The Energy of Collision

It is indeed possible to estimate the energy of the collision between the iceberg and the *Titanic*. The model used is that of a ship collision with an immovable, smooth object. We also must take into account that the ship was in the process of turning to port under hard-astarboard helm (left full rudder) at the time. We take the following:

Calculation Assumptions

- **Approach speed 38 ft/s (22.5 knots); Ship's Heading 0°**
- **Speed at impact 35 ft/sec [reduction due to hydrodynamic drag in turn]***
- **Angle of impact relative to centerline = 12°**
- **Location of ship's pivot point ~ 160 ft aft of bow****
- **Titanic's displacement April 14, 1912 = 48,300 long-tons [Wilding]**
- **Kinetic energy of ship before impact = 2,070,000,000 ft-lbs**
- **Point of max impact force taken ahead of bulkhead *B***
- **Center of gravity (CG) of ship taken at amidships near bulkhead *H***
- **Coefficient of friction steel-on-ice ~ 0.03 (set to 0 for calculation simplicity)**
- **Coefficient of restitution ~ 0 (hull deformation only)**
- **Mass of iceberg >> mass of the ship (set mass of berg to infinity for calculation simplicity)**

* *Titanic's* turning diameter-to-length ratio = 4.53. Steady-state turning-speed-to-approach-speed ratio is 0.77. At time of collision we have the speed down to 35 ft/sec.
** For *Titanic,* the location of turning pivot point is $X = R \sin \lambda$ ahead of the ship's center of gravity, where λ is the drift angle = $18L/R = 8°$.
[Footnote References: *http://web.nps.navy.mil/~me/tsse/TS4001/support/1-11-1.pdf*.]

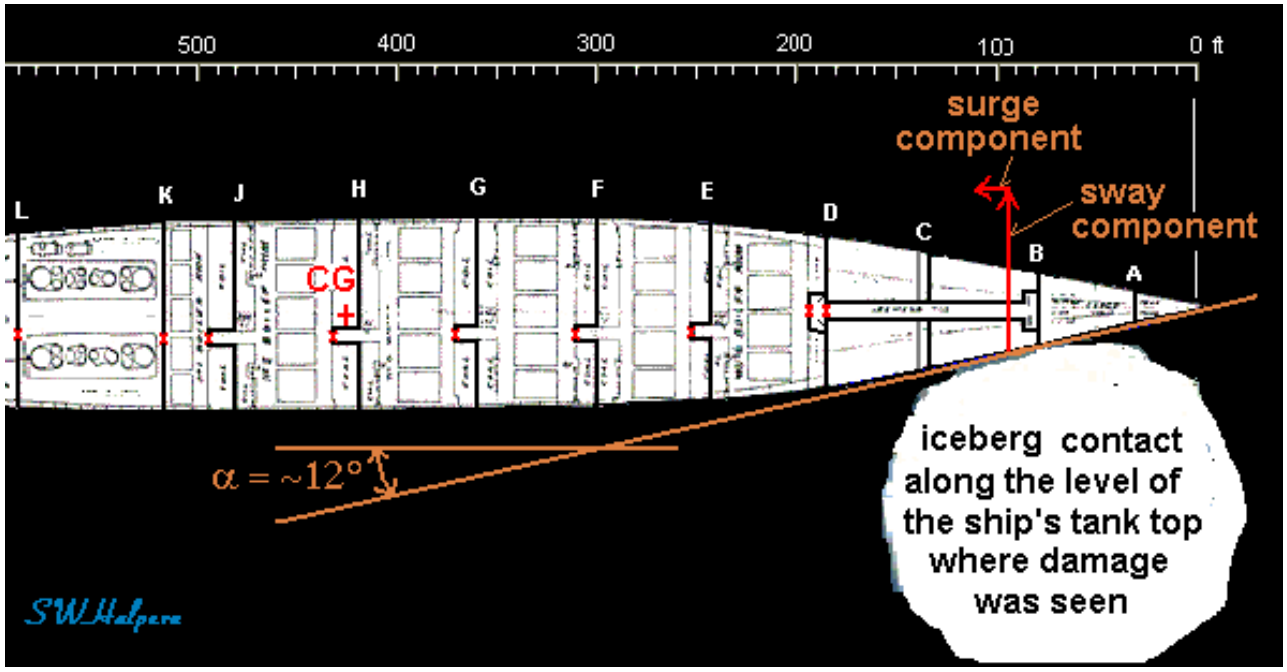
The contact situation is pictured below. Since the pivot point was located close to the contact area, the velocity component of the ship at that point is parallel to its centerline. Contact with an object of low frictional coefficient means that only two components in the horizontal plane need be calculated at the contact point, sway and surge. Sway is perpendicular to the ship's centerline while surge is parallel to the ship's centerline. Contact angle is the angle of the ship's hull relative to the centerline as shown below.

Calculation Results

[Reference: S. Zhang, "The Mechanics of Ship Collisions," Dept. of Naval Architecture and Offshore Engineering, Tech. University of Denmark,1999.]

- **Energy loss from collision = 31,540,000 ft-lbs**
- **Percent of ship's kinetic energy that was lost = 1.5%**
- **Contact impulse = 8,660,000 lbs-sec = app. 3,870 long-ton-sec**
- **Added rotational velocity imparted to the ship = 0.99° per sec**
- **Velocity of ship after collision = 34.5 ft/sec**
- **Sway velocity after collision = 1.4 ft/sec**

Notice that the total loss of energy to the ship was very small. Also note that the ship's speed immediately after the impact was not significantly reduced. All this matches well with many eyewitness accounts that the collision was barely perceptible. To many it was just a grinding sound that lasted a few seconds. To others, a slight vibration. Some people actually slept through the collision and were awakened afterward. A few were said it felt like a large wave struck the ship producing a slight swaying motion.



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