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Evaluation of the stability of vehicles during floods: state of the art review

Ricardo Andres Bocanegra Vinasco (1), Felix Ramon Frances (2), and Francisco Jose Valles Moran (3)

(1) Universidad Politécnica de Valencia, IIAMA, Departamento de Ingeniería Hidráulica y Medio Ambiente, Spain (ricardoaboc@hotmail.com), (2) Universidad Politécnica de Valencia, IIAMA, Departamento de Ingeniería Hidráulica y Medio Ambiente, Spain (ffrances@hma.upv.es), (3) Universidad Politécnica de Valencia, IIAMA, Departamento de Ingeniería Hidráulica y Medio Ambiente, Spain (fvalmo@hma.upv.es)

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Floods can significantly affect vehicles, which in turn can increase the negative effects of floods when they are washed away by the water flow and become debris that impact existing infrastructure and buildings and clog hydraulic works. In cities the highest number of deaths during floods occurs inside cars. Consequently, it is necessary to establish the stability thresholds for vehicles during this type of events with the objective of providing necessary information for the proper flood management. This study presents an exhaustive review of the state of the art of vehicles stability in floods.

Methodologies available to determine the stability of vehicles address their watertightness in various ways. According to some authors, to assume that vehicles are completely impermeable during floods is a highly idealized condition, so they consider the entry of water into automobiles to determine the stability threshold, which is defined through expressions that establish relationships between depths and flow velocities (Teo et al., 2012a, Teo et al., 2012b). Other authors consider that it is appropriate to assume that vehicles are impermeable during floods and some of them determine the stability threshold using the total energy of the flow (Ausroads, 2008; Kramer, 2016) and others using linear relationships between the flow velocity and the depth or the product of these parameters; (Moore and Power, 2002, DIPNR, 2005, Shand et al., 2011, Smith et al., 2014, Smith et al., 2017, Martínez-Gomariz, 2017). Finally, some authors developed methodologies that allow the determination of the stability of a vehicle considering or discarding its impermeability; one of these methodologies establishes the stability threshold through the record of combinations of the flow velocities and the depths that generate the imbalance of the car (Toda et al., 2013), another one by comparing the forces acting on the vehicle (Oshikawa and Komatsu, 2014) and another one using the Froude number and a mobility parameter (Arrigui et al, 2015).

The stability thresholds proposed by each one of these methodologies were compared with each other. It was found that these thresholds vary in a relatively wide range, which also could be due to the diversity of decision criteria adopted and the simplifications made in each study. Additionally, data obtained experimentally were compared with the results of these investigations and it was found that some cars lost their stability with depths and flow velocities considered safe by some methodologies.

It is necessary to carry out new researches that focus on: (i) addressing the simplifications that the available methodologies have made in the experimental part or in the deduction of the stability thresholds, (ii) trying to standardize the decision criteria that must be adopted for define the stability thresholds (iii) performing measurements on a representative number of vehicles of different characteristics and (iv) developing measurements on vehicles of scale 1: 1