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INSPECTION AND MAINTENANCE

OF CONCRETE BRIDGES

By

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Presented to the American Society of Civil Engineers Specialty Conference, May 18, 1984

INTRODUCTION

I am very pleased to speak to you this afternoon on the subject of inspection and maintenance of concrete bridges.

I'll start out with some background on the different types of bridge structures we have on our highways in Texas; with emphasis, of course, on concrete structures that include both cast-in-place and precast, prestressed types. We'll then talk about some of the different items of inspection considered peculiar to concrete structures, followed by some items of maintenance common to concrete structures. I also want to cover some of the remedies of problems found on concrete structures, as well as some of the remedies of design deficiencies.

STRUCTURE TYPES

There are many ways to type classify bridges. As to function they may generally be classified into two groups: (1) crossings of streams and other similar topographical features and (2) grade separation structures.

On our highway system these two groups break down to about 77% and 23% respectively. Of the 30,000 bridge classified structures there are about 23,000 stream crossing bridges and about 7,000 grade separation structures. In bridge inspection there are of course many items that are looked for that are associated with the function; like, for instance, overheight load damage on grade

STRUCTURE TYPES

TYPE	NO.	PCT.
TIMBER	116	.39
STEEL	3910	13.00
CONCRETE (CIP)	9159	30.50
CONCRETE (PS)	3978	13.30
STEEL TRUSS	134	.45
CULVERTS	12470	41.60
MISC.	241	.80
	30008	100.00

FIGURE 1

STRUCTURE TYPES

TYPE	NO.	PCT.
Concrete (CIP)	9159	30.5
Concrete (PS)	3978	13.3
Other	16871	56.2
	30008	100.0

FIGURE 2

STRUCTURE TYPES

TYPE	NO.	PCT.
CONC GDR (CIP)	1424	10.8
CONC GDR (CIP) (PF)	3537	26.9
CONC SLAB (CIP)	4198	32.0
CONC GDR (PS)	3728	28.4
CONC BOX GDR (PS)	250	1.9
	13137	100.0

FIGURE 3

separation structures and stream drift damage on stream crossing structures.

Now, as to structure types proper, we've got a wide selection of bridge types in our State./(Fig. 1) Of the approximately 30,008 bridges, about 13% are steel stringer or girder; 30.5% are cast-in-place concrete, and prestressed concrete represents 13.3%. Timber, steel truss and miscellaneous types represent small percentages at .39%, .45% and .80% respectively. Of course, bridge-classified culverts represent the largest group at 41.6%. Most of these are of the cast-in-place concrete multiple-box type but we are building a few precast boxes these days too.

As to the bridges on our public roads and streets that are off the State Highway System. We have about 16,100 of those. Our Department does not have maintenance responsibility for these structures nor do we have statutory authority to regulate them. However, we do have records of these bridges in our statewide inventory file that are used to prioritize replacement and rehabilitation projects. So, we do inspect these Off-System bridges as necessary to keep the records up-to-date. The biggest percentage of these Off-System bridges are of timber at 35.8%, followed by steel and culverts. Cast-in-place concrete structures amount to approximately 12.2%.

Now, as to the concrete structures on our State Highway System, we said the cast-in-place and prestressed types represent 30.5%

and 13.3% respectively for a total of 43.8%, which leaves all the other types lumped together at 56.2%. (Fig. 2)

The cast-in-place concrete group mostly consists of the T-Beam, pan-formed concrete girder and integral slab types./ (Fig. 3) We've built several different configurations of T-Beams and slabs. We've built them both simply supported and continuous, and constant depth as well as variable depth.

We began building pan-formed concrete girder structures in the mid 50's as an alternative to the more expensive T-Beam design. The pan girder construction uses reusable metal forms while T-Beam and slab construction use the conventional throw-away lumber form work. Until recent years all our pan girder structures were constructed in simply supported spans.

Most of our prestressed structures are of the pre-tensioned concrete I-Beam type, but during the last very few years we've also built a number of prestressed concrete box girder bridges./ (Fig. 3) The box girder bridges are becoming popular primarily because of their simplicity of construction; erection and form work for slab-pouring are relatively simple.

Virtually all our prestressed concrete I-Beam structures have been constructed in simply supported spans; but often in recent years we've made the deck slabs continuous over several spans. This makes for a smoother ride plus results in fewer deck joints to maintain, and less deicing salt meltwater and other contaminated drainage flowing down onto the substructure.

INSPECTION OF CONCRETE STRUCTURES

As you probably know we are required under the National Bridge Inspection Standards, to perform bridge safety inspections on all our highway bridges every two years with qualified inspectors.

We support this bridge inspection program not only as a requirement to meet in order to qualify for Federal bridge funding, but as being one of the responsibilities in properly maintaining the State Highway System. We believe the public has every right to expect safe and properly maintained bridges on the Highway System, and that attainment of this ideal can be assured only through proper bridge inspection and follow-up maintenance and repair.

We train our inspectors to perform these inspections in a thorough, systematic manner taking care to check each of the bridge's six components and the elements within each of the components. These components include the roadway, superstructure, substructure, channel and channel protection, retaining walls and the approaches. Each component is assigned a condition rating which is a one-digit code of "0" through "9".

In performing his inspection and reporting results, our inspectors use a form we call the Bridge Inspection Record. This form serves the purposes of both checklist to assure no important component or element is overlooked, as well as the very important function of reporting inspection findings. For the inspector's ready reference the rating descriptions are printed on the form. Condition ratings are taken from this form and posted to the computerized bridge inventory inspection and appraisal file maintained at the main office in Austin. Other information on problems or potential problems found on the bridge is referred to the Maintenance Engineer's Office for scheduling of remedial maintenance and repair .

Now, concrete can crack, spall, scale and delaminate from the reinforcing steel. Additionally, prestressed concrete can be shattered by impacts, or perhaps even have reverse deflection due to creep of the concrete. The inspector looks for these faults and evaluates them as to possible effects on the structure and the degree of remedial maintenance or repair required.

In particular, concrete decks typically will exhibit some cracking and scaling and in many instances, spalling and delamination will additionally occur.

A problem typically found on our simply supported concrete T-Beam spans is spalling of the girder web over steel bearings. This problem is widely believed to be due to "freezing" of the bearing, but probably the problem is at least contributed to by clogging of the deck expansion joints.

Our pan girder structures seem to be particularly susceptible to corrosion of reinforcing steel, when even small amounts of deicing salt or salty marine environment are present. This appears to be due primarily to the relatively thin sections and typical use of minimum cover over the reinforcing steel, and small cracks do occur. It does not take much of a crack to allow salt-contaminated moisture to get to and corrode the reinforcing steel. Corrosion is an expansive process that allows even more moisture to intrude and more corrosion at a faster rate, and eventually serious damage.

Another problem with our pan girders lies with the deck joints that eventually become clogged with incompressibles. So, when the spans expand in warm weather the movement occurs, not in the expansion joints as it should but can't due to the clogging, but in breaking the bent caps and/or bending the bents in longitudinal direction away from the center of the bridge. Now, this bending can be serious because piling and round columns are not designed to take bendings, not very much anyway. The clogging problem is further compounded by the extreme difficulty in cleaning out the joints. The joints are formed between the solid endwall diaframs of adjacent spans, and are typically 30" deep and only about 1" to 1½" wide. High pressure water jet machines can do a lot but usually some hand labor is also required to remove the larger, jammed-in particles.

To date our prestressed concrete I-Beam structures have served well. We haven't had much of a maintenance problem with them, except perhaps for those on grade separation structures that get hit by overheight loads. Shattering of the concrete away from the prestressed tendons is common. It doesn't seem to take much of a lick to do a lot of damage, as compared to cast-in-place members. Now, what we do with these damaged prestressed beams leads into what I wanted to say anyway about some other remedies we take for various problems.

REMEDIES OF PROBLEMS ON CONCRETE STRUCTURES

As to the collision damaged prestressed beams, if we consider a significant amount of structural capacity has been lost, we replace the beam. If not, then we patch the beam over. To date we haven't attempted the procedure of restoring prestress and then patching, because of the extended length of time shoring would be required from underneath. This shoring would usually require closure of the underpassing roadway, a practice that's very undesirable on the Interstates and other high-volume traffic highways on which these collision damages usually occur.

On concrete deck repairs we try to use the low-slump, high density conventional concrete if we can. If the curing time this takes, gives us problems we often use a nonchloride set accelator.

For the spalling webs over bearings on concrete girder T-Beams, we typically try to restore support by installing concrete or steel pedestals between the girders and underneath the end diaframs. Movement is allowed by the pedestals being topped off with rollers or neoprene pads.

On the pan girder bridges with the clogged joints, if the problem hasn't progressed to excessive rotation of or damage to bents, we try to remedy the situation by cleaning out and resealing the joints. If this is not sufficient, the damaged bents are either replaced or supplemented with additional supports; some more elaborate than others.

In any event at least the joints are cleaned out and resealed, which is a maintenance function we try to keep up with before the serious problems occur. Obviously we don't always get this maintenance done in time; usually due to so many other maintenance priorities our Department has.

MAINTENANCE OF CONCRETE STRUCTURES

In maintaining bridge decks, our Department's practice is to seal them with linseed oil or an asphaltic system or a combination of the two, as part of construction. Also, for decks without an asphaltic protection system that are exposed to coastal saltwater or deicing salt, additional linseed oil treatments are used. We are convinced that our linseed oil program has saved many bridge decks over the years that otherwise would have required replacement or extensive repair.

For decks on which it is usual practice to use three or more salt applications per year a protection system is provided, usually consisting of a two-course asphalt surface treatment and asphaltic concrete overlay. Our practice is to apply a surface treatment on a bridge deck ahead of an asphaltic concrete overlay. We learned at considerable expense a long time ago that asphaltic concrete by itself does not adequately seal.

Also, in deicing salt use areas we typically will flush and sweep the deck off once a year to remove salt residue from the previous season. Left intact this salt becomes reactivated every time moisture is present, and this can cause nothing but eventual deterioration of the bridge deck.

Speaking of moisture, something else that gives a lot of maintenance problems is the improper handling of deck drainage. If the drainage is just dumped at the end of the bridge the approach fill could become saturated and cause problems. If the drainage is salt contaminated and not directed away from the structure properly, concrete deterioration problems could occur.

REMEDY OF DESIGN DEFICIENCIES ON CONCRETE STRUCTURES

The last major area I wish to discuss is a remedy our Department has implemented to address a problem that was "designed-into" our pan girder structures. As I said the problem had to do with the deck joints being difficult to clean out, and allowed to clog up with incompressibles.

Our Bridge Design people have developed a design that ties these spans into three-span continuous units, thereby drastically reducing the number of deck joints. Open expansion joints of the armored type, are provided at the ends of each three-span unit. Also, underneath the open joint between the girder stems, ports are provided to better accommodate clean-out of the joints. So, the benefits of this remedy are threefold: (1) the fewer number of joints results in fewer to clog up and require attention in the first place; (2) we have a smoother ride; and (3) the clean-out port capability. This is an excellent example of what bridge maintenance and bridge design people can accomplish if they will just communicate with each other. This communication is a two-way street; however, they both have to work at it to make it happen.

CONCLUSION

In closing I hope the information I've tried to share with you this afternoon is helpful and contributed at least in a small way to our knowledge of this broad, complex and very essential field of bridge inspection and maintenance.

Indications are that bridge inspection and maintenance is going to have to play an even more prominent role in our highway operations in the years ahead. Traffic volumes keep rising on our bridges but we cannot replace and rehabilitate those bridges at as high a rate. So, this means many obsolete and deficient bridges are going to be kept in service longer, and its going to be only through proper monitoring and timely maintenance that these bridges are going to be kept safe and in dependable, continuous service in a cost-effective manner.

Thank you.

BIOGRAPHICAL DATA

- Ralph K. Banks, Supervising Field Maintenance Engineer , Safety and Maintenance Operations Division, State Department of Highways and Public Transportation.
- Native of Mt. Vernon, Texas
- 1963 Civil Engineering Graduate of the University of Texas at Austin.
- Has been with the State Department of Highways and Public Transportation for 21 years and has had a wide range of staff-type highway maintenance assignments.
- Currently is assigned as a Maintenance Liaison Engineer for 4 of the 24 DOHPT Districts, and staff coordination at the DOHPT Main Office level of bridge maintenance and bridge safety inspection.
- Author of numerous papers on bridge maintenance and inspection:
  - (contributing author) "Routine Maintenance of Concrete Bridges", Concrete International, October 1983.
  - "Condition of County Road and City Street Bridges in Texas", AASHTO Quarterly, July 1982.
  - "Bridge Deck Restored By Partial Depth Replacement", Public Works, December 1978.
  - "Bridge Inspection Techniques", Public Works, September 1978.
  - "Manual of Procedures for Bridge Inventory, Inspection and Appraisal Program (BRINSAP)", Texas State Department of Highways and Public Transportation.
- Member, American Concrete Institute Committee on Bridge Construction and Maintenance - 6 years.