Rainwater Ponding on Roof Structures with Interaction between Main Girders and Purlins

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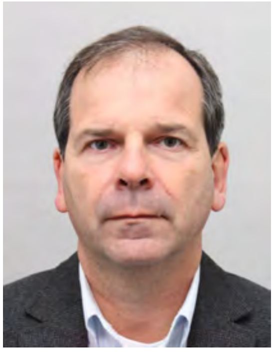

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1 Abstract

Rainwater causes flat roofs to deflect resulting in ponding. Due to the deflection, extra rainwater flows to the lower area of the roof, resulting in a larger loading with a larger deflection, resulting in more rainwater flowing towards this area, etc. Failure of flat roof structures due to ponding under heavy rainfall frequently happens in The Netherlands with an average of 15 incidents each year in the last decades. An increase in rain intensity due to climate change is expected to increase these numbers in the near future. Nevertheless, ponding on light roof structures is still underestimated as a significant load case in design. Moreover, the design calculations necessary are complex due to geometrical non-linear behavior. A number of software programs are available, but to keep insight in the process of rainwater ponding, a simple analytical design method for ponding of flat (steel) roof structures was developed including the interaction between main girders and purlins. The paper presents this method which avoids an iterative calculation procedure. Subsequently, this method is used to analyze a roof structure concluding that the interaction between main girders and purlins cannot be neglected.

Keywords: ponding; roof; rainwater; structural behavior; main girder; purlin; safety; failure.

2 Introduction

In case of well-designed and constructed flat roofs, the deflection due to ponding where rainwater causes the structure to deflect resulting in more rainwater loading, etc., will reach an equilibrium with the roof structure having enough capacity to resist the rainwater loading. In other cases, when flat roofs are not well designed and constructed, the deflection process continues without limit provided the availability of sufficient water, leading to failure of the roof. Rainwater ponding can be prevented by adequate construction measures. The rainwater load is of minor importance compared with other live loads on the roof, like snow and wind loads, in case the structure has sufficient slope and stiffness and the emergency drains are able to limit the water level on the roof. However, the necessary combination of these construction measures cannot easily be determined. An iterative case based calculation method may be used, but does not give insight in the governing parameters other than by trial and

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