TECHNICAL MEMORANDUM

Road Design Series

TRANSPORT SERVICES

Preferred method for calculating road surface water run-off in New Zealand

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Purpose

To advise on the preferred method of calculating surface water flow and the limited use of the Gallaway method in New Zealand.

Background

The Waka Kotahi NZ Transport Agency recommended method used to analyse water flow depth (WFD) in New Zealand was developed by the Road Research Laboratory (RRL) in the UK in 1968. It was incorporated into the *Highway Surface Drainage Design Guide for Highways with a Positive Collection System,* published by the Ministry of Works and Development, for use in New Zealand in 1977. Subsequent studies have shown that this method tends to yield more conservative results when compared to other analysis methods, with greater WFD for a given pavement shape (slope and length of flow path). NZTA requires that calculated WFD using the RRL method is 4.0mm or less.

Modifying the design of the pavement to compensate, and therefore reduce this calculated WFD, could lead to undesirable pavement shape. Rates of change in superelevation, vertical profiles and crown positions are each adjusted and the combination of these effects assessed in order to minimise the lengths of the flow paths and therefore the WFD. While these adjustments are usually accommodated within acceptable and safe limits, there have been occasions when the design modifications became excessively complex, producing an unpredictable and therefore unsafe environment for the motorist. If constructed, this safety risk would be ever-present, compared to the risks associated with the design-year event that precipitates the unacceptable WFD.

Gallaway method

In 1979 the US Department of Transportation adopted a method for predicting WFD developed by B.M. Gallaway and detailed in the Texas Department of Transportation Hydraulic Design Manual. This method goes further than the RRL method in that it provides a way to predict the aquaplaning speed based on the estimated WFD. When calculating the WFD, Gallaway's equation uses the same parameters of flow path, slope and rainfall intensity as the RRL method, but with significantly different indices applied to each, this tends to result in lower WFD results when compared with the RRL method, especially for long flow paths.

Gallaway also takes into account the texture depth of the pavement, which further reduces the predicted WFD. Austroads Guide to Road Design part 5A (2013) makes use of the Gallaway method for calculating WFD with the following limitations; a maximum rainfall intensity of 50.8mm/h, drainage lengths up to 14.6m and slopes up to 8%. Austroads also states the desirable WFD should be limited to 2.5mm.

Effect of high rainfall intensities

The 1977 NZTA design guide alludes to the fact that drivers slow down in ‘areas of high intensity rainfall’, however this phenomenon has been omitted from the analysis method.

Austroads part 5A (2013) lists further research into driver behaviour at higher rainfall intensities, and adopts an upper limit for rainfall intensity of 50mm/hr.

In some New Zealand cases, current future allowances for climate change events are pushing design rainfall intensities well above 50mm/hr. This can make the design modifications required to achieve an acceptable WFD excessively complex and may be counter to providing a predictable and safer environment for the motorist.

Recommended practice

In the absence of more definitive research and/or evidence as to which is the better prediction for the NZ environment, the RRL method of estimating WFD should be used. If the resulting WFD prediction is excessive, then the designer should first look to make adjustments to the shape of the pavement at each individual location, in order to reduce the flow-path lengths. Note that this should be done within the boundaries of normal design practice wherever practicable, and care must be taken to not develop an unsafe, unpredictable environment for the road user ie a road surface shape that is unpredictable or complex to maintain. A common example of this would be a crown line that moves diagonally across the road as the driver moves along it. This is also referred to as a rolling-crown or sliding-crown. The various options investigated in this scenario, and their effects on WFD must be carefully documented.

If the design constraints prohibit an acceptable solution being developed, then the designer may analyse the individual problem areas firstly using a capped rainfall intensity of 50mm/hr, and secondly using the Gallaway WFD formula. In order to assess the level of risk indicated by the analyses, it is also helpful to identify the storm intensity that would result in a flow depth that is right at the upper limit of acceptability.

A table, showing all sets of figures for each location should be produced and submitted to the Project Manager for approval. Wherever possible, the analyses should be accompanied by a plan of each area in question, showing the flow-paths and water flow depths. This will help with the risk assessment process in demonstrating where the maximum depths are eg running lane or shoulder or in areas of high braking or surface friction demand, and also where interventions eg catch-pits should be paced for optimum efficacy.

The Gallaway method should be applied in accordance with the Austroads Guide to Road Design; Part 5A. This method should only be used to assess the WFD in areas that have been identified as predicting unacceptably high values using the RRL method. The Gallaway equations should not be used as the default analysis method for any NZ Road Projects.

The Project Manager should assess the acceptability of the range of WFD’s predicted by the methods described above, against the solutions investigated by the designer in attempting to solve the issues by re-shaping the road surface.

Important note

There is an error in the formula on page 3 of the Transport Agency document *Highway Surface Drainage Design Guide for Highways with a Positive Collection System*. The factor to which the slope parameter should be raised is 0.2 and **not** 0.5 as written in the formula on that page. However, the correct value has been quoted in the formula reference with Chart 8 on page 37 of that document.

The correct formula is therefore:

$$d = \frac{0.46\left(l_f \times p\right)^{0.5}}{S_f^{\ 0.2}}$$

The flow path slope should be expressed as decimal (mm/m) rather than percentage.