DEFECTS IN CONCRETE AND WOODEN BRIDGES

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Abstract

The daily traffic on bridges and the factors that causes the tiredness of materials, cause damages, even the collapse of these works, if there is not a policy of maintenance allowing the detection of possible defects in these structures and the intervention in the convenient period. To intervene in order to prevent defects and to restore damaged bridges, is very important that these defects to be identified correctly.

Key words: damage, bridge, concrete, timber, delamination, fungi

INTRODUCTION

Building materials are decayed by the effects of adverse environmental conditions and the extent of damage depends on both the materials and the conditions.

Bridge decks is exposed to aggressive environmental factors such as freeze-thaw cycles in addition to ever-increasing traffic loads that make it the weakest link of the bridge system in terms of performance and service life. The deterioration of the deck affects the quality of the riding surface and traffic safety, stiffness, load distribution characteristics, and load carrying capacity.

DAMAGE ASSESMENT IN CONCRETE BRIDGE

The concrete slab-on-girder system is one of the most common bridge superstructure systems in forestry crossing works. The termination of the service life of concrete bridge decks is associated with the accumulation of irreversible damage resulting from corrosion of reinforcement, freeze thaw cycles, traffic loading, in addition to the initial damage resulting from poor design and /or construction and inadequate inspection and maintenance practices.

The main factors that control the durability of concrete bridge decks include:

- Depth and permeability of its cover that provides a mechanical barrier to the action of water and oxygen;
- Protection of the deck (membrane, epoxy coating, cathodic protection);

- Routine inspection and maintenance such as drainage and joint systems and repair of cracks.

It should be pointed out that most failures of bridge decks are due to loss of serviceability and functionality and not loss of strength and collapse. The ultimate limit state strength of concrete bridge decks is greatly enhanced by the high level of compressive membrane action that makes failure due to punching shear the governing failure mode as opposed to the flexural failure mode. The two most common causes of **reinforcement corrosion** are: localized breakdown of the passive film on the steel by chloride ions and general breakdown of passivity by neutralization of the concrete, predominantly by reaction with atmospheric carbon dioxide. Cracks in concrete formed as a result of tensile loading, shrinkage or other factors can also allow the ingress of the atmosphere and provide a zone from which the carbonation front can develop. If the crack penetrates to the steel, protection can be lost.

Delamination occurs in reinforced concrete structures subject to reinforcement corrosion, in which case the oxidized metal of the reinforcement is greater in volume than the original metal. The oxidized metal therefore requires greater space than the original reinforcing bars, which causes a wedge-like stress on the concrete. This force eventually overcomes the relatively weak tensile strength of concrete, resulting in delamination of the concrete above and below the reinforcing bars.

Concrete spalling is usually caused by corrosion of the steel reinforcement bars embedded in the concrete matrix or by the exposure of the concrete to high temperatures. Spalling itself is actually the deterioration of the concrete causing chunks of the concrete to separate from the concrete structure.

Traffic damage mostly results from trucks. Wheels cause the road to flex slightly, resulting in fatigue cracking, which often leads to cracking. Vehicle speed also plays a role. Slowly moving vehicles stress the road over a longer period of time, increasing ruts, cracking, and corrugations in the asphalt pavement.

TYPES AND CAUSES OF TIMBER DETERIORATION

Timber remains one of the most useful in a world of diminishing resources and is a major component in most historic buildings. It has many positive structural and aesthetic properties as well as being an energy-efficient and renewable resource.

Wood is an amazing combination of polymers that exhibits both strength and durability as a structural material. Nevertheless, from the time it is formed in the tree, wood is subject to deterioration by a variety of

agents. Damage ranges from relatively minor discolorations caused by fungi or chemicals to more serious decay and insect attack. Wood outperforms most other materials when used in a properly designed and maintained structure; however, when used in adverse environments, it must be protected to ensure adequate performance. Although the use of pressure-treated wood has significantly extended the life of timber, decay is still the primary cause of bridge deterioration.

Wood deterioration is a process that adversely alters wood properties. In broad terms, it can be attributed to two primary causes: biotic (living) agents and physical (nonliving) agents. In most cases, wood deterioration is a continuum, whereon the degrading actions from one or more agents alter wood properties to the degree required for other agents to attack.

Fungi - Decay is the primary cause of timber bridge replacement. Decay is the process of living fungi, which are plants feeding on the cell walls of wood. The initial process is started by the deposition of spores or microscopic seeds. Fruiting bodies (e.g., mushrooms and conks) produce these spores by the billions. The spores are distributed by wind, water, or insects. Spores that survive and experience favorable growth conditions can penetrate timber members in a few weeks. Favorable conditions for fungi to grow can only occur when these four requirements exist:

- a minimal amount of free oxygen can sustain them in a dormant state, but at least 20 percent of the volume of wood must be occupied by air for fungi to become active;
- below freezing, 0ºC, the fungi become dormant but resumes its growth as the temperature rises above freezing to the 24ºC to 29ºC range, where growth is at its maximum;
- as the entire bridge serves as the food supply, the only prevention is to poison the wood supply with preservatives;
- wood must have a moisture content of 20 percent or greater for the growth of fungi to become active. Rain or snow is the main source of wood wetting. Secondary sources are condensation, ground water, and stream water.

Insects – Termites (Isoptera), beetles (Coleoptera), and bees, wasps, and ants (Hymenoptera) are the primary causes of most insect-related deterioration. Insects tunnel in and hollow out the insides of timber members for food and shelter.

Natural Defects - defects that form from abnormal growth or from the lumber drying process include:

Checks - separations of the wood fibers, normally occurring across or through the annual growth rings, and generally parallel to the grain direction;

Splits - similar to checks except the separations of the wood fibers extend completely through the piece of wood; a split is also known as a through check;
Shakes - separations along the grain which occur between the annual growth rings;
Knots – inter grown limbs which cause the separation of wood fibers.

These four defects provide openings for decay to begin and in some cases indicate reduced strength in the member when the defect is in an advanced state.

Delaminations - occur in glued-laminated members when the layers separate due to failure within the adhesive or at the bond between the adhesive and the laminate. They provide openings for decay to begin and may cause a reduction in strength.

Corrosion - wood degradation from metal corrosion is frequently overlooked as a cause of bridge deterioration. Corrosion begins when moisture in the wood reacts with iron in a fastener to release ferric ions that in turn deteriorate the wood cell wall. In addition to the deterioration caused by corrosion, the high moisture conditions associated with this damage can initially favor the development of fungal decay.

Loose connections - may be due to shrinkage of the wood, crushing of the wood around the fastener, or from repetitive impact loading (working) of the connection. Loose connections can reduce the bridge's load-carrying capacity.

Surface depressions - indicate internal collapse, which could be caused by decay.

Fire - large timbers build a protective coating of carbon after the first 30 minutes of exposure. Small size timbers do not have enough volume to do this before they are, for all practical purposes, consumed by fire. Preservative treatments are available to retard fire damage.

Mechanical Wear - vehicular traffic is the main source of wear on timber decks. Abrasion occurs on timber piles that are subjected to tidal flows. Mechanical wear of timber members sometimes occurs due to movement of the fasteners against their holes when connections become loose.

Overstress - each timber member has a certain ultimate load capacity. If this load capacity is exceeded, the member will fail.

Weathering - is the affect of sunlight, water, and heat. Weathering can change theresulting in changes in the strength and dimensions of the wood. Uneven reduction in moisture content causes localized shrinkage, which can lead to warping, checking, splitting, or loosening of connectors.

Protective Coating Failure:

- cracking and peeling extend with the grain of the wood. They are caused by different shrinkage and swell rates of expansion and contraction between springwood and denser summerwood;
- decay fungi penetrate through cracks in the paint to cause wood to decay;
- blistering is caused by paint applied over an improperly cleaned surface. Water, oil, or grease typically are responsible for blistering;
- chalking is a degradation of the paint, usually by the ultraviolet rays of sunlight, leaving a powdery residue;
- erosion is general thinning of the paint due to chalking, weathering, or abrasion;
- mold fungi and stain fungi grow on the surface of paint, usually in warm, humid, shaded areas with low air flow. They appear as small green or black spots.

Ultraviolet Light Degradation - results from the action of the ultraviolet portion of sunlight, which chemically degrades the lignin near the wood surface. Ultraviolet degradation typically causes light woods to darken and dark woods to lighten, but this damage penetrates only a short distance below the surface.

Protective systems are a necessity when using timber for bridge construction. Proper preparation of the timber surface is required for the protective system to penetrate the wood surface and perform adequately.

CONCLUSIONS

Depending on the quality of the initial design and protection, the time to damage initiation can vary considerably. Once corrosion is initiated at concrete bridges, irreversible changes accumulate such as cracking, delamination and spalling that lead to a loss of cross-sectional area of concrete and steel, loss of bond between the steel and concrete, loss of serviceability and strength of the deck, and complete failure.

Checking the humidity is the simplest and most economical way to reduce the risk of degradation of wood bridges. This is an effective and practical technical maintenance to extend the life of many existing bridges. When exposed to moisture is reduced, structure elements become dry and the percentage of moisture falls below the level of 25%, that favor the development of fungi and insects. Remote monitoring systems can be very useful in increasing the efficiency and decreasing the cost of maintenance programmes. They can be especially useful for checking the moisture

content of inaccessible timbers in roof spaces, behind decorative finishes and in walls.

Although wood degradation is beneficial in the ecosystem, returning carbon and other elements to the soil and air, it becomes detrimental when the deteriorating material is part of a bridge or other structure.

To avoid these inconvenience, wood as construction material for bridges, can be improved by applying modern techniques and methods, such as conservation treatment by spray, impregnation or soaking conservation substance (creosote, pentachlorophenol, copper naphthenic) and fumigants (Vorlex, Chloropicrin, Vapam).

Although wooden bridge applies a preventive maintenance, at first sign of damage, it appeals to a rehabilitation maintenance:

- mechanical repairing: augmentation, constraining and joining, lamination;
- epoxy repair: pointing, binding;
- replacement of damaged parts.

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