mass for the impact of a ship and a dolphin[1]. Recently Blok and Dekker published model test results for berthing impacts conducted with a fixed underkeel clearance of 20% of the ship's draft[2].

(4.2) Finally results are plotted on the Figure from model tests berthing impact performed some 15 yr ago in Hamburg[3, 4]. However, these were actually conducted for ship *collisions*, i.e. with an opposite direction of energy transfer between ship and water, and with a much higher Froude-number and smaller "system dynamics number". In contrast to the results gained in Manchester for berthing impacts, we in our tests for collisions experienced only a very small increase in the added mass due to the effect of underkeel clearance (even too small to become clear from Fig. 1). It seems these latter model tests are the only ones conducted on the effect of shallow water on collisions with structural damage to date.

1. O. Grim, Das Schiff und der Dalben. Schiff und Hafen 1955, Nr. 9, S.535–545.
2. J. J. Blok and J. N. Dekker, Hydrodynamic aspects of ships colliding with fixed structures. IABSE Colloquium Copenhagen 1983, Preliminary Rep. pp. 175–185.
3. H. G. Hattendorff and H. Espenhain, Versuche zur Bestimmung der hydrodynamischen Zusatzmasse bei Kollisionsvorgängen auf flachem Wasser. HSVA-Bericht Nr. F17/69, Hamburg 1970.
4. G. Woisin, Schiffbauliche Forschungsarbeiten für die Sicherheit kernenergiegetriebener Handelsschiffe. STG-Jb. Bd.65 (1971), S.225–263 (hier S.228–231).

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Reply

The authors value the contribution made by Mr. Gerhard Woisin and make the following reply.

(1) Current work at Manchester is directed towards understanding the hydrodynamics of ship collisions with fixed structures. If the results show a significant viscosity effect then they could be checked using small ships such as canal boats, provided the problem was considered to be of sufficient importance to justify finance for such large scale tests.

(2) The criticism regarding the direct relevance of berthing tests to ship collision is valid in the context of collisions between ships underway but not necessarily in the case of a collision between a drifting ship and a structure or reef. The authors' main justification in presenting these berthing tests was that they draw attention to the importance of parameters, not previously examined to the limits of their effects, which gave results quite different from those obtained under more 'normal' conditions.

(3) The question of energy flow to and from the water is more complex than Mr. Woisin suggests. His example of a ship, struck in collision, passing energy to the water is incomplete, as some of that energy has been transmitted *from* the water to the impacted ship via the deceleration of the impacting ship. The authors would agree, however, that the added mass is a variable quantity, both during a specific event and between different events, and hence every case has to be examined carefully to determine its effect.

(4) The authors disagree with the generalisation that the added mass of collision is usually not dependent on the history of flow. In many collision situations the ship may have completed a manoeuvre just prior to impact or be in the process of carrying out a manoeuvre; this would affect the hydrodynamic flow field and hence added mass effects. Current investigations by the first author include impacts of a ship executing a turn at the moment of impact because the authors are concerned that this could give quite different results to those obtained for straight course collisions. Until measurements are available, the question of whether the history of flow before collision affects the forces must remain open.

(5) The figure presented by Mr. Woisin highlights the quite different added mass effects obtained for ship to ship collision and ship berthing. It remains to be seen where on this diagram the results will fall for cases such as a turning ship hitting a bridge pier and a drifting ship grounding on a reef.

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