‘Engineering for Defence’ – the Problems and Solutions

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Coast Defences were specialist jobs - with specific high-tech functions, but which also had to withstand bombardment. Delicate instruments had to work in coarse, rough, damp, armoured buildings, and therefore be liable to a shaking and dusting. So the engineering designers of coast defences had to provide in them both nimble-finger and thick-hide solutions – which I discuss later under the heading ‘Fine and Coarse’.

But there were other engineering problems that beset these designers. These are illustrated from the two distinct eras, as the Victorian engineering (1880s-90s) issues differed from those of the 1930/40s.

1. Isolation of sites

Most sites chosen in 1885 for the first round of fortifications were isolated, despite being on the periphery of the main inhabited harbours. Very few were connected by roads, and most were a lengthy boat ride and a landing – weather permitting - on an uncertain and usually rocky shore. In 1887 Arthur Bell described Palmer Head as ‘a pleasant hour and a half’s ride’ from Wellington: Taiaroa Head was half a day’s journey from town.

Roads tended to follow the construction of batteries, both in a sense of time and order of priority. The road was not necessary for the battery to be built or serviced, but made for easier re-ammunitioning and getting troops there for training. The roads to all the forts on Miramar Peninsula, for instance, was a major work, in the early 1890s, which left from the north-west of the Miramar suburb (corner Maupuia Rd and Akaroa Dr), and connected the submarine mining base at Shelly Bay, with the forts at Halswell Pt, Kau Pt and Gordon Pt, and the infantry redoubt on Mt Crawford. It predated the road-around-the-foreshore, called Massey Road, by over 30 years and is itself now a candidate for historical registration.

The main method of overcoming isolation of these sites was the erection of wharves or jetties nearby the intended works, to take a small steamer. For these the Defence Department started running a small steamer to service the forts in each port. This extended the range of skills required by otherwise land-based military people to include marine engineering and seamanship (a set of skills initiated with the arrival in 1884 of the four torpedo and minelaying boats).

The jetties sprang up in anticipation of the fortification construction. Those built at the Submarine Mining Depts were to serve both the torpedo and minelaying boats, as well as landing the materials for the forts. In this category are the jetties at Shelly and Mahanga Bays, Bastion Pt and Ripapa Island (though the latter very early on lost any role with submarine mining). The jetties built off the eastern end of North Head or at Harrington Pt were specific to the fortification needs. In other instances existing jetties were used, such as Kaiwharra Stream (which had been used for loading explosives from the Kaiwarra magazine since 1879) or Takapuna's commercial jetty.

The isolation problem in WWII meant less upheaval while the sites were connected by road (existing, or able to be built for the purpose), but the size of the batteries to be built and their remoteness were factors that increased exponentially from the Victorian era. The batteries built, for example, on Motutapu Island in 1937-38, or in the Marlborough Sounds in 1942, fall into this category. Very difficult jobs, requiring major workforces to be housed on site for many months. But even some of these very big jobs on the mainland were serviced only by barge (such as Whangaparaoa).

An adjunct to coast defences were the searchlights. These, by their very nature, were required to be located forward of the guns and usually close to the waterline. With the battery sites themselves being on often rocky promontories, the searchlight emplacements were therefore sometimes on incredibly precarious cliff faces, leading to considerable engineering problems. Those in 1890s North Head had short tunnelled accesses, but by the 1930s the adoption of ever more barren shorelines on which to place batteries led, for example, to a 480-foot low tunnel at Godley Head to reach one of its lights. Many of these emplacements have since fallen into the sea (as a Whangaparaoa) or threatened to, and suffer significant damage and undermining from the actions of the sea, such as those at Castor Bay. By most often being visible from the shoreline, they have also suffered a high disproportion of state vandalism in the form of removal by local authorities in the name of civic beautification or child safety (I think here of all of Wellington's many searchlight emplacements).

Often the very promontories on which our batteries were sited were unstable ground, which on the west coast saw an advancing sea undermine them totally (in the case of Manukau South Head emplacement, which fell into the sea in the late 1980s). The generic nature of War Office plans did not take into account differences in ground conditions. New Zealand's softer greywacke or rotten rock ground was easier to tunnel, but perhaps less stable. When two 6-inch guns were being considered for Napier's Bluff Hill the Harbour Board worried that the hill had been significantly weakened by the earthquake a decade earlier: the Army were also concerned that the hill would be the battery's weak point if enemy shellfire were directed on to the cliff face below the guns.

2. Elevation of sites

Not only were the sites isolated, they were also high up. The *average* height of the 20-odd Victorian batteries was 124 feet above sea level, but Auckland's Fort Victoria was in fact 260 or so feet, and Battery Point's upper gun 238 feet. Where a battery wasnt high up, such as with Dunedin's Ocean Beach at 33ft ASL, it suffered incredibly from wind-blown sands - that ultimately choked it to death.

Elevation was a problem when you consider the volume of materials that had to be delivered to them – such as the 20,000 Mt Cook bricks ordered in January 1889 for Kau Pt 8-inch battery, which had 50 yards of brickwork in its subterranean walls, or the weight of the ordnance to be mounted at the end, such as the 13-ton barrels for the Armstrong 8in BL. Cement was also delivered to these sites, in casks.

The engineering problems faced in coast defence construction in the 1930/40s related to scale. Many problems were the same as faced by Victorian engineers, but on a much greater scale. For instance heights above sea levels grew, with the trunnions at Wrights Hill being almost 1200ft up.

2. Moving heavy loads

All the Victorian work is before the advent of the internal combustion engine and while there seemed to be some traction engines in NZ at this time, they were not used for military hauling. So loads were limited to what could be moved by hand or horse-drawn waggon. In 'repository drill', gunners learned how to move such loads with mere ropes and baulks. The gun barrels were the largest loads handled. They were usually brought by ship to a wharf as close as possible, then rolled or dragged to the bottom of the tramway to be winched up the incline.

On the inclines the loads were pulled up on trolleys by winding drums driven by small steam engines. There were too few of them. The engines had to be moved about from job to job as required, a schedule that ran well (if not slowly) until an unexpected need arose. When, for instance, a damaged gun from North Head had to be taken out for replacement, it required a winding engine to be returned to Auckland - disrupting the schedule. Their power was not always up to it, usually offering only 1- or 2-tons lifting weight, the guns having to be assisted with manpower on block-and-tackle.

The inclines were also prone to gravity-fed accidents, such as that at Halswell Pt in January 1889. Prisoners there "were engaged lowering a truck loaded with stone," Major Messenger reported, "when owing to the shackle not having been properly fastened it broke way, coming with great force on to the 8-inch gun which was standing on a truck on the line ready to be parbuckled on to the pit, it drove this some 12 or 15 ft back although it was scotched up with sleepers placed behind the wheels, but beyond breaking the skid and making some slight indentations in the muzzle of the gun no further damage was done" [AD57/14]. He requisitioned for the skid broken by prisoners.

By WWII of course the size of ordnance also grew, with the 9.2-inch gun barrels weighing 28 tons - over twice that of the largest gun installed by 1900. This increment, however, was made up by the fact of heavy haulage tractors and cranes able to move the much larger loads employed and roads could be put in by bulldozers (which often had to assist the tractors pulling the gun trailers).

Whangaparaoa is an example of where the difficulties of barging materials to the site itself led to downstream transport problems. The barges were loaded in Auckland's commercial harbour, from ships bringing the 9.2-inch guns and parts from the UK, and towed to Whangaparaoa. They had to make their way out past the inner harbour defences, which included a minefield and boom stretching across between North Head and Bastion Point. On one voyage delivering parts in October 1943, the barge collided in the narrow friendly channel with the Boom Defence Vessel, a small ship that controlled the gate in the boom.

4. Permanence vs Temporary

An engineering problem peculiar to the Victorian coastal defences was one of permanent works having to be built over extemporised works. Most of the headlands had been identified up to three decades beforehand as the most suitable for coastal batteries. The war scare of March 1885 encouraged a very hasty erection of guns on these promontories, in works redolent of earthen redoubts from the NZ Wars. They were dug by men of the NZ Constabulary Field Force who were used to building such in the frontier districts, bordering the Aukati or confiscation lines. This war scare had been the spur to "put the defences in order", as was the clamour, so many of these temporary works were made permanent. Permanent materials had to replace timber and sandbags, whilst at no time preventing the gun from going into action at short notice.

This was not helped by a change in design approach half way through, from masonry and concrete-heavy designs to those using earth for natural and more-effective defence against enemy fire. The materials used in the first extemporised works were usually sandbags and timber. The timber decayed after not too long in the ground, with the Commandant Lt Col Fox noting in 1893 that a number of works had magazine walls dozy from rotting timber.

This issue was not confined to the Victorian era, as is shown by a photo from the Marlborough Sounds emplacements, but in WWII the needs for quick defence were more often met by a mobile medium gun, a big wheeled piece that could be towed away when no longer needed.

The exigencies of war, such as shortages of time and steel in WWII, led to more work. When delays counted in years were, for example, indicated before such weapons as the 9.2-inch or 6pr Twin guns would arrive in NZ, temporary batteries had to be erected to fill the void (such as Rangitoto's Quarry Battery).

Decay is not confined to timber. The concrete used in ultra-rushed jobs tended to be of poorer quality, leading to early problems. This was seen in Taylor Battery overlooking Lyttelton harbour, the pad of No.2 emplacement cracking in March 1941 only weeks after being poured. (Though, after being fixed, it served on for 5 months.) At Fort Opau in Wellington, a PWD foreman was sacked at about the same time for using dirty aggregate.

The concrete of some structures is also decaying now, leading to safety concerns. DOC has stabilised the overhead covers at North Head's North Battery, and the local council put stays under the overhead covers at Castor Bay, but similar worries exist for other sites (Wellington Ohariu Bty or Fort Opau at Makara).

Coast defence was also very costly. Premier Seddon mentioned in 1904 a figure of £645,000 for all expenditure to that point - which the Reserve Bank Inflation Calculator converts to around $86 million in today's value. The cost of C20th coast defences would add several times that - the 9.2-inch batteries alone (costing $1.2 million in 1944) comes to the same amount today, ie equal to all coast defences built in the C19th.

5. Fine and coarse

I mentioned at the beginning the dichotomy under which the builders of coast defences had to work – characterised as 'Fine and Coarse'. This was another unique requirement that had significant engineering implications. Fortifications had to be not only proof against heavy bombardments – requiring coarseness – but also allow for the workings and tolerances of very fine instruments – requiring fineness. It was pugilism meeting rocket science, perhaps.

Thick walls and roofs for defendability were understandable from both eras, but the requirement for housing fine instruments in the Victorian era is possibly not so well known. Each battery was ultimately to have a fire control instrument, a Watkins rangefinder, operating in a post nearby. The measures taken to protect them from destructive fire involved revolving armour-plate iron cylinders erected inside a concrete Observation Post. Speaking tubes (and later electro-mechanical dials) transmitted the data to the guns for Case II or Case III firing (those in which data for range and/or bearing came from this instrument, rather from the gun sight itself). By the end of the century they were connected to tide gauges as well.

In the WWII period, of course, this fine/coarse dichotomy comes into its own, especially for the gunners in the long-range counter-bombardment batteries who were never intended to see their targets directly, getting the aiming information instead from fire control instruments in the plotting rooms. Sites for all batteries were Surveying to 1/10th inch, so that their exact locations and heights above sea level were known for the trigonomic and geometric calculations carried out by the instruments. A Fortress Plotting Room in a counter-bombardment battery received information from various Fortress Observation Posts around the coastline, with details of distance and bearing to a possible target, which the plotting instruments had to convert into information each gun could use – bearing, elevation and the charge required. A full kit out had both a Fortrress Plotting Room sending data to Battery Plotting Rooms in each battery, and a Fire Commander using a Fortress Plotting Table, Coordinate Convert, Fire Direction Table, Ballistic Correction Calculator and Fall of Shot Encoder. At the end of this calculation the data was sent to the guns via Magslip Box and 1-inch armoured cables, an early digital system devised by the Royal Navy in WWI. We now take for granted digital data, dialing up the internet via twisted copper, but in 1944 when this was being installed in our counter-bombardment batteries, it WAS rocket science.

Camouflage requirements had engineering implications if added from the start. As well as designing a building with both fine and course needs, the designers had to make it look like something else. This happened in greatest relief at Castor Bay, where the BOP was built from the start to look like a beach resort ice cream kiosk, and the gun covers adapted soon after the concrete had cured to look like houses. The battery camp so successfully looked like civilian housing, with tennis courts, that the RSA complained, saying there's a war on. Others, such as at Whangarei, Bluff and Dunedin, were also modified to look like cottages.

As well as defence against bombardment, the earth's own destructiveness in the form of earthquake influenced planning, in Wellington at least. Earthquakes had already reduced a fortification in Wellington area, the two-storey stone Paremata blockhouse. Its poorly-mortared stones were unsettled first by the 1848 earthquake then irrevocably by the magnitude-8.2 shocker in 1855. After the first shake proposals by Royal Engineer advisor, Lt Hutchinson, took earthquakes into consideration when designing batteries for Wellington, rejecting brick and casemates as a result (these designs were not built).

By the 1930s/40s the destructive power of enemy fire had also grown exponentially, requiring a much greater degree of protection afforded by the design and in the build. The solution was to go further underground than anything dug beforehand, leading to its own set of unique engineering problems. Bulldozers and mechanical excavators replaced the human labour of the first era, but drainage problems were never completely resolved.

6. Kiwi Adaptation

NZ adaptation can be seen in the engineering approaches to building coast defences. The building plans originating with the War Office in London were invariably prepared to meet the Empire's varied needs, taking account of all contingencies and types of ground. NZ engineers often stripped out the unnecessary to simplify and speed them up in the NZ context, tailoring the designs to local conditions. The desire to 'wing it' might be seen in Capt Falconer's confidence to make submarine mining work before the survey of the Auckland minefield had been undertaken in the late 1890s. Battery blueprints had to be adapted to the NZ ground, such as Boddam's standard 2-gun 6-inch battery layout which, for Wellington, had to be distributed vertically to make it conform to the hilly site, Fort Kelburne.

Cost too led to a desire to use less concrete and more earth. The last Victorian battery built from scratch, Fort Victoria in Auckland, was simplified after the publication of *Clarke's Fortification*, by Sir George Clarke, the guru from the Colonial Defence Committee who had by then become Governor of Victoria. Less concrete was used, the emplacement made smaller and without an overhanging lip, and the natural defences of the earth being relied on to a greater extent. This was a culmination of modifications to the 1880s forts, which replaced slab-sided concrete walls with earth-covered defences and filled in the deep anti-personnel ditches in favour of shaped ground which produced killing zones of musketry fire.

The Government's chief fortifications overseer, the Public Works Dept, used local precedents to cut costs - such as using Tawa Flat Railway tunnels designs and forms for magazines and engine rooms in the 9.2-inch batteries. This used existing 10ft-wide forms, placed up against the excavated tunnel interior, behind which concrete was poured. After the concrete had dried, the form was moved 10 ft further along.

Another adaptation of War Office designs for the 9.2-inch guns was for safety. At Whangaparaoa, the two engine room exhaust vents were found to be in the line of fire, allowing concussive blast to travel down them and into the engine room. They were moved.

Burster slabs had been used in Motutapu 6-inch Bty according to War Office plans, but were not repeated at the hastily-erected 6inch battery at Whangaparaoa in 1940 or Castor Bay in 1941. Tunnelling was easier in NZ's greywacke than in Britain's cliffs, and sinking the magazines 40ft into the ground was estimated to give the same protection as a burster slab, allowing them to be dispensed.

The exigencies of war also have an effect on the heritage longevity of defence structures. A good example is the use of impermanent materials caused by a shortage of resources, such as in the overhead covers built on the Waitata Pt emplacement near Russell. With reinforcing steel in such short supply for the covers which were normally cast in concrete and called the 'frying pan' covers, for obvious reasons, Northern Military District built these in timber. They sourced huge old wharf piles and splayed them in arrangement like the outstretched fingers of a hand, which smaller timbers running across them to support the asphalt 'plastic armour' on top. This was an anti-blast cover, from air-bursting enemy rounds. The long-term implications of this can be seen now, in that both these covers have collapsed.

While overhead covers were deemed necessary, and helped justify the decision not to build burst slabs over the magazines, their construction was usually left to after the gun had been made ready for action with the minimum of work. This in the minds of some made them seem unnecessary and wasteful of steel that was also needed for the country's boat-building or munitions programme. While the frying pan cover design used lots of steel, it had the advantage (in a 2-gun battery) of allowing 330° traverse by both guns (and 360° by one gun), whereas a conventional bulky Colchester type design, which used less steel and more concrete, restricted the guns to 180-220° traverse. Those building the Palmer Head guns even tried an experimental overhead cover to get round these problems, but without success.

A kiwi gung-ho approach can also be identified when the word lighthouse is spoken. At two locations, Godley Head and Oamaru, the headland chosen for the coast defence battery also happened to be that in use for the local lighthouse, which had guided shipping into port for decades. The presence of the lighthouse, that might at worst impede the actual line of fire or at best limit the angle over which the gun or guns could fire, did not deter the local army officers. To the military men choosing these sites, the safety of local shipping came a poor second to that of the whole port and populace – and the lighthouse would simply have to be moved, and were.

Conclusion

When NZ embarked upon a major fortification building programme in 1885, it faced a range of engineering problems. These were associated with the remote coastal locations and advanced specifications of what essentially were armoured buildings with high-tech functions. The engineering solutions applied were not always apparent but involved local modifications to the Imperial designs, and the cleverness of local civil engineers. The know-how and can-do approach continued to be applied as long as fortifications were built – until WWII.