Ocean Engineering 37 (2010) 1389–1391

Contents lists available at ScienceDirect

Ocean Engineering

journal homepage: www.elsevier.com/locate/oceaneng

Discussion of "Study of Air-Ventilated Cavity under Model Hull on Water Surface" by K.I. Matveev, T.J. Burnett, and A.E. Ockfen [Ocean Engineering 36 (12–13) 891–1038 (September 2009)]

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ARTICLE INFO

Article history:
Received 21 August 2009
Accepted 2 June 2010
Available online 19 June 2010

The authors presented a study of the ventilated air cavity beneath a ship hull model. The aim of this discussion is to show that (a) there is a broader range of relevant literature in ship research and spillway aerator studies, and (b) model studies may be affected by significant scale effects when extrapolated to full scale.

There is a long list of pertinent studies of ventilated air cavities for a range of flow conditions (Fig. 1). Some key studies include Verron and Michel (1984), Michel (1984), and Stutz and Reboud (1997) for hydrofoils and wedge-shape bodies. A related study is that of the half-cavity by Laali and Michel (1984). Another application is the bottom aeration device installed on high-head spillways (Wood, 1991; Chanson, 1997). The bottom aerator is designed to aerate the spillway flow and to prevent cavitation damage of the chute invert on dam spillways when the flow velocity may exceed 12–15 m/s. As part of these studies, a number of jet trajectory and cavity length calculation techniques were developed (Schwartz and Nut, 1963; Laali, 1980; Tan, 1984; Franc et al., 1995). A larger number of studies investigated the relationship between the cavity pressure, air flow rate and flow conditions (Vischer et al., 1982; Tan, 1984), including a study with positive and negative cavity pressure number (Chanson, 1990). The experimental investigations showed further that the ventilated cavities were characterised by a fluctuating, cyclic behaviour at low to medium air flow rate (Franc et al., 1995). Both the cavity length and pressure fluctuated periodically with a growth, filling and breakoff phase.

A few studies investigated systematically the air–water flow properties with geometrically similar models using a Froude similitude under controlled flow conditions (e.g. Pinto and Neidert, 1982). These results demonstrated that the scale effects may be significant on small-size models. A recent study suggested that dynamic similarity is impossible to achieve but at full scale (Chanson, 2009). Following the initial work of Low (1986), several studies conducted detailed two-phase flow measurements in the vicinity of ventilated air cavities to investigate the air bubble entrainment and advection processes: i.e., Chanson (1989a, b), Stutz and Reboud (1997), Kramer et al. (2006), Toombes and Chanson (2007). These studies were conducted in relatively large size physical models, with flow velocities between 2 and 20 m/s, nearly 5–50 times larger than the velocities used by the authors. The physical results provided some useful insights into the air bubble distributions downstream of the cavity with direct implications in terms of cavitation damage prevention on spillways and drag reduction beneath ship hulls (Marie, 1987; Chanson, 1994). Numerical modelling of ventilated cavities may be a future research direction, and future studies may be based upon some composite models embedding numerical and physical studies.

In summary, the present discussion highlighted that there is a broad range of relevant literature on ventilated air cavities that should not be missed nor ignored. Detailed two-phase flow measurements around and downstream of the air cavity may provide further useful insights into the flow physics, and a number of previous results may be relevant to the development of numerical models.

DOI of original article: 10.1016/j.oceaneng.2009.06.004
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0029-8018/$ - see front matter
doi:10.1016/j.oceaneng.2010.06.004

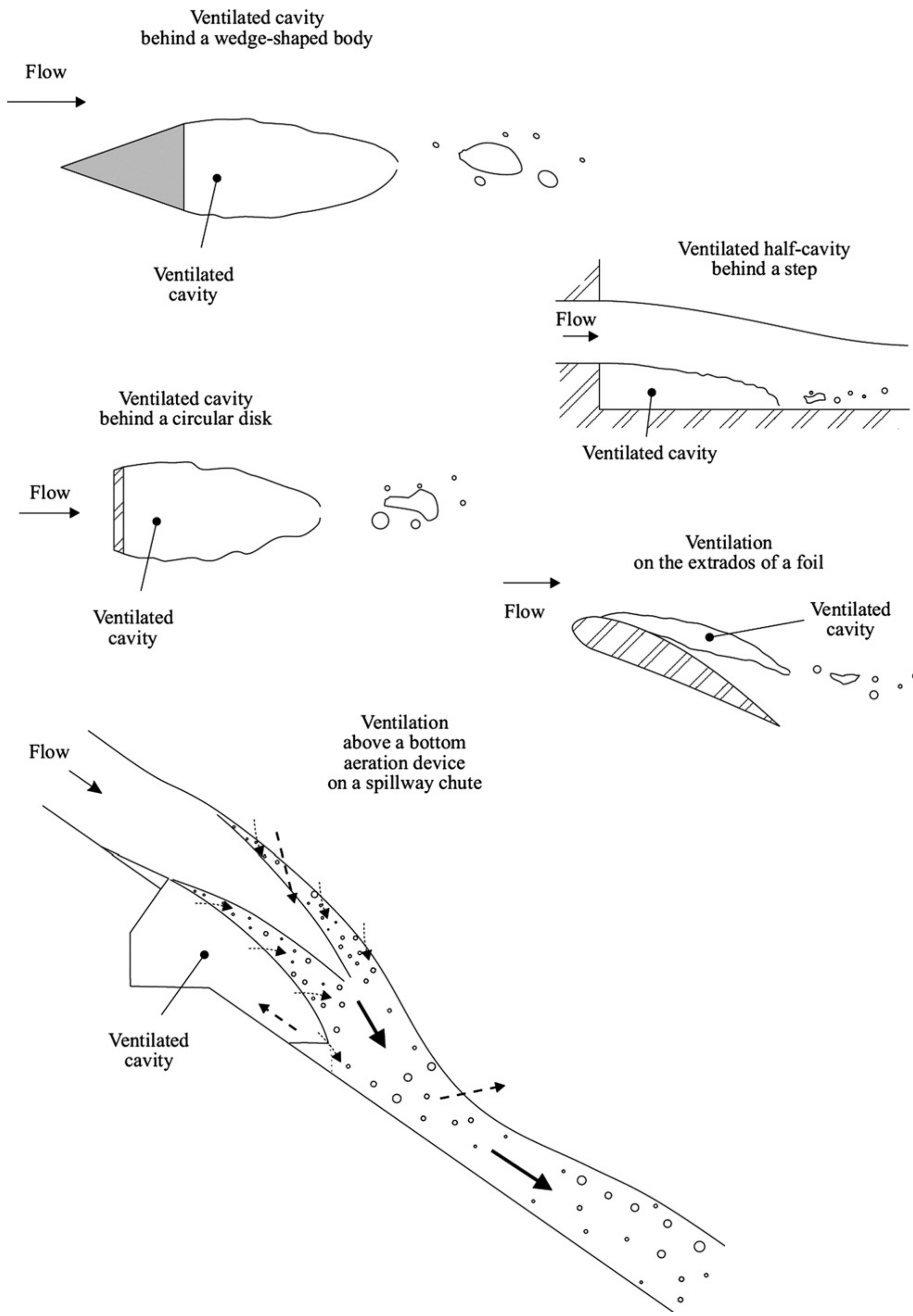

Fig. 1. Examples of ventilated air cavity flows.

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