Bridge Component Condition Forecast—Base Models

Base models are deterministic statistical models that are easy to understand and implement. With base models, historical time durations for each bridge component (i.e., deck, superstructure, and substructure) of each bridge group are computed from the training subsets of the National Bridge Inventory (NBI) (Federal Highway Administration (FHWA), 1995) data. These historical time durations are applied to bridges of the same type to forecast their condition ratings for deck, superstructure, and substructure.

To date, base models have been developed for bridges with cast-in-place (CIP) decks and three types of superstructures: steel girder, prestressed concrete girder, and concrete slab. In the future, more factors, such as climatic zones and route classification, will be incorporated when assembling the training datasets to improve the performance of the models. The following is a step-by-step description of the modeling approach.

Step 1, Bridge Grouping

Bridges are grouped based on two items in the NBI database: deck structure type (NBI item 107) and main structure type (NBI items 43A and 43B). The inventory data show that more than 75 percent of all bridges have CIP concrete decks. Steel girder, prestressed concrete girder, and concrete slab bridges are the top three main structure types. Models are developed for components of the bridges with these three main structural types and CIP concrete decks. The NBI query criteria and the corresponding number of bridges for each group are shown in Table 1.

Table 1. Bridge Grouping Criteria and Number of Bridges.

Concrete CIP (NBI Item 107 = 1)			Number of Bridges (Based on 2018 NBI Data)	
	NBI Item 43A	NBI Item 43B	Training (Defined in *Step 2*)	Total
Steel Girder	3 or 4	2 or 3	11,892	118,851
Prestressed Concrete Girder	5 or 6	2 or 3	5,453	65,225
Concrete Slab	1 or 2	1	8,483	55,907
Prestressed Box	5 or 6	5 or 6	1,759	30,333
Prestressed Slab	5 or 6	1	405	2,582
Prestressed T-Channel	5 or 6	4 or 2	1,472	6,196
Concrete Girder	1 or 2	2 or 3	3,711	9,639
Concrete Box	1 or 2	5 or 6	914	6,778
Concrete T-Channel	1 or 2	4 or 2	4,646	25,996

Source: FHWA.

Step 2, Training Data Preparation

Bridges that satisfy the following requirements are included in the model training datasets:

1) At least 30 years of NBI data.
2) No increase in deck condition rating.

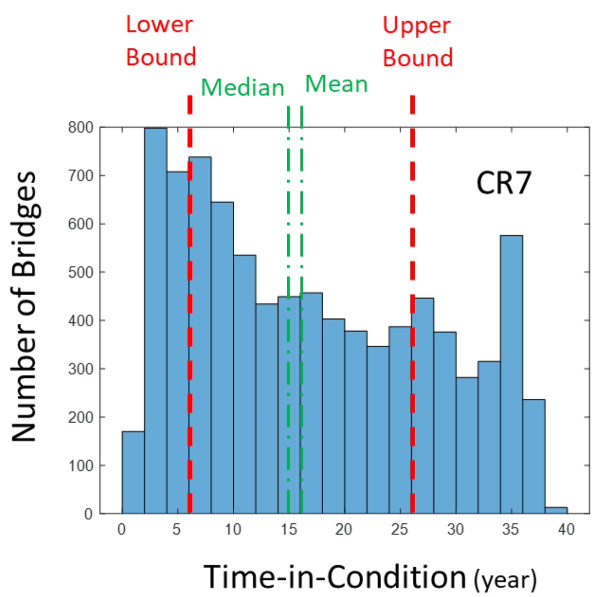
3) No historical data discontinuity.

The number of bridges in each training dataset is shown in Table 1.

Step 3, Computing the Time-in-Condition Statistics

Statistics, including lower bound, upper bound, mean, and median of the time-in-condition for each bridge group and each bridge component (i.e., deck, superstructure, and substructure), are computed from the training dataset for steel girder, prestressed concrete girder, and concrete slab bridges. The lower bound and upper bound of time-in-condition are defined as the 25th percentile and the 75th percentile of the dataset, respectively. A percentile is a measure used in statistics indicating that the value or values fall lower than a given percentage of observations. For example, at the 25th percentile, the observed values fall lower than 25 percent.

Figure 1 depicts the histogram of the training dataset for decks of steel girder bridges with condition rating 7 (CR7). The lower bound, upper bound, mean, and median values computed from the training dataset are shown as vertical lines in the figure. For each bridge group, time-in-condition statistics are computed for each bridge component to generate the values needed for the next step.



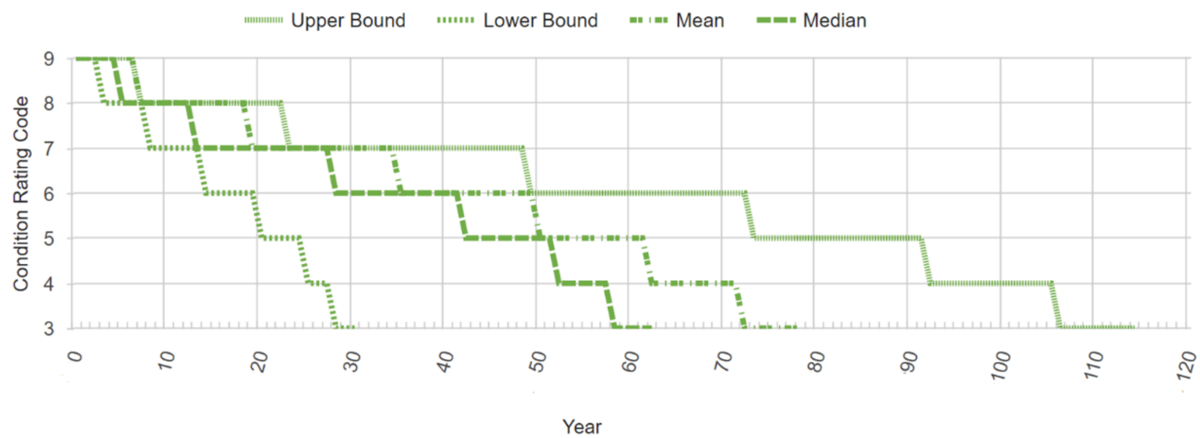
Source: FHWA.

Figure 1. The Histogram of CR7 of CIP Concrete Decks of Steel Girder Bridges.

Step 4, Creating Condition Rating Life Cycles for Each Bridge Group

The time-in-condition statistics computed in the previous step are used to create bridge component life-cycle predictions for bridge components of each bridge group. The life-cycle prediction stops at condition rating 3 (CR3). The assumption is that reaching CR3 will trigger rehabilitation or replacement projects, and consequently, forecasting beyond that level would be futile. In addition, data at CR3 or lower are sparse and would not result in reliable forecasts.

As an example, Figure 2 presents the life cycles for CIP concrete decks of steel girder bridges. The lower bound, mean, median, and upper bound values of the life cycles are shown as stepped curves.

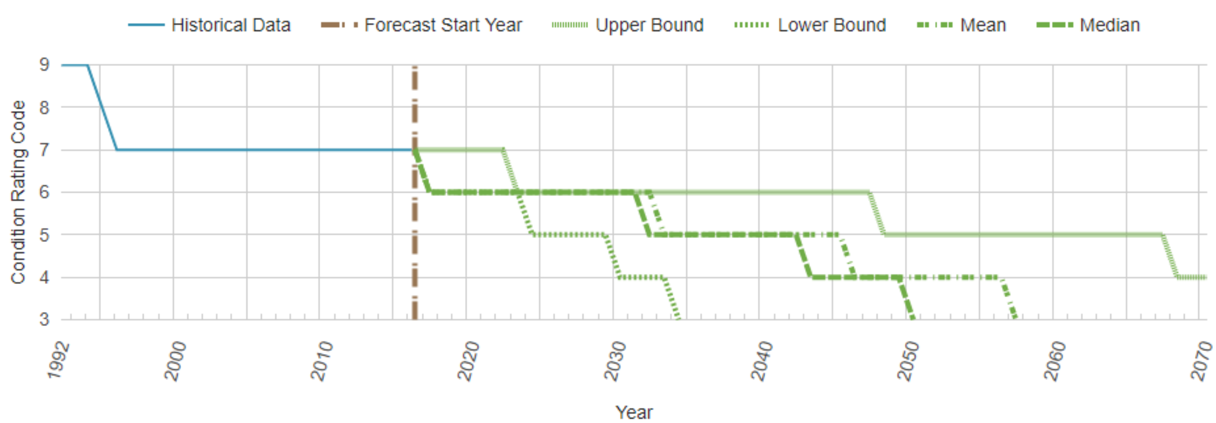


Source: FHWA.

Figure 2. The Life Cycles for CIP Concrete Decks of Steel Girder Bridges.

Step 5, Condition Forecast for Each Bridge Component

The life-cycle curves developed in step 4 are used in conjunction with the historical condition ratings to develop condition forecast curves. Four condition forecast curves are created for each bridge component representing the lower bound, median, mean, and upper bound of condition ratings. Figure 3 presents an example of the developed condition forecasting curves and how they appear on the Long-Term Bridge Performance (LTBP) InfoBridge™ (FHWA, 2019) website.



Source: FHWA.

Figure 3. An Example of Deck Condition Forecasting Curves.

References

1. Federal Highway Administration. (1995). *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, Report No. FHWA-PD-96-001*. Washington, D.C., obtained from: https://www.fhwa.dot.gov/bridge/mtguide.pdf, last accessed March 18, 2020.

2. Federal Highway Administration. (2019). *Deck Condition Forecasting Curves*. InfoBridge. Washington, D.C., obtained from: https://infobridge.fhwa.dot.gov/, last accessed March 18, 2020.