SYNTHETIC DAMAGE CURVES FOR CONCRETE GIRDER BRIDGES UNDER FLOOD HAZARD

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THERE IS A SIGNIFICANT NEED TO PERFORM ADEQUATE ASSESSMENT OF THE VULNERABILITY OF BRIDGES AND BRIDGE NETWORKS PRIOR TO FUTURE FLOOD EVENTS IN AUSTRALIA. THIS RESEARCH AIMS TO DERIVE DAMAGE INDICES FOR A TYPICAL GIRDER BRIDGE IN AUSTRALIA DUE TO A FLOOD EVENT AND GENERATE FRAGILITY CURVES USING THE EXISTING MOMENT CAPACITY OF THE BRIDGE GIRDERS.

Reinforced or pre-stressed concrete girder bridges are a common design configuration used in Australia. During the Lockyer Valley floods in 2013, vulnerability of girder bridges was observed by significant damage to these structures. This study aims to find out:

- The failure mechanism and critical structural components of a typical girder bridge under an extreme flood event in Australia.
- The damage to bridges due to impact of floating items under different flood scenarios
- Generation of fragility curves with the use of Damage Indices verses flood velocities and establish limiting flood velocities for different scenarios before the bridge fails.

BRIDGE CHARACTERISTICS

The most common bridge type in Australia is precast concrete girder bridges. The Tenthill creek bridge is selected for the study. The Tenthill creek bridge is a simple span reinforced concrete bridge in Queensland. The bridge is 82.15m long and about 8.6m wide. It is supported by a total of 12 pre-stressed 27.38m long beams over three spans. Both ends are supported by two abutments and two headstocks

Research Questions

- What are the typical failure modes of bridges during a flood event?
- Why do these failures occur?
- How can a girder bridge be modelled to include flood loading?
- What is the relationship between flood velocity, flood depth and other input parameters?
- How can the damage to bridges under flood be captured for decision making?

FLOOD LOADING ON BRIDGES(AS 5100)

$F_{ds} = 0.5 C_d V^2 A_s$

F_{ds}= Flood force (kN)

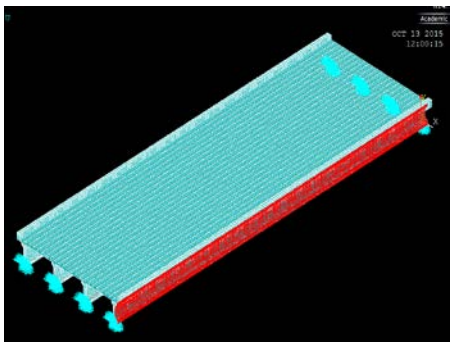
C_d= Drag Coefficient

V= Flood Velocity (m/s)

A_s= Area normal to flood flow (m^2)

NUMERICAL MODELING OF THE BRIDGE

Three dimensional analytical models were developed using ANSYS 14.5 software. The middle span of the bridge deck has been modelled as per the structural drawings. All 4 girders were assumed simply supported and rest on the headstock of the piers. Gravity force and the flood force on the deck as per AS 5100 were considered in the analysis.



DERIVING DAMAGE INDEX

Damage Index (DI) = $\emptyset M_u / M^*$

M_u= Existing moment capacity of the girder
M^*= Flood induced bending moment on the girder
$\emptyset$ = Safety factor

Maximum bending moment induced by the flood load (M^*) on the bridge girder was derived for different input values of flood velocities and the corresponding damage index was then calculated using the above formula.

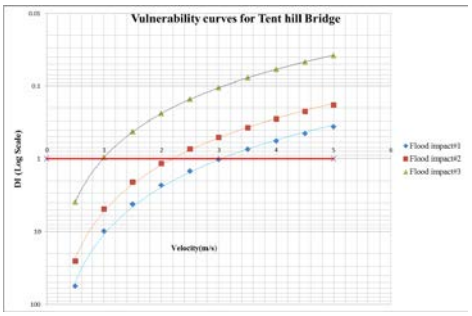
DEVELOPMENT OF FRAGILITY CURVES

Damage Index values were plotted against the flood exposure condition to develop fragility curves. These curves were generated for three different types of flood impact as shown in the figure below.

Flood Impact#1 = Flood only

Flood Impact#2 = Flood+Debris

Flood Impact#3 = Flood+Debris+Container



LIMITING FLOOD VELOCITIES FOR BRIDGE FAILURE

For the girder not to fail under flood loading, the existing moment capacity of the girder ($\emptyset M_u$) must be greater than the moment induced by the flood force (M^*). In other words $\emptyset M_u / M^* > 1$. The maximum allowable flood velocity to satisfy this condition could be read from the above structural vulnerability curves.

Type of Flood Impact	Limiting Flood Velocity (m/s)
Flood only	3.66
Flood+Debris	2.46
Flood+Debris+Containers	0.89

END USER SUPPORT STATEMENT

The outcome would be damage states to the bridges subjected to Floods. The damage states could be used by Emergency Management (EM) to assess evacuation routes, trafficability for response and time to re open.