Improving Bridge Risk and Deterioration Modeling

Mohammad Dehghani, Caitlin McKinley, Zach Rubin, and Wayne Francisco, GHD

Minneapolis, MN

July 11, 2016
Background

Agency’s questions:

How our bridges deteriorate?
What factors influence our bridge deterioration?
Importance

- Performance Forecasting
- Life Cycle Cost Analysis
- Financial Planning
- Risk Management

ORGANIZATIONAL STRATEGIC PLAN
Vision, mission, values and business objectives

ASSET MANAGEMENT POLICY
System, program framework, principles and objectives

STRATEGIC ASSET MANAGEMENT PLAN
Strategies for policy implementation and program improvements

ASSET MANAGEMENT PLAN(S)
Tactical plans for managing our assets to sustain performance

ASSET MANAGEMENT PROGRAM
Requirements, processes, procedures, practices, technology, data

CONCEPT DESIGN ACQUIRE MANAGE DISPOSE
Main Questions

- Native Deterioration (no preservation or rehabilitation)
- Post-rehabilitation Deterioration
- Impact of Preservation on Deterioration

![Graph showing condition rating over years]

Condition Rating

Native Deterioration | Post Rehabilitation Deterioration

Year

Extended life due to preservation
Deterioration Analysis

Deterioration Modeling of:
- 16000 bridges (deck, superstructure, substructure, wearing surface)
- 6000 culverts

Statistical Analysis of the Impact of the Following Factors on Bridge Deterioration:
- Material
- Traffic
- Truck Traffic
- Functional Classification
- Construction Year
- Freeze Thaw Rating
- Business Plan Network
- Bridge Length
Method: **Condition State Duration Prediction**

*Estimates the expected years that a bridge remains in each condition state*

![Graph showing Condition State Duration Prediction](image)
Native Curves

Deck

Superstructure

Substructure

Wearing Surface
## Results

### Expected Life to Structural Deficiency without Major Rehabilitation/Reconstruction (yrs) – Numbers are Illustrative

<table>
<thead>
<tr>
<th>Category</th>
<th>Deck</th>
<th>Superstructure</th>
<th>Substructure</th>
<th>Wearing Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall</strong></td>
<td>36</td>
<td>39</td>
<td>36</td>
<td>23</td>
</tr>
<tr>
<td><strong>Concrete</strong></td>
<td>41</td>
<td>41</td>
<td>39</td>
<td>23</td>
</tr>
<tr>
<td><strong>Steel</strong></td>
<td>32</td>
<td>36</td>
<td>33</td>
<td>22</td>
</tr>
<tr>
<td><strong>P/S</strong></td>
<td>32</td>
<td>37</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td><strong>Rural</strong></td>
<td>36</td>
<td>40</td>
<td>37</td>
<td>23</td>
</tr>
<tr>
<td><strong>Urban</strong></td>
<td>34</td>
<td>39</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td><strong>BPN 1</strong></td>
<td>30</td>
<td>34</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td><strong>BPN 2</strong></td>
<td>33</td>
<td>38</td>
<td>36</td>
<td>22</td>
</tr>
<tr>
<td><strong>BPN 3</strong></td>
<td>36</td>
<td>41</td>
<td>37</td>
<td>23</td>
</tr>
<tr>
<td><strong>BPN 4</strong></td>
<td>36</td>
<td>40</td>
<td>37</td>
<td>24</td>
</tr>
<tr>
<td><strong>ADT &lt; 1000</strong></td>
<td>37</td>
<td>40</td>
<td>37</td>
<td>24</td>
</tr>
<tr>
<td><strong>1000 &lt; ADT &lt; 5000</strong></td>
<td>37</td>
<td>42</td>
<td>38</td>
<td>22</td>
</tr>
<tr>
<td><strong>5000 &lt; ADT &lt; 15000</strong></td>
<td>35</td>
<td>39</td>
<td>36</td>
<td>23</td>
</tr>
<tr>
<td><strong>ADT &gt; 15000</strong></td>
<td>31</td>
<td>36</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td><strong>Pre 1919</strong></td>
<td>37</td>
<td>42</td>
<td>36</td>
<td>23</td>
</tr>
<tr>
<td><strong>1918 - 1931</strong></td>
<td>38</td>
<td>40</td>
<td>35</td>
<td>22</td>
</tr>
<tr>
<td><strong>1931 - 1944</strong></td>
<td>37</td>
<td>37</td>
<td>33</td>
<td>22</td>
</tr>
<tr>
<td><strong>1947 - 1979</strong></td>
<td>32</td>
<td>35</td>
<td>35</td>
<td>22</td>
</tr>
<tr>
<td><strong>1983 - 2000</strong></td>
<td>37</td>
<td>36</td>
<td>36</td>
<td>23</td>
</tr>
<tr>
<td><strong>Span Length &lt; 40</strong></td>
<td>39</td>
<td>41</td>
<td>38</td>
<td>23</td>
</tr>
<tr>
<td><strong>40 &lt; Span Length &lt; 80</strong></td>
<td>33</td>
<td>38</td>
<td>36</td>
<td>23</td>
</tr>
<tr>
<td><strong>80 &lt; Span Length &lt; 100</strong></td>
<td>32</td>
<td>36</td>
<td>35</td>
<td>23</td>
</tr>
<tr>
<td><strong>100 &lt; Span Length &lt; 150</strong></td>
<td>30</td>
<td>34</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td><strong>Span Length &gt; 150</strong></td>
<td>33</td>
<td>36</td>
<td>32</td>
<td>23</td>
</tr>
</tbody>
</table>
Incorporating Risk...

![Graph showing the relationship between condition state and years. The graph illustrates the transition from accelerated to decelerated conditions over time.](chart.png)
Risk-based Decision Making

Projection of Structurally Deficient Bridges based on three Deterioration Scenarios (Illustrative Figure)

- Decelerated Decay Rate
- Expected Decay Rate
- Accelerated Decay Rate
Summary

✓ Current method can be used by any transportation agency that collects bridge condition data
✓ Easily repeatable and the results can be easily updated with new inspection data
✓ Incorporates deterioration uncertainties with standard deviations
✓ Agencies are able to define multiple forecasting and financial planning scenarios to consider risk
Questions

Mohammad Dehghani  
GHD Consulting Inc.  
240-206-6858  
Mohammad.dehghani@ghd.com

Zach Rubin  
GHD Consulting Inc.  
240-206-6828  
Zach.rubin@ghd.com

Wayne Francisco  
GHD Consulting Inc.  
704-342-4910  
wayne.francisco@ghd.com