NTEC
Nottingham Transportation Engineering Centre

Modelling Railway Bridge Asset Management

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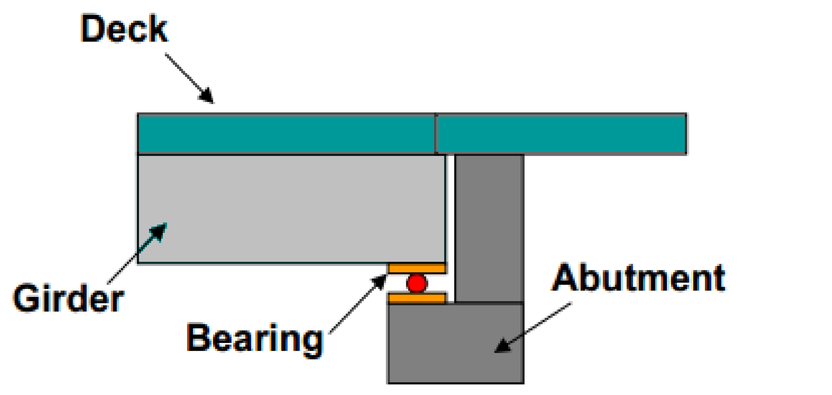
Research Aims

1. Use real historical work done to develop degradation models;
2. Develop a model of bridge *degradation, inspection, servicing, maintenance* and *scheduling of maintenance*;
3. Use the model to investigate bridge components lifecycle, different maintenance strategies and their effectiveness.

Degradation Study



Component and structure

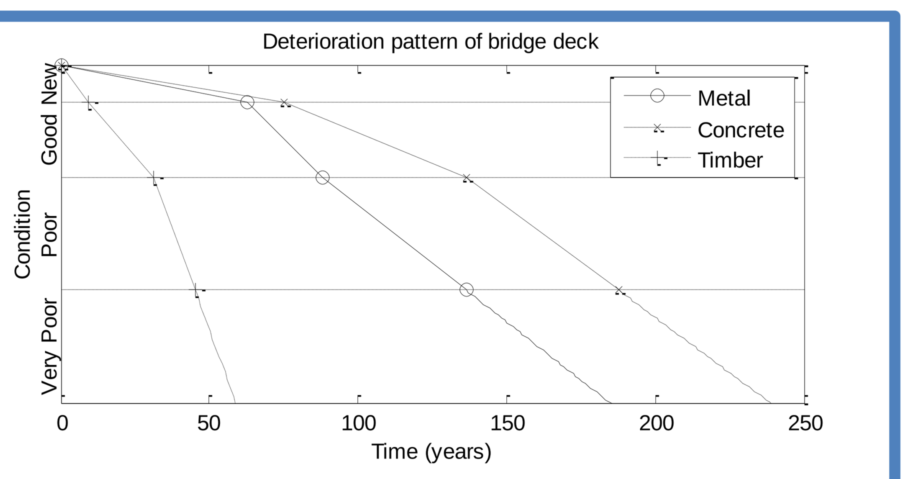
- Metal Underbridges:
  - Girder (Metal)
  - Deck (Metal, Concrete, Timber)
  - Bearing (Metal)
  - Abutment (Masonry)

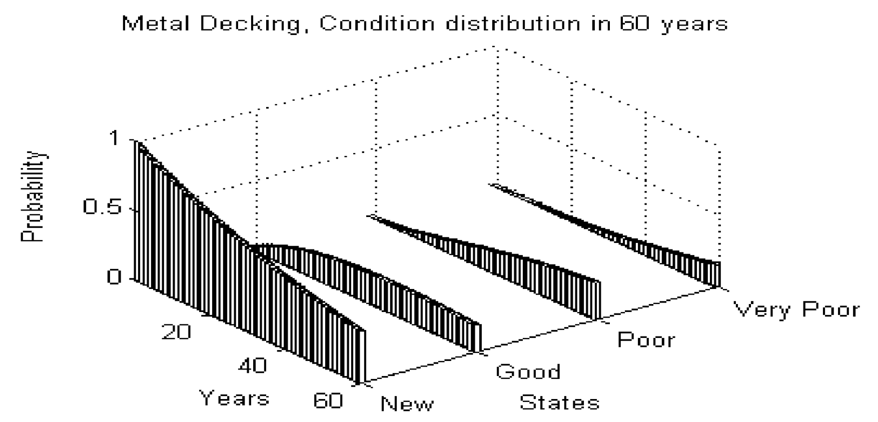
Intervention types

- No intervention
- Minor repair
- Major repair
- Replacement

Component conditions

- New
- Good
- Poor
- Very Poor

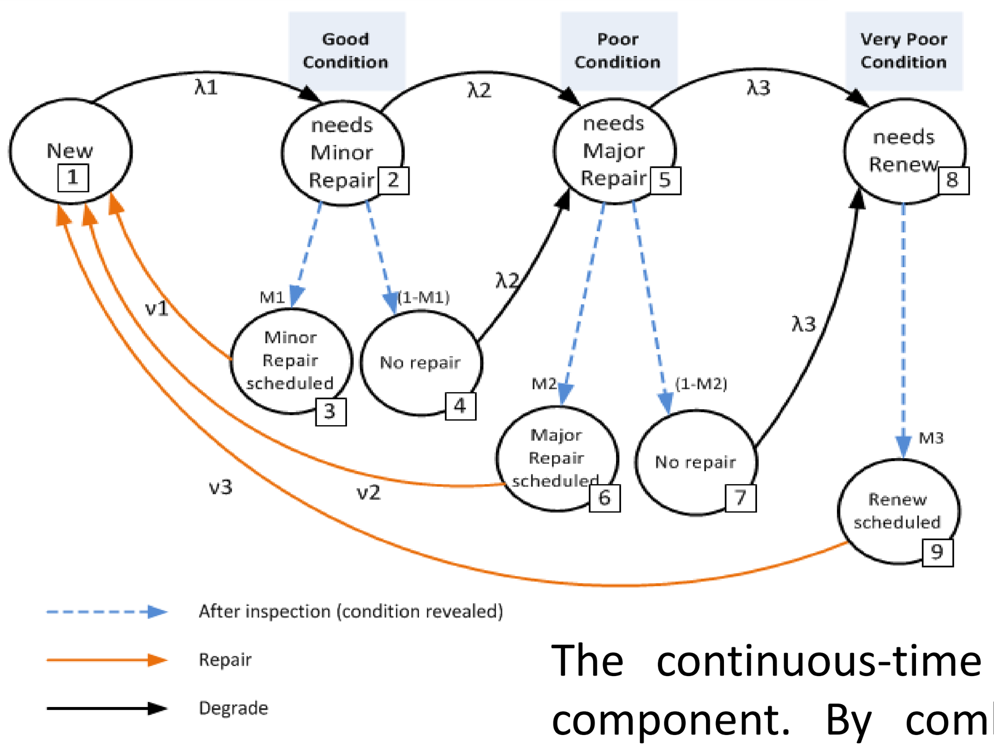




Methodology

The degradation process is determined by examining the maintenance records and analysing the times that each element takes to deteriorate to the point where maintenance of a certain severity classification is required. A distribution is fitted to these times to model the probability of a component requiring a certain type of interventions at any given time. The deterioration patterns of a component can be seen by plotting the mean time a component reaching a certain states. Understanding the characteristics of the components allowing the future condition to be predicted.

Bridge Model



Model Inputs

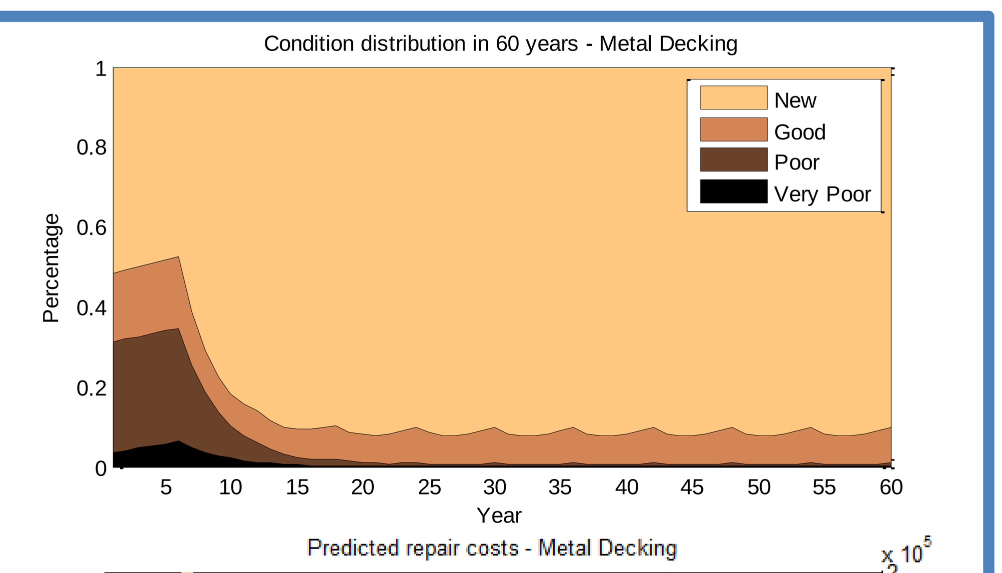
- Servicing interval
- Inspection interval
- Repair scheduling time
- Asset criticality
- Environment
- Initial condition
- Maintenance strategy
- Asset structure information
- Maintenance costs
- Opportunistic maintenance

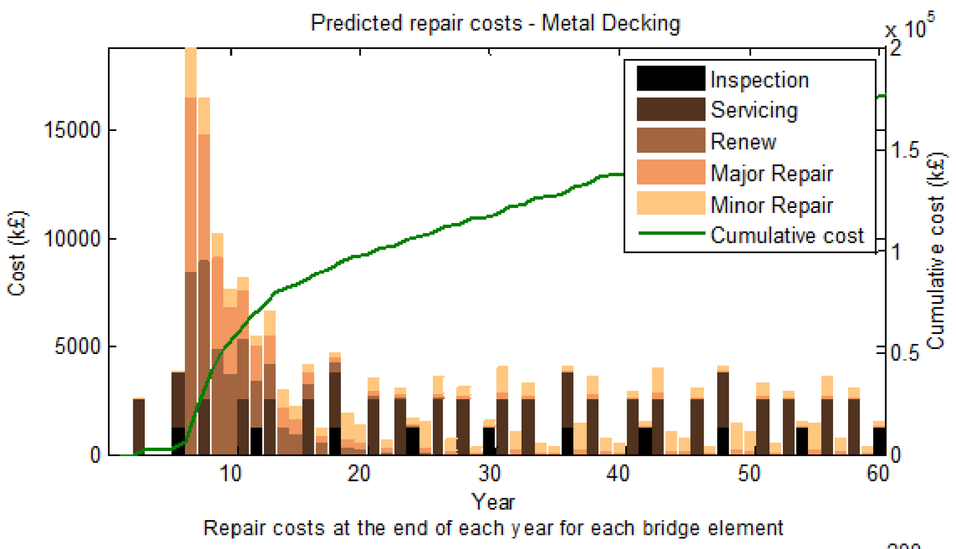
Model Outputs

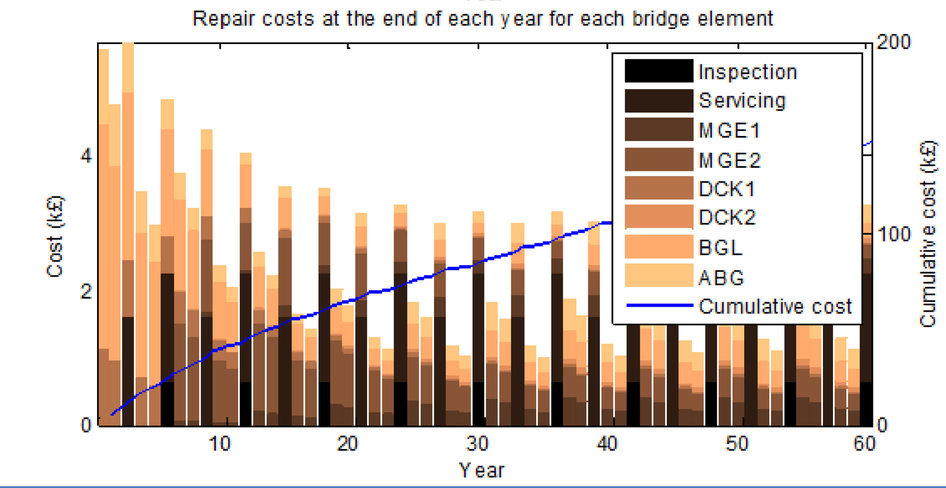
- Future condition distribution
- Expected maintenance costs for each type of repairs
- Possession hours and costs
- Total expected maintenance expenditure costs (WLLC cost)

The continuous-time Markov *Elemental model* was first developed for a single bridge component. By combining these *Elemental models,* a complete *Bridge model* is then developed. A simulation of the bridge model produces the predicted future condition distribution for each bridge elements, the expected maintenance costs for that particular element and the total expected repair costs for all the elements in a bridge (demonstrations of the simulation results for a Metal Deck in a bridge is presented on the right).

As well as the capability of modelling the effects of different *servicing* and *inspection interval*, the model allows different maintenance strategies to be employed. *Maintenance strategy* is defined by user which is set to intervene when the asset reaches a certain condition (e.g. repair when the component reaches poor state); or not repairing at all. Furthermore, the model has the options to delay a repair (*scheduling time*) and carrying out opportunistic maintenance. *Opportunistic maintenance* considers carrying out repair on the adjacent component of the same type that does not necessarily need the same type of repair as the first component but is in the state where repair is possible. It was found that opportunistic repair can reduce the total maintenance costs to about 5-15%.







Optimisation

The optimisation of the model is based on Genetic Algorithm (GA) technique. The following model inputs are varied in the optimisation: *servicing interval, inspection interval, minor repair scheduling time, major repair scheduling time, renewal scheduling time, maintenance strategy, opportunistic maintenance.*

The objective function is to minimise the total expected maintenance costs subjected to the component condition (e.g. must be always in good condition etc.) and maintenance budget. By adopting GA techniques, an optimum maintenance strategy in achieving the objective function can be found.

Future work

- Developing the next generation model, the Petri-Net model that is capable of modelling the non-constant deterioration rate.
- Optimisation of the Petri-Net models
- Comparison and discussions of the two developed models

The University of Nottingham