Review of Mitigation Measures for Bridge Protection from Floating Large Woody Debris

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Abstract: In this study, various factors influencing the floating large woody debris (LWD) accumulation and various methods to mitigate the problem at the bridges was reviewed. The factors influencing the FWD are natural environmental factors like geology and age of the watershed area, soil characteristics, hydrology/river characteristics, hurricanes, heavy rainfall and man-made factors like logging. The mitigation methods to prevent large wood accumulation included mechanical devices upstream of a bridge pier, flow alteration devices, design specifications to account for debris forces on bridge piers and disaster debris management plan.

1. Introduction

During and immediately after a heavy rainfall or storm event, Floating Large Wood Debris (LWD) from upstream watershed areas are transported by the streams and rivers. Debris accumulation has been recognized as a significant concern for Bridge Engineers causing a great change in the forces acting on the bridge piers leading to their failure. Estimated damages are about $ 1 billion for each weather disaster as reported by NOAA.

2. Objective

The overall objective is to identify the potential mitigation methods for protecting the highway bridges from floating wood debris in Houston area. The specific objectives are as follows:

(a) Literature review on the effects of LWD on bridge structures
(b) Review the methods used for mitigating the LWD problems for highway bridges.

3. Discussion

Trees growing in the riparian zone contribute majorly to woody debris due to bank erosion, logging, disease, landslide, old age among other reasons(4). Also, alteration of natural conditions changing the watershed and channel characteristics is predominantly responsible for stream bank erosion. (2) High debris supply rates are also likely in streams characterized by meander. (4)

4. Acknowledgements

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Table 1 : Literature review on Floating Large Woody Debris (LWD)

Reference	Hydrology & Geology	Cause of the FWD	Quantification	Mitigation Methods	Remarks
(1) NCHRP Report 445 Debris Forces on Highway Bridges (Transportation Research Board 2000)	Debris in floodway transported to waterway as flow depth increases. Debris transport depends heavily on secondary currents.	Grass and woody remains of trees that have lost soil support around their roots due to stream bank erosion. Flood events.	Size of Wood: N.A. Volume: N.A. Cost : 1989 flood event – Great Miami River bridge collapsed - 2 people died Cause : Debris accumulation on one Pile-bent	Draft specifications to quantify drag and hydrostatic forces that result from debris loads based on the influence of flow-blockage ratio.	1 Effect on bridge - Drag & Hydrodynamic forces 2.Mitigation – Design Specifications 3.Damage to Piers – Bridge collapse 4.Erosion / Scour – N.A 5.Practical design specifications to quantify forces on bridge piers and superstructures due to debris accumulation.
(2) Controlling Debris at Pennsylvania Bridges , Final Report (Oct,2008) Common Wealth of Pennsylvania, Pennsylvania Department of Transportation	<u>Influencing Factors</u> : a) Stream and watershed characteristics. b) Stream bank material/stability c) Channel sinuosity d) Bed irregularities e) Upstream infrastructure f) Bridge characteristics	Heavy Rainfall events, Hurricane events, Trees growing in close proximity to stream, bank erosion, logging, wind throw, ice accumulation, disease, landslides, old age.	Size of Wood: 26m ~ 50m (Typical heights of trees in eastern USA likely to affect accumulation) Volume: N.A. Cost : N.A.	a) Debris Fins b) In-channel Debris Basins c) Flow Altering devices – Iowa Vanes, Spurs, sacrificial piles d) Crib Structures e) Debris deflectors f) Debris Sweepers	1.Effect on bridge - subject to debris load 2. Mitigation – available 3. Damage to Piers – N.A. 4.Erosion / Scour – N.A 5.Attempt to determine appropriate, cost-effective methods for controlling debris accumulation at bridge piers in Pennsylvania
(3) Brazoria County, Texas (Sept,2009) Brazoria County State and Federal Statutes Disaster Debris Management Plan	Brazoria County: 1386 Sq. miles land & 211 Sq. miles of waterways. Coastal geographic location of the County makes it extremely susceptible to hurricanes, tornadoes, flooding and thunderstorms.	Hurricane / Tropical Storm, Tornado, High Winds, Flood, Man-made, Wild Fire	Size of Wood: N.A. Volume : 130465 CY (After Hurricane Ike) Cost : 24 Billion $ nationwide (Hurricane Ike – Sept,2008))	Debris Forecasting, identifying roles and responsibilities of County departments, action plan – pre-event checklist, post-event response, post-event recovery checklist, Debris estimation models based on BDR estimates, Debris management site report. To establish a working plan to quickly and effectively respond to future debris-generating events.	1. Effect on bridge - N.A. 2. Mitigation – N.A. 3. Damage to Piers – N.A. 4.Erosion / Scour – N.A 5.This is a Disaster management plan with a list of debris removal contractors
(4) Iowa State University, Institute of Transportation (Final Report June 2012) Bridge Engineering Center, Debris Mitigation methods for Bridge Piers	Rivers and Streams with active bank erosion and those that drain wooded/forested areas or corridors.	Bank erosion, Landmass failures, wind action, biological decay, changing seasons, wind throw, animal activities, riparian zone erosion.	Size of Wood: N.A. Volume: N.A. Cost : Qualitative comparison available (High/Moderate/Low over a 10 yr period)	a) In-channel debris dams – Treibholzfange debris detention device b) In-channel debris basin c) River training structures – weirs on outer bank , Iowa Vanes d) Crib Structures e) Debris deflectors f) Debris Sweepers g) Debris Boom h) Debris Racks	1. Effect on bridge - additional forces 2. Mitigation – available, also suggested to incorporate additional features like extra freeboard, pier type, location, spacing 3. Damage to Piers – N.A. 4.Erosion / Scour – N.A 5.In response to survey questions, most preferred and satisfactory method is Debris deflectors. It has also been cost effective.