David Muir Wood

CIVIL ENGINEERING

A Very Short Introduction

David Muir Wood

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A Very Short Introduction



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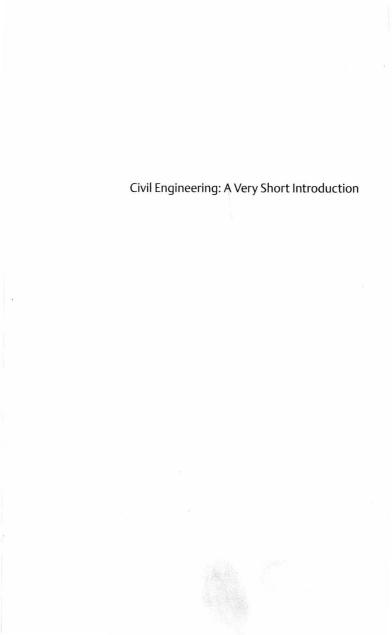
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David Muir Wood Monikie April 2012

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Introduction

In 1828, the Royal Charter of the Institution of Civil Engineers, drafted by Thomas Tredgold, defined the purpose of the Institution:

The general advancement of mechanical science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a civil engineer; being the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states, both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation, and docks, for internal intercourse and exchange; and in the construction of ports, harbours, moles, breakwaters, and light-houses, and in the art of navigation by artificial power, for the purposes of commerce; and in the construction and adaptation of machinery, and in the drainage of cities and towns.

Setting off on a camping trip in the hills the associated needs are evident. You need shelter from the elements and from potential predators. You need a supply of fresh water, food, and energy for cooking, heating, and light. There is some advantage in thinking ahead about 'waste disposal' and possibly the need for medical supplies. Wandering the wilderness has its attraction but more

frequently there will be some form of pathway in existence for you to follow. The pioneering people reaching the Americas or other unfamiliar lands had the same requirements. Interdependence encouraged the formation of settlements which became villages and then towns and cities. The benefits of scale and collaboration in provision of this infrastructure were obvious—common means of protection against predators (human or animal), common sources of clean water (no need for each household to have its own well), common strategies for disposal of waste (one man's waste disposal can become another man's pollution), common sources of energy, common networks of transport. The advantages of sharing skills and resources would have rapidly become apparent.

All these elements of infrastructure come under Tredgold's definition of 'civil engineering'.

The emergence of civil engineering

The term *civil engineering* has been used, and its meaning has evolved for rather more than 200 years. Chambers Dictionary defines an engineer as 'one who designs or makes, or puts to practical use, engines or machinery of any type, including electrical; one who designs or constructs public works, such as roads, railways, sewers, bridges, harbours, canals, etc; one who constructs or manages military fortifications, etc., or engines'. A civil engineer is 'one who plans and builds railways, docks, etc. as opposed to a military engineer, or to a mechanical engineer, who makes machines etc.'

'Engineer' comes from the Latin *ingenium* meaning skill, linked with the design and construction of clever devices (*engines*)— such as catapults—for inflicting damage in military campaigns. The term *civil engineering*, introduced to distinguish those working with non-military engines, seems to be almost an oxymoron. But the term now relates to that branch of engineering

which is concerned with the creation of the infrastructure of society: the *civil* implying this link with the citizen and with civilization. The techniques used for these *civil* projects have general application: civil engineers may well be working with the military on provision of buildings, roads, bridges, airfields—specifically *un-civil* engineering under the original meaning of the term

Of course, even before the term civil engineering was coined, civil engineers were in existence even if they were then described using other terms. The person (or persons) unknown who organized the construction of the Great Pyramids, some 5000 years ago, must be called an engineer. He (probably a man) certainly had acquired, by observation and experience, the skills necessary to translate a concept into reality using effective technology. The Greeks (Anthemius of Thrales and Isidorus of Miletus) put in charge of the design of the church of Hagia Sophia (in Constantinople -Byzantium or Istanbul) by the Roman Emperor Justinian in around AD 600 were, like Christopher Wren 1000 years later, expected both to solve the day-to-day problems of detailed construction and also to plan the overall shape and form: they were civil engineers. The Greek word μηγανή (mechani) means 'a machine, or a clever trick'. Odysseus had the attribute πολυμήχανος (polimechanos): 'one who knew many tricks and could cope with difficult situations'. This would be a good description of an engineer, but today a mechanic would be expected to have a narrower range of skills than an engineer. Anthemius and Isidoros would have been described as αρχιτέκτονες (architektones): master builders. The potential for confusion of engineering and architecture is apparent. The inventiveness of cathedral builders such as Brunelleschi in devising special cranes for safely raising construction supplies would have qualified them for the description of engineer too. Words like mechanic, engineer, architect now resonate in a way which does not begin to think about their origins two or three millennia ago.

Much mediaeval engineering was based on geometric rules based on prior experience of successful structures. Scientific understanding developed slowly as people such as Galileo sought explanations for phenomena and began to apply mathematical concepts to the analysis of structural elements. The Industrial Revolution which began in Britain in the early 18th century produced both a large number of ingenious steam-powered machines, which replaced man-power in the new factories, and also a new building material—cast iron—which had a strength greater than the timber that it replaced in many bridges and large buildings. With care in the manufacturing process, there was a predictability and narrow variation of the mechanical properties which made its use more straightforward.

The cathedral builders (or engineers) organized themselves into a closed community, keeping the secrets of their experience within the community. The notion of engineering as a profession is a development from this but it occurred in different ways in different countries. The French, with an emphasis on Cartesian analysis and mathematical representation, made rapid progress in what we now see as the various branches of engineering mechanics, with state encouragement. The British, with an emphasis on observation and practice, and less desire for central control, developed a more autonomous profession. The national routes to the *formation* of engineers differ widely in the balances of practice and theory or of training and education.

In late 17th century France, the military engineer was given formal status by the creation of a *Corps des Ingénieurs du Génie Militaire* in 1690 by Maréchal Vauban. Vauban was famous for the design of fortifications, which usually consisted of masonry structures retaining compacted earth (within the remit of civil engineering today). In 1716, this was followed by the creation of the *Corps des Ingénieurs des Ponts et Chaussées* who were charged with the construction and maintenance of networks of communication (roads and bridges). The training of these latter

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