Please read and send in as full a discussion as possible at earliest date.

The Canadian Society of Civil Engineers.

INCORPORATED 1887.

ADVANCE PROOF—*(Subject to revision.)*

MILITARY ENGINEERING.

Its History and Connection With Civil Engineering.

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To be read before the General Section, Autumn, 1905.

HISTORICAL, MILITARY, CIVIL, AND "ORNAMENTAL" ENGINEERING.

Man was a fighter before he became an agriculturist or a manufacturer, and so military engineering preceded civil engineering, and has still retained (and always will retain) some of its primitiveness.

Indeed, between military engineering and civil engineering there is historically an intermediate stage which we may call "ornamental engineering,"—to this stage belong the Pyramids, the Colossus at Rhodes, Cleopatra's Needle, and the enormous monoliths in the Phoenician temple wall at Baalbec in Syria. Wherever we notice this stage of "ornamental engineering," we may infer a lengthy period of previous civilization, which will be confirmed by the researches of archaeology.

We know that Egyptian civilization had existed for a long time when the Great Pyramid was built by Cheops, though that event took place nearly 4 000 years B.C., because the art of that same period had long passed the barbaric state, and shows signs of elaboration; and the religion that brought the enormous granite sarcophagi of the underground temple of Serapis hundreds of miles down the Nile, was not that of a primitive people. It would seem that the ancient world had no call for utilitarian engineering, for

the energies of the engineer in peace time were only turned to unproductive and monumental works.

Perhaps the earliest civil engineering works now in existence are ancient canals and irrigation works;—we read of a celebrated Chinese engineer named Yü who was engaged in canal building in B.C. 2,200, and we know that there were very ancient irrigation works in connection with the Nile and its annual flood.

Probably the oldest military engineering work nox extant is the great wall of China;—similar to this, but following thousands of years after, are the Roman walls built from sea to sea across the north of England, to keep off the invasions of the Picts and Scots.

Many of the greatest military engineering works of old have from the nature of things disappeared, such as the bridge of boats built by Xerxes across the Hellespont, the damming of the River Euphrates at Babylon to effect an attack of the city along the dried river bed, the ignition of the besieger's ships at Syracuse with burning-glasses by Archimedes and his lifting of the same ships by huge cranes.

The earliest road making was for military purposes,—perhaps the best known (though not the most ancient) example of which is the Roman roads in Great Britain; the peculiarity of these roads is, that they run often in a perfectly straight direction for many miles, ignoring hills. They are still in many cases in use, and retain their ancient names, such as Watling Street, Fosse Way, &c.

As in the case of the Chinese and Egyptian civilizations, the first example of civil engineering on the part of the Romans took the form of hydraulic works and aqueducts, and are in many places still in existence.

But one might almost say that civil engineering is the growth of the last century;—up to that time the word "engineer" meant military engineer, and when Shakespeare said

"'Tis sport to see the engineer, hoist by his own petard,"

it was not necessary for him to qualify the word.

The engineer in Shakespeare's time was engineer and artillerist in one,—he managed the engines of war, which then used gunpowder instead of the more primitive propelling forces of the catapult, and he blew in the gates of a town or castle with a petard instead of using the more primitive battering ram. In those days the word "artillery" was applied to the art of the archer, as will be seen in the authorized translation (date about A.D. 1,600) of the Bible (story of David and Jonathan).

Likenesses and Contrasts in the Various Branches of Civil and Military Engineering.

In the enormous development of civil engineering during the nineteenth century, it was the steam engine that set the avalanche rolling, gaining volume at every foot of its onward progress.

There has been no corresponding development of military engineering, but it has been rendered increasingly difficult to become a good military engineer. The military engineer must scan the whole field of hydraulic, railway, mining, electric, mechanical and sanitary engineering, and pick out from each branch what will be useful to him. He cannot afford to neglect any, and must be dependent on the specialist in each for the advancement of his own science, for though he may very often become a specialist himself, yet he must never neglect a knowledge of the other branches.

It is not, however, a case of being "master of all trades," for he need only know what of each trade is capable of military application. To take an example:—Development in bridge building has scarcely affected the military art at all, which still remains primitive,—military bridges are almost entirely built of timber, rope and nails. It is true that the military engineer may be called upon to repair steel bridges or stone arches as in the South African war, but he does this primarily by erecting a temporary timber structure (completed in a few hours) and then proceeds more leisurely to a permanent repair if the proximity of the enemy permits. Boat bridging is almost entirely a military art, and a branch of the Royal Engineers called the "Pontoon troop" has this as its special occupation. Again, the destruction of bridges is a problem seldom faced except by the military engineer.

Of course, the functions of the civil and military engineer often overlap; principally in survey, in railway engineering, and in telegraphy.

For many reasons it may be convenient to carry out surveys by a military organization, as in the Ordnance Survey of the British Isles, the Survey of India, &c., and in some cases it may be absolutely necessary (as on a hostile frontier); but the methods and instruments employed by military engineers are almost exactly the same as those of civil engineers. It is convenient to build many railways on or close to the India frontier under military direction, and it was absolutely necessary so to build the railway from Cairo to Khartoum by which the Soudan was re-conquered; and here again the methods of military and civil engineer are the same.

As far as mechanical engineering is concerned, the military engineer takes a civil invention, such as the steam engine, oil engine, bicycle, motor car, and adapts it for military purposes;—similarly

with the lathe, shaping machine, drilling machine, &c., when applied to the manufacture of big guns and other military material.

The principles of sanitation are the same for the military engineer as for the civil engineer, but they have respectively to apply them to widely varying conditions, as will be seen by comparing the problems of water supply and disposal of refuse for an army of 30,000 men spread out for a variable period along, of a front of (say) 15 miles, and that for a similar number of inhabitants occupying permanent dwellings in a city.

Telegraph and telephone work (including wireless telegraphy) are almost exactly similar in their military and civil developments, civil inventions being applicable almost without adaptation to military requirements; but these sciences come in warfare under a large head whch may be called "signalling," and include the conveying of signals to a distance by semaphore, waving flags or flashing lights.

Electric lighting has been applied to harbour defence, search lights or fixed beams taking about 25 H. P. to run them, and also to siege operations.

Fortress Warfare From a Civil Engineering Point of View.

To turn from generalities to an actual example of modern warfare, let us imagine a staff of civil engineers, experts in all the branches, placed under the command of the general who is besieging Port Arthur, to give him the benefit of their advice. How can the fortress be reduced? First, the water supply may be cut off, and the railway rendered useless to the besiegers.

The throwing of explosives from a distance is now the work of the artillery, and the preparation of the sites for the guns requires more military knowledge than particularly scientific engineering.

But how to approach the chain of forts that protects the fortress? Can the engineers devise any means to protect the attacking troops from the hail of lead than mows them down in swathes like grass, even at a distance of 600 yards,—can shields be devised light enough to carry and yet impenetrable to bullets? Can any means be devised to cut those terrible wire entanglements? or to divert the electricity with which they are charged?

The fortress must be reduced in six months;—can tunnelling equipment be procured that can drive a tunnel 2,000 yards in that time and so enable a charge of explosive to be placed under a fort? Can any modern methods of excavating be employed? or are the pick and shovel to be the only tools for earthworks?

We can see how essential telegraphs and telephones would be to the conduct of the siege, and how ballooning would have a field of its own; but for the most part the refinements of civil engineer-

ing would be useless,—none the less there would be ample scope for the common sense, readiness of resource, and energy which every successful civil engineer should possess.

Final Broad View of Subject,—the Patriotic Standpoint.

Taking a final view of the subject discussed, and from the broadest point of view, we find a close connection between civil and military engineering. Civil engineering has been defined as harnessing the great force of nature for the service of man, and *military engineering may be defined as harnessing those great forces for the service of one's country.*

Looking at it from this point of view; can the building of the Siberian railroad be called distinctively either a military or civil operation? And can the building of the Canadian Pacific Railroad be considered entirely a civil operation? Can a strike, when organized labour enlists natural forces on its side against organized capital be considered a really peaceful operation?

There are more ways of conquering a nation than by actually shooting its inhabitants;—its food supply (for instance) may be cut off, and this may be done by apparently peaceful operations. In the establishment of the internal communications of Canada free from all warlike interruptions, that might disturb its supply of food, of fuel, and of raw material for manufacturers, are not the civil engineers of Canada doing the work that is most essential for the defence of their native land?

In such works as the new Transcontinental Railway, the Georgian Bay Canal, and railway communication to Hudson Bay, Canadian Civil Engineers are carrying out nothing less than the peaceful conquest of their own country.