase market share is to bring effective innovations to market. So, what is the next big thing for the concrete bridge industry?

In terms of technological advances, further development and acceptance of ultra-high-performance concrete applications and other advances could provide an opportunity for expanding the concrete bridge market share through the use of shallower and/or longer spans. Developing strategies for enhancing structural resilience and sustainability also offer an avenue for improvement and growth. Leveraging these opportunities could ultimately lead to engineering solutions that elevate the concrete bridge industry and have the potential to positively affect our communities.

References

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