Materials

HMS Warrior was Britain's first iron-hulled, armoured warship, and is the last surviving nineteenth-century ship of her kind in the world. Due to her superior design, she dominated the seas and was such a deterrent to all other warships that she never had to fire a single shot in battle.

HMS Warrior 1860, Portsmouth Historic Dockyard
Image courtesy of *HMS Warrior 1860*

The *Warrior's* design makes use of a wide range of different materials. These materials have different properties. It was the designer's job to know what these properties were so that the right material could be used for the right task.

Warship design hadn't changed much in the 100 years before *HMS Warrior*. Part of the reason for this was that naval architects only had the same materials to work with over this time. By the nineteenth century different materials with different properties were becoming available and this meant that different ships could be built.

By 1860 it was possible to build a faster, larger, stronger and more powerful warship than ever before. Steam powered vessels could steam in any direction irrespective of wind direction. They could out-manoeuvre the traditional sailing frigates which were the fastest vessels of their time.

A view through one of *HMS Warrior's* gunports, showing the layered construction of her hull.

Iron hulls could be larger as well as lighter, and more durable than wooden ones. *HMS Warrior's* hull was built in a sandwich construction, with an outer skin of wrought iron iron in its purest commercial form. This had the advantage of being both tough and ductile, was resistant to corrosion and only required simple welding. The wrought iron outer skin of the hull was backed with a layer of East India teak. Armoured plates measuring 5 m x 3 m and weighing 4 tons each were bolted to the teak to form the inner skin. These 11 cm thick plates were made from hammered scrap and puddle iron.

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The cast iron guns were all placed on one long deck, giving a good weight distribution and helping to keep the ship stable. The majority of these guns were protected from bombardment by a 65 metre (213 foot) long armoured box or 'citadel'. The citadel was built of 11 cm thick wrought iron bolted on a 46 cm thick layer of solid teak. This was mounted on the 16 mm thick plating of the ship's hull. This was in turn mounted on the ship's frame with an internal finish of pine.

Warrior's armour was so effective that it could not be pierced by the most powerful cannons of the day, even at point-blank range. The reason for this amazing strength was the wood sandwiched between layers of iron. Combining materials in this way produces a structure which is much stronger than any of the component materials on their own.

Manoeuvrability of the ship depended very much on weight, so the ship's designers gave armament priority over comfort not many labour-saving Victorian innovations were used onboard. This was probably deliberate because it meant that there was plenty of manual work to keep the men occupied when they weren't in battle!

When sailing under steam the *Warrior* used an enormous propeller. The hub was cast in iron and the blades were cast separately in brass. These were bolted on meaning that a damaged blade could be replaced at sea with one of the spares carried on board.

Lignum Vitae
'The Wood of Life'

One of these is kept in the laundry area, so you can see just how impressive it is for yourself. To reduce drag, the propeller could be disengaged and lifted out of the water when the ship was under sail. It took 400 men using a rope and pulley arrangement to raise or lower the 32 tons of propeller equipment.

The pulley blocks were made of wood and vary in size, from ones as big as your hand to some as big as a barrel. They comprised of components of several types of wood (including lignum vitae, the densest wood there is), iron, bronze and rope.

Ropes were made from hemp, leather or steel. Old hemp rope was made into oakum. This was used for sealing the gaps between the wooden deck planks or 'caulking' the deck.

Life for the sailors on the *Warrior* was pretty good by the standards of the day. They had a well balanced diet and a good standard of health and life expectancy was better on board the *Warrior* than in some parts of British cities at that time.

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The seamen slept in traditional hammocks made of flax canvas, whereas the Captain's Quarters were furnished in the style of the Victorian period. The Captain and his officers had wooden furniture in their cabins possibly including a bed or a 'cot', which was a swinging bed that could double up as a coffin if you were unfortunate enough to need it. Floors were covered with painted canvas, generally made using old sails.

Sails, clothes and bags made of canvas, cotton and linen were made and repaired by hand or sewing machine in the sailmaker's locker.

A sailor's uniform had been introduced in 1859. Dress varied according to the job, the day of the week and the time of day. Blue serge 'frock' tops or very dark blue jumpers and white cloth trousers formed the most normal outfit, but white dress was worn for drills. Stokers wore white duck suits all the time. Sailors had a number of uniform shirts - varied, being either white, blue, coloured or check, made of flannel or cloth.

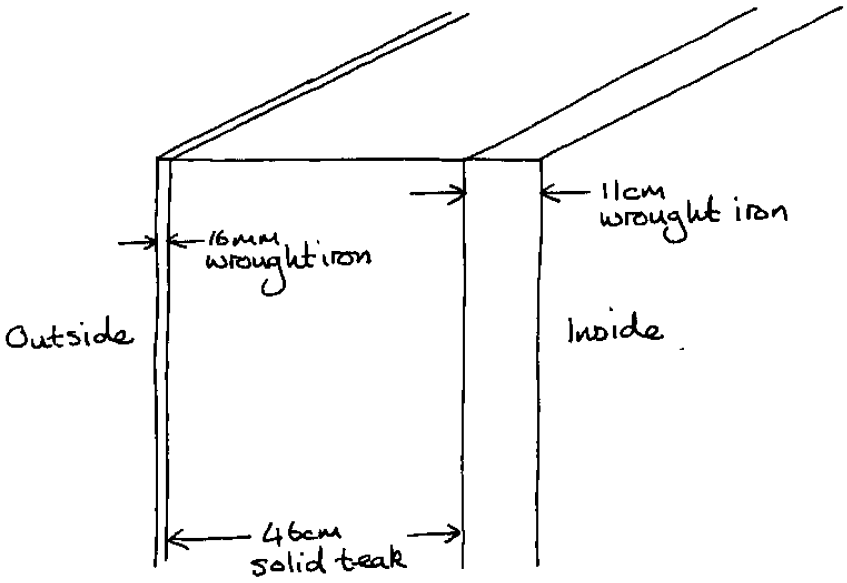
Food preparation took place at each mess table by the mess cook. Each mess had a canvas tablecloth. The prepared food was then taken to the galley where it was cooked. About 600 meals were generally boiled in large copper pans heated by the coal-fired, cast iron range.

The *Warrior's* cast iron range

Provisions were weighed out from the issue room, where dry ingredients and the ship's biscuits, were kept in canvas sacks and wicker baskets or in wooden barrels, known as bread barges. Metal mess kettles or meat tins (fannies) were used for not only collecting the grog issue, but also food. One metal drinking cup had to be shared between four men. Senior ratings may have had ceramic bowls and plates.

When he was fortunate enough to have a guided tour of the ship as she was being fitted out with her armament, Charles Dickens understood the importance of the innovative combination of design and modern technology and materials that the *Warrior* demonstrated. He wrote: 'Mere dogged bravery and reckless bulldog courage will not do now; we shall want science and more comprehensive schemes of combination.'

Testing to Destruction



Scale drawing of the *Warrior's* citadel wall

The amazing strength of the *Warrior's* citadel was due to the 'sandwich' type structure of the walls.

The 16 mm wrought iron outer skin of the ship was backed with 46 cm of solid East India teak which was in turn backed with 11 cm of wrought iron plate.

It was so strong that even the most powerful guns of the time couldn't blast their way through it - even at point blank range!

Don't believe it? Well why not have a go at building your own citadel walls and testing them to destruction?

Here's what you need:

An old 'D' cell battery
A plastic sandwich box or jug - a circular one is best if you can get it
A 60 cm length of 40 mm plastic waste pipe - if you don't have this to hand you can tape together two cardboard tubes from rolls of kitchen towel.
Some kitchen towel
A sheet of newspaper
A sheet of tinfoil
A couple of rubber bands that will fit tightly around the top of your jug or sandwich box

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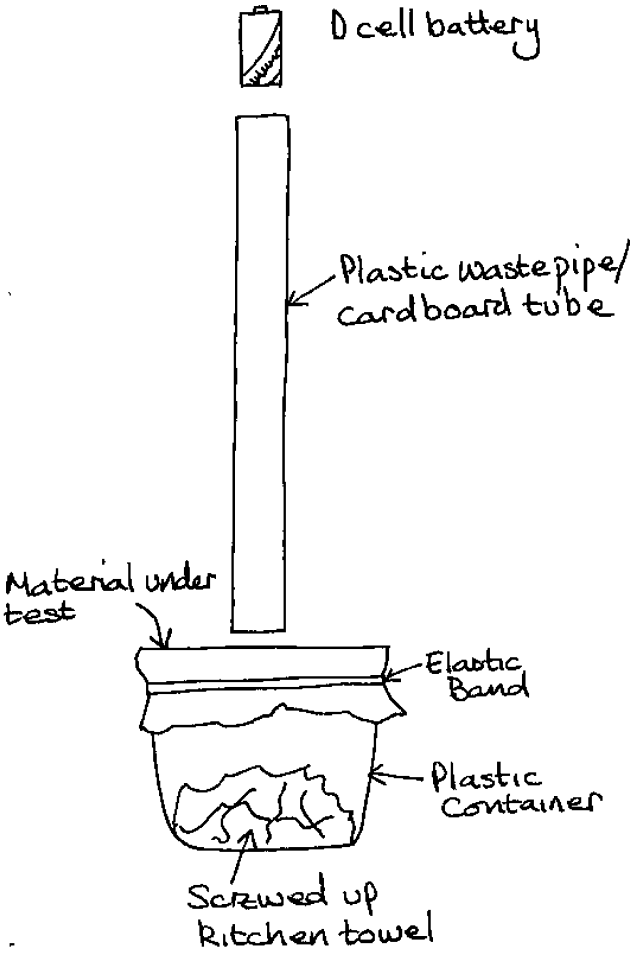
Testing to Destruction



Start off by screwing up some kitchen towel and placing it in the bottom of the plastic container. This will cushion the fall of the battery and stop it from breaking open or damaging your container and the floor / table it might be resting on.

The take a piece of tinfoil big enough to cover the opening of your container with some left over. Bend this over the edge of your container and fix it in position with an elastic band. You should now have what looks like a tinfoil drum.

Now hold your plastic pipe / cardboard tube straight above the tinfoil surface so it is just touching it.

Hold the battery in the top of the tube. Have one last check that you are properly lined up with the centre of the tinfoil - then let go of the battery.

Make a note of what happens. Did the battery go through the tinfoil?

Now try the same again with a newspaper sheet and make a note of what happens.

When you have done that try sandwiching the materials together to see what difference it makes. You might want to have a go with:

- A piece of newspaper sandwiched between two pieces of tinfoil
- A piece of tinfoil sandwiched between two pieces of newspaper
- Two pieces of newspaper sandwiched between two pieces of tinfoil

There are many different combinations to try and you might want to try some different materials as well - how about tissue paper?