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Deterioration of flood affected Queensland roads – An investigative study

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Abstract

The aim of this paper was to investigate the impact of recent flooding events on the structural and surface condition (such as roughness and rutting) of the pavements of the Department of Transport and Main Roads, Queensland, and the Brisbane City Council. The paper also reviewed the major flooding and cyclone events that occurred in the last six years in Queensland. Generally, a rapid increase in deterioration of the structural and surface conditions such as roughness and rutting was observed in pavements after the flood as a result of the inundation. An increasing need for road rehabilitation was also observed after the recent flooding events from 2010 to 2015 in Queensland. Assessing the rapid deterioration of the structural and surface condition of the flood affected pavements is a prerequisite for the accurate prediction of pavement performance, a better decision making process and the management of these roads. Although this paper did not include any model for roughness and rutting, deterioration models for roughness and rutting of flood affected pavements are currently being developed as a part of the future scope of this research.

Keywords: Pavement deterioration; Flooding; Structural and surface condition

1. Introduction

Australia has long had a history of extreme weather. These extremely variable climate events range from droughts to floods. Extreme weather events, such as intense heavy rainfall, tropical cyclones, flooding, hail storms, and heat waves are often short-lived, abrupt events lasting from several hours or up to several days. Such events are described as 'shocks' within the climate system; moreover they tend to be noticeably different from previous events [1]. The flooding events have an impact on individuals and communities, as well as social, economic, and environmental consequences. The consequences of floods, both negative and positive, vary greatly, depending on the location and extent of flooding, and the vulnerability and value of the natural and constructed environments they affect [2]. Unpredictable calamities, such as the January 2011 flooding in South-East Queensland, Cyclone Olga in 2010, Cyclone Yasi in 2011, Cyclone Oswald in 2013 and Cyclone Marcia in 2015, affected the road infrastructure system across the area.

In total, Australia has a road network system of over 800,000 km (kilometres) and worth over AUS$100 billion. Queensland has some 186,859 km of public roads. The stewardship of this network lies with two organizations, the Department of Transport and Main Roads, Queens-

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land (TMR) and the local government agencies. TMR manages approximately 33,344 km of State-controlled roads [3]. This road network is an important physical asset for the state and local governments.

The increasing frequency of extreme rainfall, cyclones and flooding events in recent years has significantly influenced the increasing rate of deterioration of the structural strength and surface conditions (such as roughness and rutting) of the pavements. The aim of this paper was to investigate the impact of recent flooding events on accelerating the deterioration of structural and surface condition such as roughness and rutting of flood affected pavements in Queensland. This paper also presents a review of literature on the recent flooding events and the adverse effects of recurrent occurrences of these events on the pavements of Queensland. The assessment of the rapid deterioration of the structural and surface conditions of flood affected pavements is a prerequisite for the accurate prediction of pavement performance, better decision making processes and management of these pavements. The study has a practical application in planning a systematic way of monitoring and managing flood affected pavements in future.

This study collected and analysed the surface condition data (roughness and rutting) of the flood affected pavements, of TMR, Queensland and the Falling Weight Deflectometer (FWD) deflection data of Brisbane City Council (BCC). The FWD test is the most widely used technique for non-destructive evaluation of pavements. During the FWD test, the pavement deflection response is measured by transducers at different offsets from the load. The maximum pavement displacements at transducer locations collectively referred to as the deflection bowl (or deflection basin) or the displacement time histories at each receiver location are then reported as pavement response. With pavement layer thicknesses as a given input, the measured pavement response is then analysed or back-calculated to infer the in situ pavement layer elastic moduli. The back-calculated pavement moduli are then used to design overlays, estimate remaining life of a pavement, identify weak areas in the pavement structure, or perform network level monitoring [4].

2. Literature review: Impact of recent flooding events

In Australia, Queensland experienced widespread and devastating flooding from December 2010 to January 2011 [2]. Tropical Cyclone Yasi, a Category 5 cyclone wreaked Northern Queensland in 2011. Some 59 rivers flooded, with 12 breaking flood records; approximately 19,000 km of state and local roads were affected by the 2010–2011 floods. It was estimated that the reconstruction and restoration of the flood affected areas would cost in the order of AUS$5 billion, with damage sustained from Tropical Cyclone Yasi estimated to exceed AUS$800 million [5]. Heavy rainfall also occurred over many parts of Queensland from 24 January to 8 February, 2010 associated with Tropical Cyclone Olga as the system weaved a path across the state [6]. Many roads were flooded in the area of Yeppoon and Rockhampton on February 1, 2010.

Similarly, Brisbane City Council's 5600 km road network sustained inundation and extended high rainfall periods during the 2010 and 2011 summer wet season in Queensland. Brisbane experienced a significant river flood event of a scale not seen since the 1974 flood. Rainfall of between 600 to 1000 mm was recorded in most of the Brisbane River Catchment during December 2010 and January 2011 [7]. Two years after the flood, Brisbane City Council restored the city with work in excess of AUS$400 million, including AUS$127 million for roads and related infrastructure. Approximately 145,659 square metres of pavements were resurfaced by the council [8].

Tropical Cyclone Oswald tracked along the east coast of Australia from Mossman to Sydney from 22 to 29 January, 2013. Over, just four days, Gladstone (Queensland) received approximately 820 mm of rain. Major flooding devastated many areas in Queensland, extending from 22 January until 17 February, costing an estimated AUS$2.4 billion [9]. The flooding events and associated heavy rainfall, a result of Tropical Cyclone Oswald, had a catastrophic effect on Queensland; for example, approximately 5845 km of State roads and 2800 km of State rail network were closed [10].

Following an unprecedented number of natural disasters between 2010 and 2013, extensive damage was caused to communities as well as key road, rail, port and waterway infrastructures. As a consequence, TMR reconstructed large sections of the state-controlled road network through the Transport Network Reconstruction Program (TNRP). These reconstruction works, costing approximately AUS $6.4 billion, were completed on approximately 8741 km of the state-controlled road network, some 1733 structures (including bridges and culverts), some 1421 locations requiring earthworks and batters, and approximately 3335 locations needing silt and debris cleared [11].

In general, the procedures for the assessment of damage and deterioration of flood affected pavements are complex and time consuming [12]. One of the most important factors in analysing deterioration of flood-affected pavements is the existence of historical data and collection of data prior to, and after, the flood for the same road section [13]. A very crucial part in analysing these pavements is to compare the before and after scenario. To understand the deterioration of roads under flooding conditions, it is necessary to monitor flood affected pavements frequently and regularly (at least once a year or once every two year).

After the January 2011 flood, FWD testing was undertaken on flood affected roads of Brisbane City Council to identify the impact of flooding on the strength of the road network and its subsequent life. The selected roads included a range of known pavement types with different traffic loadings. The pavement types included granular pavement base with a thin Asphalt Concrete (AC) surface, deep strength asphalt pavement base and cement treated base (CTB) or cement stabilized pavements. The traffic