PERFORMANCE COMPARISON OF IN-SERVICE, FULL-DEPTH PRECAST CONCRETE DECK PANELS TO CAST-IN-PLACE DECKS

Esmail Shahrokhinasab, RA, Florida International University, (786)812-1047, eshah004@fiu.edu
David Garber, Ph.D., P.E., Florida International University, (305)348-4879, dgarber@fiu.edu

INTRODUCTION

Full-depth, precast concrete (FDPC) deck panels have been heavily used in bridge construction since the 1970's [1]. The use of these panels has traditionally been thought to both accelerate construction and improve the long-term durability performance of the bridge deck. While many engineers and academia are intrinsically aware that precast can perform equally or better than cast-in-place concrete, the evaluation between the two has never been studied holistically [2]. The main objective of this project was to determine the actual in-service performance of full-depth, precast deck panels compared to conventional cast-in-place (CIP) decks. The secondary objective is to determine successful and problematic details for these members.

METHODOLOGY

Initial information on behalf of FDPC deck panels and their performance were obtained through a survey of bridge owners, assembly of a full-depth precast deck panel database, and evaluation of bridge performance using available National Bridge Inventory (NBI) data [3]. The survey was sent out to all State DOTs and focused on gathering information related to FDPC deck panels including a list of successfully completed bridge projects utilizing the panels. The result of this effort was a database with over 280 bridges in the US that have used FDPC deck panels. Figure 1 shows the distribution of the database based on the states and construction time.

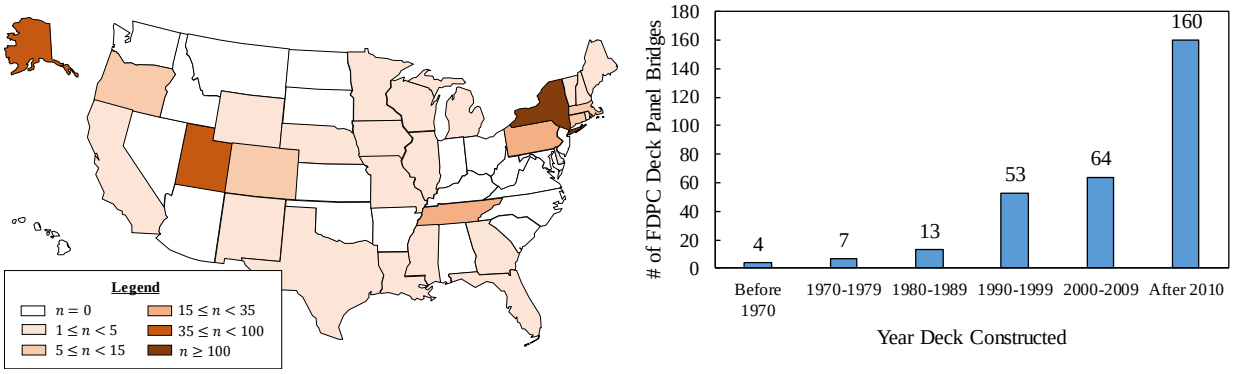

Figure 1: (a) Distribution of FDPC deck panels in all states, (b) Number of bridges utilizing FDPC deck panels in each decade

States also provided information on one or more comparison projects (two similar projects, one utilizing FDPC deck panels and the other CIP decks). Additionally, for all other bridges in the database, an appropriate comparison bridge with a CIP deck was chosen based on the specification of the bridge with FDPC deck panels. Main span materials and design, wearing surface, age, length of the largest span, and average daily traffic were the main criteria for choosing comparison projects. These comparison projects were used to evaluate the long-term performance of FDPC deck panels through the NBI, collected inspection reports, and the Long-Term Bridge Performance (LTBP) InfoBridge [3], [4].

DATABASE ANALYSIS

Analyzing database and comparing the performance of bridges with FDPC deck panels to CIP decks had been done based on two different procedures:

1- Direct side-by-side comparison according to the rating trend during the bridge life
2- Group comparison based on general system performance, which focused on classifying the important parameters like climate, structure type, traffic condition, and more.

Furthermore, two values were used to compare the performance of bridges with FDPC deck panel decks to those with CIP decks: (a) deterioration rate of the deck and (b) estimated service life.

Deterioration Rate and Estimated Service Life

The calculated variables used to compare the performance of the bridges were deterioration rate and estimated service life. The deterioration rate is the slope of the linear regression of the year and deck rating since the time of deck construction. The estimated service life of the deck was calculated based on the time it takes for the deck rating to reach a rating of 4, based on the deterioration rate and the starting deck rating. A deck rating of 4 was used as the threshold for deck repair needed as this value corresponds to the boundary between fair and poor behavior used by previous researchers [5].

Ranking of Comparison Projects

All comparison projects needed to have the same of the following parameters to be considered valid comparisons:

- Material and structure type
- Overlay or wearing surface
- Climate zone

Both comparison projects needed to either have an overlay or wearing surface or not have an overlay or wearing surface. The type of overlay did not need to be the same for the comparison projects.

Other variables could have different values between them. The quality of the comparison was rated based on how similar the comparison projects were with these other criteria. These variables included:

- Span length
- Year of construction
- ADT/ADTT

A rating was given to each comparison based on the degree of similarity of the values for each of the comparison projects.

RESULTS

The results of this study are summarized in two categories:

Side-by-Side Comparison

A side-by-side comparison was conducted for the 280 comparison projects from entire FDPC Deck Panel Database. In 49 of the 172 comparison projects, the bridge with a CIP deck had a higher deterioration rate, shown in Figure 2. The bridge with a FDPC deck panel deck had a higher deterioration rate in 76 of the 173 comparison projects. The bridges with the two types of decks had the same deterioration rates in 47 of the comparisons.

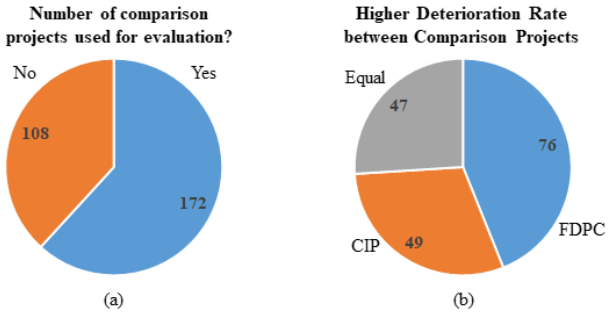

Figure 2: (a) Number of comparison projects used for evaluation (b) type of bridge with higher deterioration rate

Bridges with FDPC deck panels were found to have a similar performance (similar deterioration rate and estimated service life) to the comparison bridges with CIP decks. Table 1 summarizes the overall comparison of FDPC deck panel decks and CIP decks

Table 1: Overall average performance of bridges with FDPC deck panel decks and CIP decks

Deck Type	*FDPC*	*CIP*
$n_{bridges}$	206	177
Avg. $n_{inspections}$ *per bridge*	12.5	13.0
Avg. Year of 1^{st} *Inspection*	2004	2005
Deterioration Rate	-0.12	-0.09
Estimated Service Life (year)	33	35

Performance Comparison Based on the Classification of Variables

Important variables that were used for comparison purpose includes: joint type, impact category, climate zone, wearing surface, main span material type and traffic volume.

CONCLUSION

The performance of FDPC deck panel and CIP systems was evaluated based on the NBI deck rating. The average performance of bridges with FDPC deck panels were compared with similar bridges with CIP decks. Results showed almost similar performance for both bridges with FDPC deck panel and CIP decks. As the precast panel itself offers superior durability to CIP decks, these results may suggest that there is room for improvement with joint design and construction.

These performance comparisons were further evaluated in several subcategories. Focusing on joint types revealed that UHPC with straight bar (for transverse or longitudinal joints), longitudinal post-tensioned (for transverse joints), and conventional concrete with hooped bar details (for longitudinal joints) are most popular and have good performance. Considering climate condition showed that shortest average estimated service life is observed in cold climate zones due to a lot of freeze-thaw cycles, which combined with moisture and deicing salts. Also, results showed that all overlay types and bridges without overlays perform almost similarly. There are limitations to this approach, but this work can be used as a starting point to a more in-depth evaluation of these projects (e.g. non-destructive testing) and revisited every 5 to 10 years as the bridges continue to age and new bridges are constructed.

REFRENCES

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