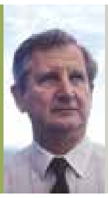
Construction aspects of boat launching from beaches and ramps in South Africa



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BACKGROUND

Small rowing-type boats have been launched from and landed on beaches since the beginning of boating, as they are generally small enough and light enough to be manhandled into the water and then back again up the beach clear of the water.

The advent of the outboard engine has led to a new class of vessel – the powerboat. Generally, these are used for recreation and inshore fishing. In Natal, a type was developed with a flush, self-draining deck suited to open beach launching and landing through the surf, known as a "ski boat". The term has stuck and is in general use for powerboats used for inshore fishing on the South African coast. Most of these boats, however, particularly in the Cape, are not ski boats at all, but normal powerboats, not particularly well suited to beach launching. They are well suited, though, to being moved around from place to place on road trailers and stored out of water.

The types of vessels considered are:

- Jet skis (also handy for surf lifesaving)
- Rigid rubber ducks (also handy for law enforcement and research)
- Traditional wooden boats
- Rigid mono-hull vessels
- Catamarans

OCEANOGRAPHY

Tides

Over the whole South African coast the tide is regular semi-diurnal, i.e. there are two tides a day – two high tides and two low tides with about 12.4 hours between consecutive high tides. The range of the tide from low tide to high tide has a maximum, the spring tides, which occur twice a month, about every 14.5 days when the sun and the moon are in alignment. The range is about 2 m. Halfway between are the neap tides when the range is a minimum – generally about 1 m. The "establishment" of the tide on the coast – the delay between the time of the transit of the moon overhead and the following high tide – is about 3 hours. Since the time between high and low water is about 6.2 hours, the preceding low tide will lead the moon by about 3 hours; and, since at spring tide the moon passes overhead at either midday (new moon) or midnight (full moon), spring low water is always around mid-morning. As fishermen generally go out in the early morning and return around midday, they do not usually use a ramp at spring low tide.

Note regarding datum: There are two data in use at the sea shore: Chart Datum (LAT) and Mean Sea Level (MSL), otherwise known as "Land Levelling Datum". The former is used by hydrographers to present water depth contours on navigation charts. That way there is never less water than the amount shown on the charts. The tide is a bonus. However, the offset of LAT (Chart Datum) from the surface of the geoid is different at each tide gauge site. Hence, the geodetic survey has adopted a single universal value to represent mean sea level throughout the country. The tides are always quoted to chart datum, and since the core objective of this article is the launching and retrieving of vessels, and the transfer of such vessels from structural to hydrostatic support and vice versa, the critical element is the depth of water. Hence, for boat ramps and launching, it is better to use chart datum.

Sea level rise

Estimates of the amount of sea level rise over the next century are still quite variable, but point to an order of 1 m. Given the time frame involved and the consequently very low net present value of any future consequences – mainly remedial costs – the issue is not very significant. However, many sites will lend themselves to a top level for the ramp at about 4 m above chart datum – enough to allow for future sea level change, and it would be prudent to use this opportunity.

Wave climate

Off the South African coast, the ambient wave swell is rarely less than 1 m.

The 10-year peak (Hs) wave height off the Cape is in the order of 10 m, reducing northwards on both the east and the west coasts. However, it is impractical to build boat ramps directly into these conditions. Some significant degree of protection, either natural or artificial, is always needed.

Since the objective is boat launching viability, an ongoing activity throughout

Photo 1: Fishing boats on the beach at Rogge Bay, Cape Town, at the beginning of the 20th Century

Photo 2: Selection of modern hulls and trailers

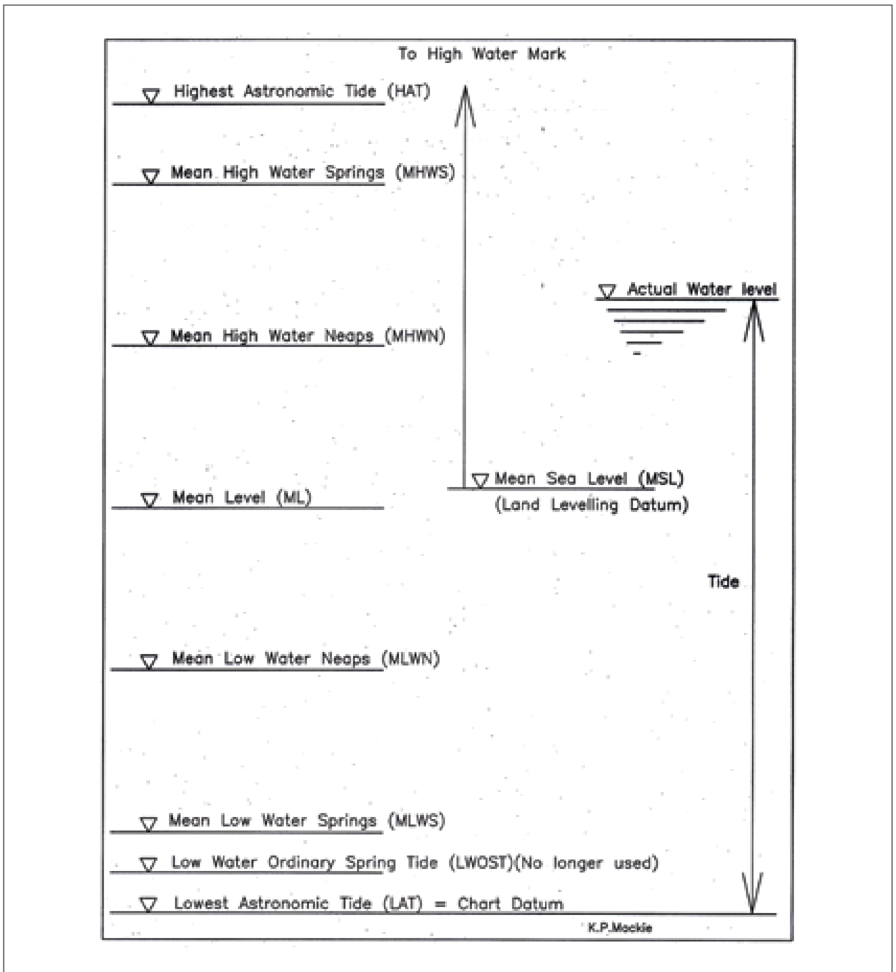

Figure 1: Tide parameters for South Africa

the year, the relevant wave climate is the prevailing condition at the site. Storm conditions that are relatively rare and of relatively short duration are only relevant to the physical integrity of any structures built in the sea or attacked by storm waves.

Sediment movement

The South African coast is predominantly rock-bound and relatively sand-starved compared to conditions worldwide. Sand is generally found in pocket beaches or in the large "half-heart" bays. These beaches are usually subject to strong littoral drift – the migration of sand in the seashore along the coast. Hence, any obstruction on the seashore will affect this drift and will result in accretion or erosion, either of which could compromise a boat ramp built on a sandy shore. Typically a boat ramp will act as a groin, with sand build-up on the up-drift side and erosion on the down-drift side.

The first issue to address on sandy beaches, to measure this effect on the beaches, is the "swept prism". This is a montage of beach sections measured at different seasons over a number of years, all at the same spot. The swept prism is the envelope of all these sections. It is not the maximum and minimum sections. It records the total capacity of the beach to change with the seasons and hence is a very valuable design tool.

The reflective beaches are commonly the low-energy summer beaches and reflect most of the incipient wave energy; the dissipative beaches are typically the high-energy winter beaches and dissipate most of the incipient wave energy in wave breaking and percolation of the swash into the sand.

South African beaches generally fall into the "Rhythmic" category and are characterised by large changes in profile with the seasons. Some, such as Muizenberg, Robberg Corner at Plettenberg Bay or Vetches at Durban, fall into the "Dissipative" category and are characterised by being very flat with little seasonal change.

The next issue is the "worked prism". Both the increase in pore pressure in the sea bed as the waves pass over the bed, and the percolation of swash into the sand induce liquefaction in the sea bed at the shoreline and a quick condition. Any structure built on the sea bed will sink into the sand to the depth of the worked prism. This can reach a depth below the sea bed of 3 m under storm conditions and over 1 m under a 2 m swell.

VESSEL TRANSPORT AND DESTINATION

Cape experience

The waters off the Western Cape offer a variety of maritime opportunities – commercial, semi-commercial and recreational. These opportunities vary constantly in time and position with the seasons and the weather. Hence most boats in the Western Cape are kept on road trailers that can easily be taken to any part of the coast.

The shape of the Western Cape yields a road system that is interior to the coast, making road transport of vessels around the coast much quicker, more economic and safer than driving vessels by water. This does require adequate launching facilities distributed around the coast, and these facilities have been provided in naturally protected sites and in small harbours. Kalk Bay is the exception since it lacks road access to the water, so that there are no public access boat ramps between Simon's Town and Gordon's Bay.

The kind of equipment needed for ramp launching, in effect road trailers, effectively limit this system to protected water free of heavy surf.

Natal experience

The situation in Natal is rather different. The coast is exceptionally straight so that the road system runs parallel to the coast. There is no difference between road and water distances along the coast, nor are there any naturally sheltered inlets or bays on the coast. The seashore is commonly backed by high dunes that make road access to the beach difficult. There is also a very large (c 700 000 m^3/annum) littoral drift on the coast that would immediately swamp any attempt to construct small-scale artificially protected water. The Natal tradition, as elsewhere, started as beach launching, but has stayed as such despite modern changes in vessel type and road transport.

Only if boats must be removed from or returned to the beach are any civil works needed. Some sort of access is nevertheless needed from the nearest roads down onto the beach. Beaches, at least in South Africa, are generally subject to wave action, and the boats and rigs are usually designed to handle strong surf. As

Photo 3: Use of break-back trailer and 4x4 with front-mounted winch and tow hook (Photo courtesy Natal Sharks Board)

Photo 4: Beach launching, Central Beach, Plettenberg Bay

mentioned earlier, the Natal ski boat was developed specifically with Natal beaches in mind.

BEACH LAUNCHING

Beach launching can be used to launch and land when there is a strong surf running, provided suitable boats with sufficient engine power, such as the Natal ski boat, are used.

In its simplest terms, beach launching is a matter of manhandling boats into the water and out again up onto the beach. The use of inflatable rubber rollers placed under the keel helps considerably. The process is made easier if the boats are on road trailers. Generally an extension drawbar allows a 4x4 or tractor to push the boat into the water. Usually the boat is driven onto the beach and a winch on the vehicle is used to draw the boat back onto the trailer (Photo 3).

At Plettenberg Bay, large open whale-watching boats are beach-launched. The dollies have a long drawbar that can be pushed through the dolly to operate from either end. After launching, the dolly is turned around and the drawbar reversed, ready to be pushed into the surf to land the boat. After landing, the process is reversed, ready to launch again.

A not dissimilar system is used to launch and land heavy wooden fishing boats at Arniston, using a large tractor purpose-modified for the function.The sandy sea bed at the Arniston ramp is very flat and, at the ramp, reaches to about half tide. The site itself is exposed to small waves that make boat handling difficult on the ramp. Although the site is nominally a ramp, effectively it is a beach launch. The modified tractor is used to push the vessels into the surf, aided by a number of men to hold it upright until it is away. In similar manner the tractor is used to haul a landed boat out of the surf and up to its parking on the upper ramp.

Ramps on open beaches do not normally work. If they are not taken down through the sand to bedrock, or if they do not have a foundation of rubble replacement taken down to below the envelope of the swept prism and below the level of liquefaction, if the ramp is founded on sand, then the sand will be washed out and the ramp will fail.

CONVENTIONAL BOAT RAMP DESIGN AND CONSTRUCTION

Geometry

Standard features of the geometry:

- Road access must have a "T" form to permit reversing onto the ramp. The ramp should be laid out at right angles to the access road as shown in Figure 2. This allows the rigs to drive a short way past the head of the ramp, reverse back and then down to the water. The width of a single lane ramp should be 4 m between kerbs or 4.5 m without kerbs; a multi-lane ramp should have a width of 3.3 m per lane.
- Road access must lead to adequate parking with over-long parking bays to accept rigs. A large parking area is needed to accommodate the rigs while the boats are at sea. Allow 30 to 40 bays per ramp lane at popular sites and 20 to 30 at less popular sites.
- The launching gradient must be exactly

1:8. If the ramp is steeper than 1:8, the towing vehicle will lose traction. If it is flatter, the boot of the towing vehicle will flood before the boat floats free.
- Depth at the end of the ramp must be at least 1 m below chart datum. This is sufficient to launch or land at all tides. When they are landing, skippers usually try to drive the boat well onto the trailer and gun the engines as they do so. The resulting prop wash will inevitably create a scour hole at the end of the ramp and deposit the excavated material offshore, just beyond the scour hole as a sand bank, which becomes an obstruction to navigation. The area in front of the ramp should therefore have a scour mattress of stone large enough to resist the prop wash.

Construction

In protected water where the wave height does not normally exceed 200 mm and never 300 mm, the design issues, aside from the geometry, boil down to normal pavement design. There is, however, a proviso. The substructure must be protected from washout and undermining. The water is in continuous motion, and if the structure is founded on fine material, e.g. sand, it will be washed out unless provision is made to retain it.

Placing concrete of any quality underwater is extremely difficult. The landlubbers' way of doing this is to coffer off the site and do the work in the dry.

Above high tide normal materials apply, i.e. concrete, paving brick, asphalt, etc. Formation below about 1 m above high tide must be constructed from mixed rubble without any fines to avoid leaching of fines. Any fine material within reach of the water will be leached out eventually, leading to the collapse of the pavement.

Quality construction below high tide, underwater, can be done without using coffer dams, the practical solution being to use large precast concrete slabs placed by crane onto a bed of stone screeded to profile. A kerb beam should be used to contain the slabs (Photo 6).

DESIGN OF RAMPS EXPOSED TO STORM ATTACK

Slab instability

This is where "concrete floats"! Plunging waves breaking onto the ramp lead to very high stagnation pressures. These inevitably feed under the slab as uplift

Photo 5: Protected ramp inside Hout Bay harbour with leading jetty, 1977

Photo 6: Witsands ramp 2008 – long approach to get correct end grade and end depth

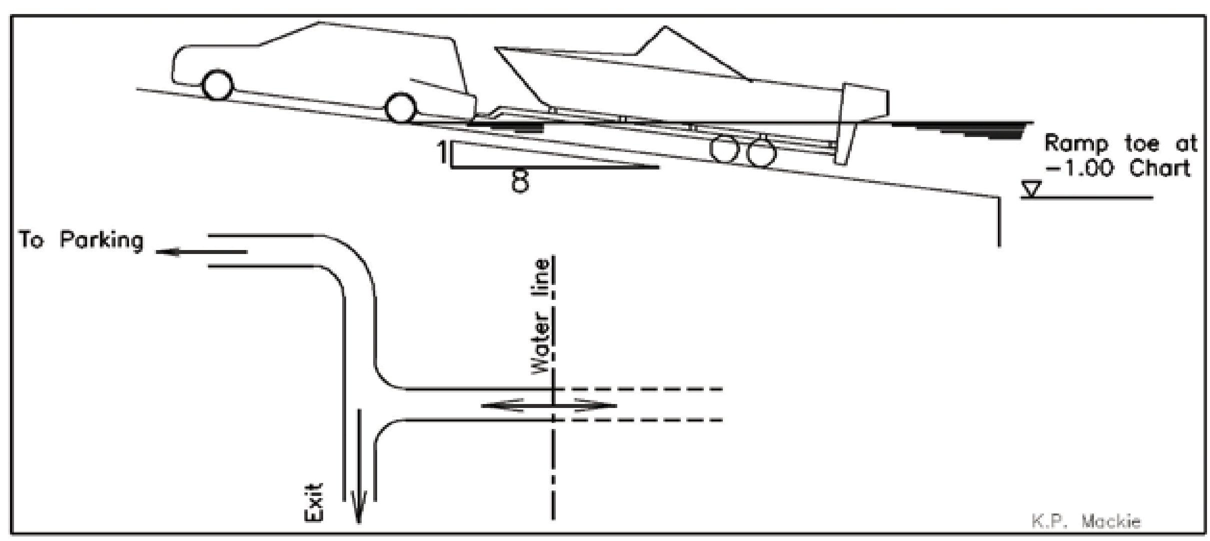

Figure 2: Boat ramp geometry

pressure – sufficient to counteract the weight of the slabs. Without any grip, the swash that follows the break is able to float the slabs out of position and break up the ramp (Photo 7).

The Yzerfontein ramp broke up in this manner under the attack of waves of about 1 m breaker height. The event was modelled at a scale of 50:1 and it was possible to reproduce the process very reliably down to the actual pattern of the movement of the slabs, confirming the presumption of the activating mechanism.

The ramp was redesigned on the basis of this theory. The slab thickness was increased from 200 mm to 250 mm. Inter-linkage between the slabs was provided and proper ramp edge constraint was added. Before this reconstruction was started, a mini-breakwater was constructed to shield the ramp from the worst of the wave attack.

The next problem proved to be wave setup on that coast. Under storm conditions the setup on the shore and inside the mini-basin created by the breakwater was about 2 m with the period of the dominant wave sets on the coast, i.e. about 2.5 minutes. This led to a surge into and out of the basin with most of the flow taking place in a period of about 30 seconds. Boats could only launch or land if they could complete the operation in the approximately 1-minute periods of slack water. Only skilled skippers could use this ramp.

The problem was partially cured by putting a rubble mound on each side of the ramp.

Selection of slab weight

Design of ramps to resist wave attack: (Figures 3, 4 and 5 refer)

- Slab design is essentially the design of revetments under breaking wave attack. The design chart in Figure 4 can be used to establish slab thickness.
- Generally a slab size of 2 m x 3 m at 200 mm to 300 mm thick should be used.
- Increase permeability by providing weep holes in the slabs and by using a coarse filter – say 75 mm stone between the rubble fill and the slab.
- Mechanical interlock: tremie concrete perimeter beams cast in situ should be used to lock the outer slabs to the surrounding rubble armouring. The corners of the slabs should also be splayed with protruding reinforcement. Where the slabs meet, the square hole that is formed by the splays can be filled with tremie concrete to lock the slabs together. If the protruding reinforcement is in the form of loops, chain can be threaded through them before they are concreted in to improve the lock.
- Precast slabs must reach from the toe to the high-tide level. They must be surrounded by robust tremie concrete walls and the slabs must he grouted together and into the walls.
- In general, unless concrete ramps are cast directly onto solid rock and dowelled into the rock, they should only be built in protected water. In the case of Yzerfontein, this was achieved post-hoc by constructing a small breakwater to protect the site.
- More recently, using these principles, a ramp has been built successfully at

Witsands, near Kommetjie, where a small breakwater is not possible (Photo 6).

ANCILLARY PROBLEMS

Transverse surge (Photos 9 and 10 refer)

The construction of a ramp to the recommended geometry into wave attack leads to an hydraulic problem of cross currents on the ramp. Not only is it difficult to handle a vessel onto or off the cradle against the fore and aft surge, the transverse currents also carry the vessel sideways making control much more difficult.

The time it takes the swash to run up and run down a beach depends on the slope of the beach – the steeper the beach the faster the run up and run down, and the flatter the beach, the slower. Hence, the run-up on the ramp rises above that to either side of the ramp and water flows off the ramp to the side. The run-down is similarly rapid and falls below the water level to the sides so water flows onto the ramp from the sides.

The only solution is to use leading walls down each side to the ramp to prevent this cross flow. These in turn can be detailed to serve as leading jetties.

If the sides are built as vertical walls and the oncoming waves are at an angle to the axis of the ramp, then they are likely to reflect back and forth across the ramp. It may be preferable to use absorbent rubble mound side walls to attenuate this effect.

Herring-bone grooving

Boat ramp surfaces can become very slippery with marine growth. The top surfaces of the slabs must be finished to provide increased grip for the vehicles using the ramp. Herring-bone grooving is the standard method used to achieve this. However, some thought is needed to get an effective grooving that will retain its efficacy for long periods. An inadequate pattern can be worn off quite quickly by spinning wheels.

The ideal pattern has a trapezoidal corrugation form with a pitch of 100 mm, a depth of 25 mm, flank angles of 45° and are oriented across the slabs at an angle of 15° to the width of the slab, this handed to adjacent slabs. To get a good profile to the grooves, they should be formed on the shutter soffit and the slabs cast upside down. A pair of handed shutters is required to cast both hands of the slabs.

Marker posts

Good practice is to provide a permanent post on each side at the seaward end of a ramp to mark the end. The top of the post should be finished with a conical cap to prevent birds roosting on it and fouling it.

Leading jetty

A leading jetty is very useful for embarking and disembarking so that the rig driver can park the rig and return to the boat after launching, or fetch the rig on landing. In sheltered water where the deck of the jetty never gets wet and slippery, this works well. Scrap tyres fitted to the face of the jetty provide both fendering and a means to clamber onto the jetty from a boat. Where a ramp is built at an exposed site, the jetty is liable to be overtopped by storm waves and becomes slippery and dangerous even in calm conditions after a storm. Under these conditions, the provision of a jetty is questionable.

LAUNCHING PRACTICE

Ramp launching

Given the availability of boat ramps in the Western Cape, the shape of the coast and the road network, the rigs of vehicles and trailers are not designed for beach launching. They are only designed for road towing and work very well. They are usually equipped with a hand winch mounted on the front of the trailer over the tow-hitch to assist in getting the vessel onto the trailer

Photo 7: Break-up of Yzerfontein ramp, 1978

Photo 8: Placing 2 m x 3 m x 300 mm slabs at Witsands near Kommetjie

and to lock it into position during a road haul.

On a well-designed boat ramp in protected water, it only needs two skilled people, a rig driver and a skipper, to launch or retrieve a vessel. On the steep 1:8 slope of the ramp, the rig can be lowered sufficiently to start the

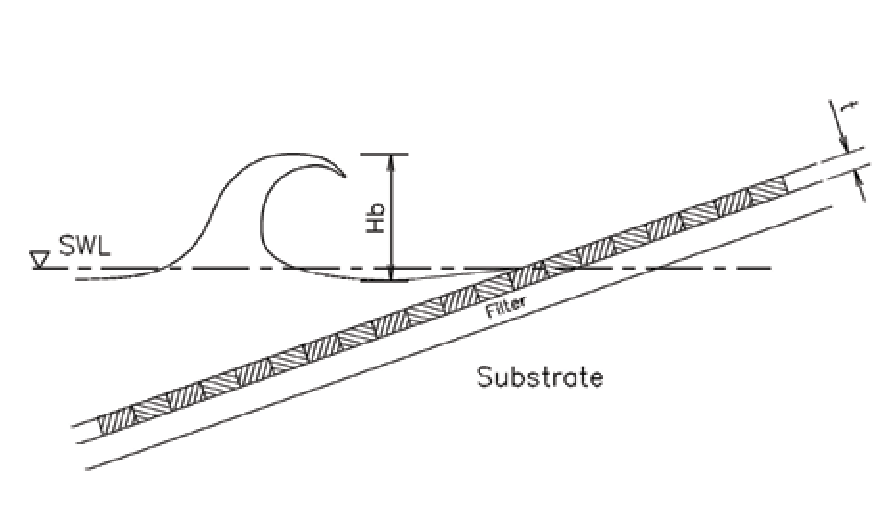

Figure 3: Schematic representation of paved revetment

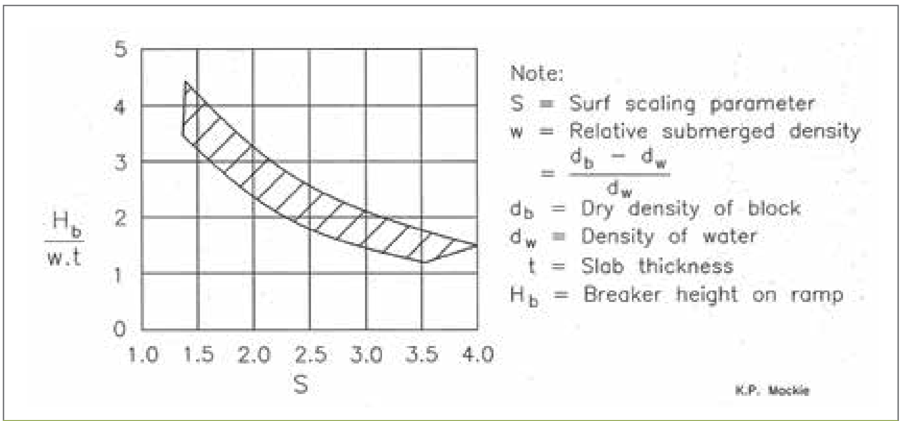

Figure 4: Block thickness selector (after Bezuijen et al)

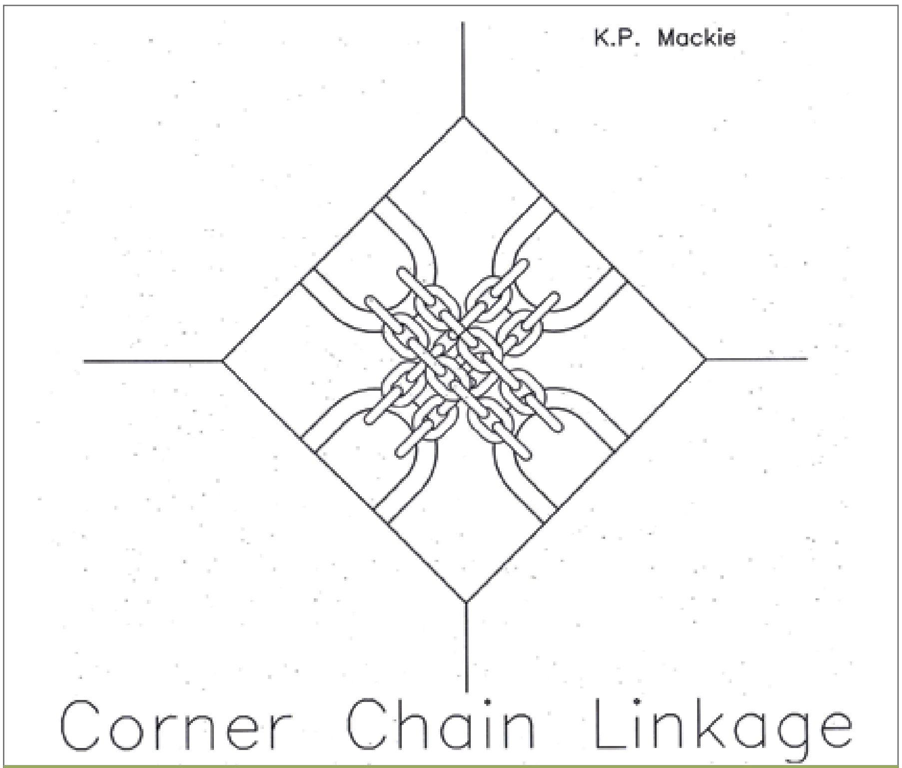

Figure 5: Typical slab detail – example of corner chain linkage

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boat engine and pull the vessel off the trailer. A reverse process is used to land a vessel. Once it has sued on the trailer, a trailer-mounted hand winch can pull the vessel fully onto the trailer. (The "sue" of a vessel refers to the first contact of the keel with the blocks and the process of changing the vessel from hydrostatic to structural support, i.e. the initial stages of bringing the vessel out of the water.)

Beach launching

For beach launching on a flat beach slope with inshore surf, a large number of people are needed to manhandle a vessel off the current Cape-type road trailer, turn it around and get it to sea. Landing the boat is somewhat easier in that the boat can be beached and then hauled directly onto the trailer using a power winch on the towing vehicle.

The whole process of beach launching can be significantly improved by purpose-designed modifications to the trailer towing bar so that the trailer can be pushed or pulled from either end, and so that an extension tow bar can be used. A "break-back" trailer makes the operations of launching or landing significantly easier.

STRUCTURAL LIMITATIONS

Generally it is possible to design boat ramps to withstand quite severe wave conditions.

There are sites where it would be convenient to have a ramp, but where a "comfortable" ramp can never be achieved. Generally it is impractical to design a ramp to withstand waves breaking on the ramp with a height in excess of 1.0 m to 1.5 m.

NOTE REGARDING TERMINOLOGY

It is common in yachting and small-craft circles, particularly in British and South African usage, to refer to launching ramps as "slipways". This leads to confusion with the slipways for dry-docking larger vessels – usually in the 100 to 1 000 ton range. Originally the term "slipway" only referred to the greased timber sliding ways used for the launching of newly built ships. The term "slipway" has been retained for the dry-docking slipways of a cradle on wheels on rails on the ways.

Hence, and to avoid confusion, the American usage ("ramp" or "launching ramp") was followed in this article.

REFERENCES

The list of references is available from the author. ☐

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Photo 9: Witsands/Soetwater, calm weather, low tide – note leading rubble mound

Photo 10: Cross currents on a boat ramp under wave attack (Strandfontein), 2013